CHAPTER FIVE

Urban Observing Programs

On any evening under the stars, a few wonderful deep sky objects (DSOs) draw me to them like a moth to flame. These are the beautiful and bright deep sky showpieces like M13, the Hercules Cluster, and M42, the Great Nebula in Orion. M13, M42, and the other bright and outstanding Messiers deserve repeated observation, certainly, but eventually you'll have to move beyond the "best of the best" or risk boredom and a loss of interest in observing. Also, just observing the bright easy ones doesn't help hone your observing skills, one of the reasons we gave in Chapter 1 for observing from the city.

I find that having an observing project, a specific program of challenging and new objects, helps me move beyond the best Messiers, see more, and keeps me interested in observing every clear night. If I have a project I'm working on, I'm more likely to get outside with the telescope than I would if I were just observing "randomly." Having a pre-prepared list of objects to view also means I don't waste time trying to figure out what to look at next—if I don't have a list, I tend to do a few of the brightest objects available on any given evening and call it a night.

What kind of observing project? When it comes to the deep sky, in the city as well as in the country, the place to start *is* the Messier list. Most of these well-loved objects are easy pickings for careful astronomers in light-polluted areas, and they give you a good idea of what you can expect from the deep sky from your location before you move on to more difficult challenges. For that reason, start with the Messiers even if you've viewed the entire list of 110 objects before from better observing sites. Don't just stay with the M13s and M42s, though. The Messier contains some frustratingly hard objects that you should make it a matter of personal pride to view from the city.

The Messier: Tough and Easy

Sure, M13, M5, M42, M45, and quite a few others are genuinely bright and easy for small urban scopes, but there are some genuine toughies, too. The hard ones fall into two categories: bright and dim face-on spiral galaxies and challengingly dim nebulae of all kinds. In the former category are those legendary island universes, M101, M74, M33, and similar galaxies. The latter group includes M97 (the Owl Nebula), M76 (The Little Dumbbell Nebula), M1 (the Crab Nebula), and a few others. All of these objects can be very difficult to see from an urban site on most nights, but don't despair if you've just hunted fruitlessly for M74 for the 10th time. It *can* be done. You just need preparation and knowledge on your side.

Preparing to Observe the Messier

Don't just haul the scope out into the yard, glance at a copy of the Messier list and start hunting. That is a recipe for frustration. Oh, you'll have some successes, but you'll have plenty of failures, too. To minimize these failures you'll need to ready yourself by knowing the "when" and "what" of urban observing. "When" as in "when do I look for a particular object?" and "what" as in "what will it look like when I find it?"

When to Look for Deep Sky Objects

You probably already know you should wait until an object is at least 30° above the horizon before trying to find or observe it. This is true in both country and city, since, even in the country, the thick air and dust near the horizon can really dim-down a galaxy, nebula, or star cluster, but this is an especially important consideration in the city, as light pollution will be at its worst closest to the horizon. In fact, you may find that you have to wait until the area of interest is considerably higher than 30° before it clears the heaviest sky glow, depending on your site. You may even have to hold off until the object is in a different part of the sky altogether. My home skies, for example, are brightest to the east, with the west being noticeably darker. It helps, then, if I wait for an object to move well away from the eastern sky before looking for it. There is always a best time to view any DSO regardless of the particular characteristics of your site: the time of its *culmination*.

Culmination: As Good as It Gets

To understand "culmination," you have to understand the term "Local Meridian." The Local Meridian or "Meridian" is an imaginary line that runs from the North Celestial Pole, though the Zenith (the point directly over your head), through the South Celestial Pole, through the Nadir (the point directly beneath your feet), and back to the North Pole. The Local Meridian never moves. As the night wears on, stars and DSOs (and the Moon and planets) rise in the east, move across the sky, cross the Local Meridian, and set in the west. By definition, then, when a star, a DSO, or anything else is on the Local Meridian, it is as high in the sky as it will ever get. Depending on an object's declination north or south, that may not be very high. When an object with a declination that places it far north or south of the Celestial Equator is on the Local Meridian, it is still not very high above the northern or southern horizon, but the moment when it is on the Meridian is *still* as good as it gets for that object elevation-wise. The moment when an object hits the Meridian is "*culmination*."

It is important for urban astronomers to know when this will happen, since the time when a DSO culminates is the time when it's farthest away from the dust, thick air, and sky glow near the horizon. Note that objects close to the celestial pole can culminate below the pole as well as above it. We're interested in the time when they culminate above the pole so they are away from the horizon as much as possible.

Planispheres, Computers, and Local Sidereal Time

How can you tell when an object of interest, say, galaxy M101, will culminate so you'll have a prayer of seeing it? An uncomplicated way is to use a Planisphere, one of those little paper or plastic "star wheels" that can be rotated to show how the stars will look at a given time and date. Rotate the wheel until M101 is on the meridian. Most planispheres will not have a marked line for the local meridian, since it has to remain still while the sky rotates beneath it, so imagine a line extending from the rivet that holds the sky-disk in place on your planisphere and running across the sky to the point marked "12 Noon" at the bottom (Plate 21). You can then read the planisphere's date/time scale to determine when M101 will be the highest in the sky. Naturally, if you've got a computer running a planetarium program, it's easy to change the sky until M101 is on the meridian and then read the time for your location.

Local Sidereal Time

Another way of determining when a DSO will be on the meridian is by using Local Sidereal Time (LST). Local Sidereal Time is easy to understand. Every object in the sky, as you're probably aware, has a Right Ascension (RA) value given in hours, minutes, and seconds. Local Sidereal Time is the value of the line of RA currently culminating on the meridian. M101's RA, which you can look up in a book or on a chart, is 14 h 03 min. When M101 is on the meridian, it's 14:03 LST.

With a special clock that reads sidereal time and a star chart at hand, we can both determine what's on the meridian now and what will be on the meridian at a given time. For example, if it's 12:03 now (in LST), it's easy to see that M101 will culminate in approximately 2 h. But how do you determine what the LST is? Formerly, you had to have a special clock, one whose day is 23 h, 56 min, and 4 sec in length rather than the 24 h of a Solar day (due to the Earth's movement in its orbit, the Solar Day is longer than the Sidereal Day). With the coming of the computer revolution to astronomy, anyone can now have a sidereal clock for little or no cost. Sidereal clock programs are available for both PCs and pocket computers like the Palm and the Pocket PC. Most planetarium programs will also provide a read-out of LST.

What Will the DSO Look Like? Surface Brightness

Finally, a good night in the city! Joe and Jane Newamateur are not about to waste it, either. They've started on the Messier list, had some initial successes, and intend to press on on this crisp and relatively dry spring evening. What to hunt for? Obviously, galaxies. If you're looking to the east, there's not a whole lot else to attract your attention during the spring of the year other than the rather lackluster globular M53. *Which* galaxies? Jane feels she's prepared well for this session. She has a notebook full of lists of objects printed with her deep-sky planning software, and has sorted the entries according to type and constellation. Looking thorough Ursa Major's entries, she comes to M101. "Here's a good one, Joe. M101. It's pretty bright, magnitude 7.9."

Joe and Jane start out bravely. At magnitude 7.9, this lovely face-on Sc spiral ought to be easy pickings for their 8-inch Dobsonian, but after half an hour of fruitless searching, they give up. This "bright" galaxy is nowhere to be seen despite the fact that they've star hopped carefully. "Oh, well. How about M97, the Owl Nebula?" It has an interesting name and looks fascinating in the pictures they've seen in deep sky guides. Its stated visual magnitude is a little dimmer than that of M101, but it should be easily visible in their dob, they think. Half an hour looking for M97 yields nothing. Joe and Jane move the scope back inside, dejected about their puzzling failures with these supposedly bright objects.

If a slightly more experienced urban astronomer had been on the scene, she could no doubt have told Joe and Jane that M101 and M97 are hardly easy from the city. Or even from the country at times. They are both, and especially M101, a face-on Sc galaxy, very subdued. But why? The catalogs clearly state that they are 7.9 and 9.9. The reason is that these stated magnitudes are the total *integrated* brightnesses of these DSOs. 7.9 *is* the magnitude of M101, but it assumes that this big 22 arc-minute-across spiral has been *compacted* to the size of a star. Find a magnitude 8 star and defocus your telescope until it fills a field of view 22 min across, and you'll soon get the idea. As the star expands, it becomes dreadfully dim. The key to the true brightness of a DSO is its *size*. The bigger a DSO is, the brighter it has to be to show up well.

How do you find the *true* brightness of a DSO? Many computer programs will give this true or "surface" brightness for DSOs (often listed as magnitude per square arc second or minute) as well as the integrated magnitude, how bright the object would be if squished down to a star-like point, which is usually labeled as the "V" ("visual") magnitude. With a little experience, you'll soon be able to get a fairly accurate idea of how really bright an object will be just by glancing at its size and

V magnitude. For example, it's easy enough to see that M33, with a size of 73 arc minutes by 45 arc minutes, is going to be very dim, even at its bright V magnitude of 5.7.

How can you figure true magnitudes, the true *surface brightness* (SBr) of DSOs yourself? A simple formula can be stated as follows:

$$\mathrm{SBr} = \mathrm{m} + 5 \times \log(\mathrm{d}) - 5 \times \log(70)$$

where

$$\begin{aligned} \mathrm{SBr} &= \text{surface brightness;} \\ \mathrm{m} &= \text{integrated (visual or V) magnitude;} \\ \mathrm{d} &= \text{size of object in arc seconds.} \end{aligned}$$

Using this formula, we find that the supposedly "bright" M101 has a "true" magnitude of 14.2, which makes it *quite* a challenge in the city. At V magnitude 9.9 and a size of 3.4 arc minutes across, M97 turns out to be at 13.63. Both of these objects are quite doable from the city with the right techniques and equipment despite these off-putting figures, but they are nowhere *near* as easy as their simple visual integrated magnitudes would suggest. The above formula, since it allows you to enter only one dimension of the object, works best for round DSOs, and will not give an accurate figure for a long, thin galaxy, for example. In my experience, though, the big round ones are the hard ones, in the Messier list. Among the Messiers, it doesn't get more difficult than face-on spiral galaxies and big planetary nebulae, both more-or-less round-shaped objects.

Aside from surface brightness issues, the size of an object can affect your ability to see it in another way. A planetary nebula can be relatively easy, even if it's large like the Owl, if it can be *well framed* in a medium-power eyepiece. If you can increase the power enough to darken the sky background, but still leave enough background *around* the object to provide a visible contrast difference. Consider M33. At 73 arc minutes across its major axis, it will totally fill the field of a medium-power ocular. All you'll have in the field will be galaxy; there will be no sky background to *compare* it to, and it will be *very* hard to see. Naturally, you can reduce power until the galaxy is better framed, but the Catch 22 in the city is that by doing so you brighten up the sky background and there *still* isn't enough contrast to pop the object out. Bottom line? Bigger equals harder.

Smaller isn't always easy, but it sure helps. Small planetary nebulae are a natural for the urban observer. With these objects, surface brightness is on your side. At approximately 1′ (arc minute) across, the Ring Nebula, M57, for example, really does look almost as bright as its published integrated magnitude of 8.8. In a 4-inch scope it can be easily seen as a delightful little smoke ring. There are countless other planetaries scattered across the Milky Way that are in the 1′ or smaller size range. With these small nebulae, you can push even a smaller scope farther than you might think, going to magnitude 10 or 11 planetaries with a 4-inch scope. At a certain point, however, as planetary nebulae get smaller, things get hard again.

The exact *small* size where they get tough will depend on the observer, telescope and magnification, but at less than 5″ (arc seconds) in diameter, planetary nebulae become difficult to distinguish from stars. You can increase the magnification in hopes of making these little things look non-stellar, but on nights of poor seeing this may increase the apparent sizes of field stars too. One way of dealing with small planetaries is to look for a blue–green color. Planetary nebulae often emit light of this color because they are radiating at the wavelength of OIII due to doubly ionized oxygen in their makeup. Unfortunately, not all planetaries look blue–green, no matter how large your scope is. Quite a few just look gray. And the dimmer they are, the harder it is to detect color.

One clever method of picking out these objects is to "blink" them with an OIII filter. Theoretically, if you compare the view with an OIII filter to that without, the nebula should be more visible with the filter in place. If you switch the filter in and out rapidly by passing it in front of your eyepiece's eye lens, it should appear to *blink* in the field. Naturally, the planetary must respond to an OIII filter well—something not all of them do—for this trick to work. Both methods of locating tiny planetaries can be supplemented by a comparison of what you see in the field to a detailed chart made with a computer program. A combination of these methods will almost always unmask even the smallest and most stellar-appearing planetary nebulae.

Urban Observing Projects Beyond the Messier

Yes, Charles Messier's famous list is the obvious place to start if you're looking for an observing project. But what happens when you complete it? What if you're struggling with the last few difficult objects of the Messier list, are waiting for an especially good night to track them down, and want another project to work on while hoping for a superior evening? Certainly you can take on the objects in this book, but you'll eventually exhaust them too. What next? A good place to look for ideas is the Astronomical League's website (see Appendix 1 for the URL). The Astronomical League is the U.S. umbrella organization for both individual amateurs and astronomy clubs. One of its most popular functions is running *observing clubs*. Complete a list of objects and you'll be awarded a nice certificate. The AL has a variety of these "clubs" ranging in difficulty from the Messier to the somewhat forbidding Herschel 400 II (a list that contains some truly difficult objects). The Herschel II might be a bit much if you're in the worst of the light pollution, but one new AL club is a natural for you, the Urban Club.

To qualify for membership in the Urban Club, an amateur astronomer must view at least 100 DSOs from a list found on the League's web site. You must observe these objects from a suitably light-polluted area (this is the only time I recall seeing light-pollution listed as a *requirement* for deep sky observing), which is defined as any area where the Milky Way is not visible. To qualify for the club award certificate on completion of the list, you must be a member of the Astronomical League, but anyone, anywhere can enjoy working through the League's well-thought-out Urban List.

There's also a second Urban List you can pursue, one composed of double and variable stars. Many observers say that they prefer "real" DSOs to stars, but doubles, in particular, can be incredibly beautiful and fun to observe.

Your Own Projects

There are numerous other lists available online and in the astronomy magazines and books for you to try as your "next" project. Unfortunately, though, most of these are not aimed at city observers. When you run out of ready-made observing programs for the city, what do you do? You make your own. The actual construction of an observing list is made easy with programs like *Skytools 2*. Or you can just use a pencil and a piece of paper. Whichever method you choose for putting together observing lists (I prefer computer programs since you can easily sort objects as desired), you'll need a source of data on DSOs to help you decide what to put in your list and what should be left out. *Skytools*, *Deepsky*, and other astronomy software will give you some information about the DSOs in their databases, but this may not always be in-depth enough to allow you to decide whether that 11th magnitude galaxy should go on your current city list or not. Most amateurs turn to one of two sources of printed information on the deep sky for help in choosing objects, *Burnham's Celestial Handbook* or *The Night Sky Observer's Guide*.

Burnhnam's

Burnham's Celestial Handbook by the late Robert Burnham Jr., first published in its present form in 1976, is a wonderful and beautiful book in every way. Composed of three fat volumes, the *Handbook* covers the entire sky from celestial pole to celestial pole. Its data is arranged by constellation, one chapter per constellation, with each chapter containing a list of interesting sights—deep sky and stellar—and detailed descriptions of the constellation's most prominent objects. The information given about the important objects is more than detailed enough to allow you to determine what the subject will be like in your urban environment.

Unfortunately, once it was published, Burnham's was never updated in any meaningful way. This mostly affects the "theoretical" information contained in the book's introductory section is dated—obviously science has come a long way in the last 30 years in understanding how stars, galaxies, and the universe work. This outmoded data won't cause a problem for observers. What *may* trouble the active astronomer is the coordinates in Burnham's. The right ascension and declination values are all given for Epoch 1950.0. Due to precession, the wobble of the Earth's axis, the R.A. and declination coordinates of DSOs have changed significantly from their 1950-calculated positions. Again, this shouldn't really be much of a problem for the practical astronomer. It's easy enough to find an object on a chart and determine its epoch 2000 or later coordinates if necessary. There are even small freeware computer programs available that will "precess" 1950 coordinates to 2000—or whichever epoch you desire.

What keeps me coming back to Burnham's? Not just the hard data, though there's enough of that in the book to last most astronomers—city or country—for a lifetime. It's the beauty of Burnham's prose. His thoughtful, aesthetic take on the heavens is something every amateur astronomer should experience. For example, he doesn't just state the bare facts on how globular cluster M22 looks—big, bright, and resolved in small telescopes. He goes on to say how it reminds him of a passage in J.R.R. Tolkien's

Lord of the Rings. He doesn't just rattle off Sirius' vital statistics; he prints a poem about the Dog Star. No matter how the heavens precess, or how many generations of amateur astronomers come and go, *Burnham's* will always be loved.

The Night Sky Observer's Guide

Just because *Burnham's* is a *good* thing, that doesn't mean it's the *only* thing. Many amateurs will tell you the recent book, *The Night Sky Observer's Guide* by Robert Kepple and Glen Sanner, is a must-have for any DSO observer. *Sky and Telescope* magazine described this as "*Burnham's Celestial Handbook*: The Next Generation." Well, not quite. This book isn't the next Burnham's, and it doesn't try to be. *Burnham's* was a special work that's not easily duplicated. What deep sky observers wanted was not really another Burnham's, anyway, but a book on deep sky observing that contained many more objects than Burnham's with more details about their visual appearances and Epoch 2000 coordinates.

The Night Sky Observer's Guide (*NSOG*) delivers this—in spades. Like Burnham's it's arranged in constellation order. Unlike the previous deep sky bible, though, *NSOG* dispenses with Robert Burnham's philosophical and cultural references. You do get a short description of the mythological background of a chapter's constellation, but after that it's all hard object data, finder charts, and descriptions by visual observers.

Of particular value for urban observers is that the authors almost always include data on how a given object looks for a particular aperture range of scope. You'll get details, for example, on a galaxy's appearance in a 6–8-inch scope, a 10–12-inch one, and a 16-inch or larger instrument. If an object is overly difficult or impossible with a certain aperture, there will, naturally, not be an entry for that aperture. This makes choosing objects for an urban list very easy. If I'm using an 8-inch instrument in the city, for example, and I see that a galaxy was dim under the good conditions used for observations in this book, or if it's not described for an 8-inch scope at all, I usually move on to something else. In addition to its numerous photographs of DSOs, *NSOG* also features drawings for many DSOs. I like that, since I can usually get a better idea how particular target will look visually from drawings by fellow amateurs rather than long exposure photos.

Other Information Sources

There are numerous other deep sky observing books, but one standout is the series of books by the Webb Society (a membership organization for deep sky observers) in the UK. These volumes cover the full range of DSOs in 8 volumes, with each book devoted to one class of object. The books, while not copiously illustrated, are well written and an excellent reference for any deep sky observer. Unfortunately, the only volumes in the series still in print are the final three: *Anonymous Galaxies*, *The Southern Sky*, and *Variable Stars*. Nice books, but a little less interesting for the general DSO fan that the earlier volumes that covered meat and potatoes DSOs like galaxies and globular clusters. You may be able to find the earlier books from used sources.

Online Information

Before the Internet, back in the medieval days of the 1970s, the data available to the average deep sky observer generally came from two sources, *Burnham's* and the monthly columns in *Sky and Telescope* by that Dean of deep sky observers, Walter Scott "Scotty" Houston. We've lost Scotty now, and every DSO observer of my generation misses his steady, knowledgeable guidance. Our loss is made up for—at least in part—by the explosion of the Internet. Turn on your computer and you can browse deep sky databases for weeks. Everything from NASA's Extragalactic Database to the huge Principal Catalog of Galaxies (PGC) is available for any amateur to peruse.

For the novice, however, most of this is a bit overwhelming. Where to start? One good place is *SEDS*, the website of the organization "Students for the Exploration and Development of Space." Their web pages include easy to use illustrated databases of both the Messier and NGC. Also very helpful is *Skyhound*, owned by *Skytools* 2 developer Greg Crinklaw. *Skyhound* is packed with information about a wide range of DSOs. One of my personal WWW favorites is *Adventures in Deep Space*. This page, subtitled "Challenging Observing Projects for Amateur Astronomers," is aimed at advanced observers blessed with dark skies, but there is still a lot here to interest the urban astronomer. You'll find the web addresses for these pages in Appendix 1.

Your Own Tours

You've got the information, now what do you *do* with it? Once you have the data, the rest is easy when it comes to producing your own lengthy projects or single-evening "sky tours." What you put on your observing lists is strictly up to you, but here's what *I* do. I generally limit myself to just one or two constellations per list, constellations that will be well placed for viewing—at or near culmination and out of the worst sky glow—on a given evening. Staying within a relatively small area means you'll develop intimate knowledge of that part of the sky, always a good thing, and it will help you focus on a constellation's less prominent treasures. In order to fill an evening's observing hours, you'll have to try for the harder stuff rather than just zipping from M13 to M57.

In selecting objects, I also try to choose a good variety when it comes to types. Just looking at one thing—galaxies, for example—can become a bit tiring after a while. I try to assemble a list with some variety; one that includes at least a couple of different species of DSOs. Naturally, in some parts of the sky—Virgo, for example—there is a preponderance of one class of DSO, and it may be difficult to find candidate objects of other types. No matter which constellation I'm "working," I always try to include a few objects challenging enough that I'm not sure I'll be able to see them at all. Growing as a deep sky observer, especially in the city, means pushing yourself.

Finally, *I save the good stuff for last*. The showpieces, the M57s and the M22s, are wonderful anytime, but looking at these first, before the harder stuff and the objects I've never seen before, always seems anticlimactic. Once I've worked through the more difficult objects on my list, it's wonderful to end the evening on a high note with a blazing Messier globular cluster or nebula. Even if I've had many failures with the earlier objects on the evening's list, viewing an easy showpiece object or two as a finale means I always end my observing run on a high, satisfying note!

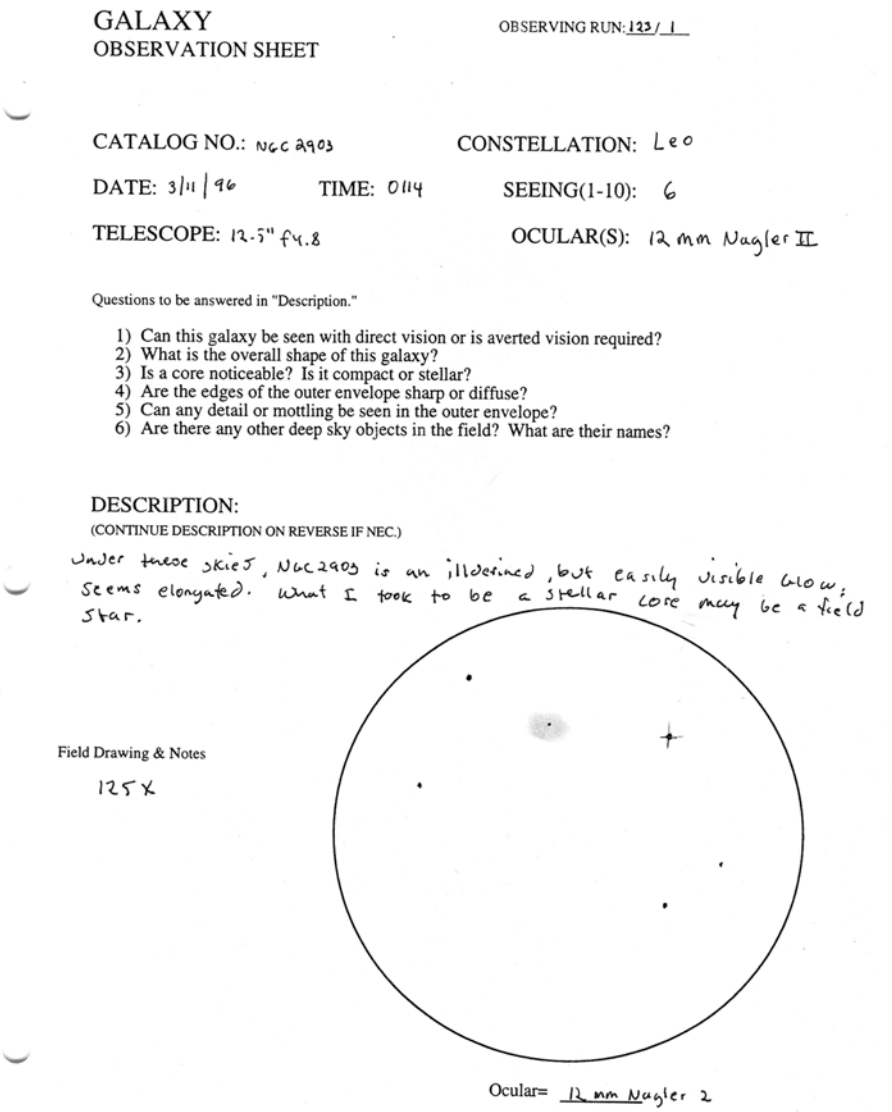
Recording Your Observations

Just as some dark sky observers find it humorous that I go to so much trouble planning my bright-sky observing expeditions, some also find it funny that I'd record what I see in a logbook and make drawings of many of the objects I observe. "What's to draw?" they ask. "A lot," is the answer. Once you take your first steps in city observing, you'll quickly see that many objects present a wealth of details worthy of recording either in prose or as a drawing. Even if there *is* enough detail in urban objects to justify drawing and describing, why bother? For a couple of reasons. First, because drawing or writing a verbal description of an object in a logbook makes you work to see every possible detail in an object. Habitually drawing and logging objects fine-tunes your observing skills. After faithfully keeping a log for a while, you'll find you've become a *far* better observer than you were before. Also, these logs make up an historical record of your observing life. In the future they'll be a source of pride, a series of fond memories, and a useful tool—whether viewing from the country or city, I find it invaluable to look back on past log entries for an object. Being able to recall what exactly I saw helps me see more the next time.

How do you keep a log of drawings and descriptions? It can be as simple as a spiral-bound notebook, full of sketches and impressions. If you want to be a little more formal, you can use a computer to make up an observing form. Mine is shown in Figure 5.1. In addition to space for an adequate description, I've got entries for time, date, seeing conditions, and other variables. I like to keep my drawings and logs together, so I add an eyepiece "field circle" for this purpose. I designed a separate form for each type of object, but one version could probably serve for all of the denizens of the deep sky zoo.

Actually, I've stopped using a physical logbook. I still use my form for making drawings and taking notes at the telescope, but the final logbook these entries go into is a *virtual* one. I've finally converted my handwritten log entries into electronic form with the aid of *Skytools 2*. In addition to the planning features mentioned earlier, this program provides an electronic logbook. You can even scan in your drawings and append them to log pages. I make a sketch and notes on my original form, but transfer them to the computer the next morning. If you use a laptop computer in the field, you can make notes directly into the program, though you'll still likely want to make your drawing the old fashioned way—with pen and pencil. Most amateurs take to keeping a log right away. There's no wrong way to do it, after all. It can be as simple as a few hurried notes about what a nebula looked like. Or it can be as elaborate as an "astronomical diary," including your subjective impressions about an object and details of the urban setting you're observing from in addition to bare object details.

Even people who get very creative with their logs can be reluctant to take up a sketchpad. "I can't draw," they say. Actually, just about anybody can be taught to draw



GALAXY
OBSERVATION SHEET

OBSERVING RUN: 123 / 1

CATALOG NO.: NGC 2903 CONSTELLATION: Leo

DATE: 3/11/96 TIME: 0114 SEEING(1-10): 6

TELESCOPE: 12.5" f4.8 OCULAR(S): 12 mm Nagler II

Questions to be answered in "Description."

1) Can this galaxy be seen with direct vision or is averted vision required?
2) What is the overall shape of this galaxy?
3) Is a core noticeable? Is it compact or stellar?
4) Are the edges of the outer envelope sharp or diffuse?
5) Can any detail or mottling be seen in the outer envelope?
6) Are there any other deep sky objects in the field? What are their names?

DESCRIPTION:
(CONTINUE DESCRIPTION ON REVERSE IF NEC.)

Under these skies, NGC 2903 is an illdefined, but easily visible glow; Seems elongated. What I took to be a stellar core may be a field star.

Field Drawing & Notes
125X

Ocular= 12 mm Nagler 2

Figure 5.1. A page from Rod Mollise's logbook.

anything given a little time and a good teacher. But there's very little to teach when it comes to drawing the deep sky. I can offer a few guidelines to get you started in this simplest form of astronomical "imaging," however.

The supplies you'll need are few and inexpensive and are available from any shop selling art supplies. Your basic drawing tools will be pencils. Choose an assortment ranging from hard—"2H" is good for making small stars—to some soft "nebula pencils," easily smudgeable ones like a "4B." If you want to draw on real drawing paper, choose something like a spiral-bound sketch diary. Make sure each page is large enough to accommodate notes as well as drawings. You'll also need an eraser, with an art-gum type being best for our purposes. If you're using a sketchpad or book for your work, take a compass and draw some eyepiece fields on the pages, leaving plenty of room for written notes.

But how do you *do* it? How do you draw something as confusingly complicated as the Orion Nebula? Even in the city, it displays so many details as to make it hard to know where to start. Easy. You make your drawings in *stages*. Begin with the brighter field stars. Using a medium-hard pencil or a pen (I like to use a black marker-type pen for the brightest stars) place these stars on the "eyepiece circle" on your paper. Take care to situate them accurately. Indicate brighter and dimmer stars with larger and smaller dots. Next, move on to the dimmer stars, again using the pen or a hard pencil. With the stars in place, take a good look at the nebula. Try to determine how it lies in relationship to the stars. Then, take a deep breath and start lightly shading it in with a soft pencil. Aim for accuracy, and take notes if you need to: "nebula fades into blackness here." Don't try to be overly artistic, just get the basic shapes and tones down. Use a variety of magnifications: low power to get a good overall impression of the object, and higher powers when you're hunting details.

When you look at your drawing in the morning, you'll probably be disappointed. Trying to juggle sketchpad, pencil, and red flashlight while peering through an eyepiece, tracking the object if you've got a dob or other unmotorized telescope, and trying to keep the city's ambient light out of your eyes does not lend itself to beautiful artwork. If you've worked carefully, however, you should have enough written and drawn "notes" to allow you to create an attractive finished drawing.

Start a second drawing, which can be either on the same page or a new page of your log, trying to place stars and nebulae in exactly the same places as you did in the original. By the light of day you can make the drawing look much better by doing simple things like smudging the shaded-in nebulosity with a finger. Once you're done, take one last look at your original drawing and notes, and search your memory for last night's impressions, adding any details you think will improve the drawing. Resist the temptation to put in things you've only seen in photos, though—you want this to be an accurate record of what *you saw with your own eyes.* When you're done, you'll have a wonderful record of your view. An example of my own style of drawing is shown in Figure 5.2. "Artistic"? Hardly, but it records what I saw on a given night with a particular telescope.

Accuracy is important, but there can be times when you have to *indicate* impressions rather than exact details. For example, it's easy enough to draw-in every star in even rich open clusters, but trying to record every single star you see in a globular cluster like M13 can be frustrating unless you're using a very small scope. Some observers do try to accurately draw every star they see in M13 and other bright globs, but it's generally good enough just to put in enough to indicate broad impressions. While we're striving for accuracy, this is still an *art*. You shouldn't try to imitate a camera; instead convey the proper *impression* of what M13 "looks like." However you do it, I urge you to keep a log of some kind. Looking over my entries of 10 and 20 years ago is always a pleasure, and often I'm surprised and gratified by my past accomplishments: "I saw that from the city? With only a 4-inch reflector?"

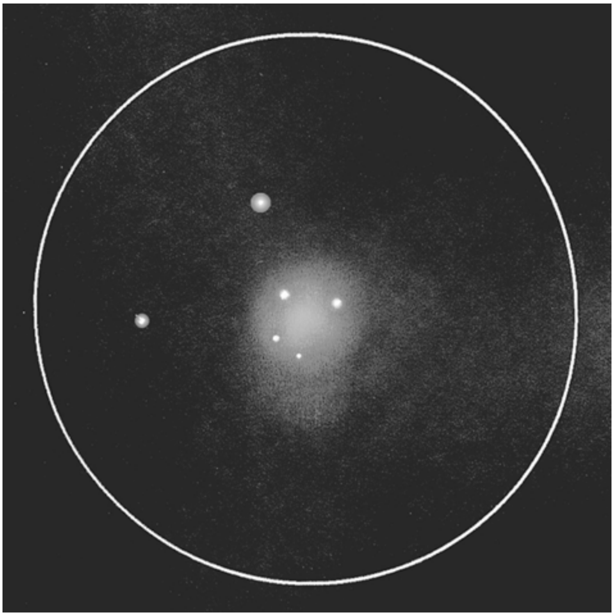


Figure 5.2. M10 drawing.

Astrophotography and Imaging in the City: The Ultimate Observing Project

Eventually, just about every serious deep sky observer dreams of making pictures of what he sees. Sure, you have fantastic memories, log entries and maybe even drawings of the hundreds or thousands of objects you've observed. But for some of us that suddenly doesn't seem to be enough. We want a *real* picture of M42 or M13. Your fellow visual observers may try to reason with you, warning you of the difficulties of astrophotography—especially in the city. But that won't matter. When the astrophotography bug bites, you won't care how hard picture taking is, and you won't care that you can get on the Internet and download as many pictures of M42 as you want. You will want your own pictures of Orion.

Actually, your seasoned amateur astronomer friends probably won't just tell you that picture taking in the city is difficult. They'll tell you that photography, film photography, is *impossible* from light-polluted areas. Impossible? Hardly. Difficult? Yes. You will have to accept the fact that, while you'll be able to make some wonderful pictures, they won't ever be as good as what you can get in the country. You'll also have to content yourself with capturing the brighter objects if you intend to use film.

Film Astrophotography

The first thing you need to get started in astrophotography is not a camera, it's a book. There are numerous good books on this challenging art available, as well as a lot of informative web pages on the Internet, but the best place to begin is with Michael Covington's classic work, *Astrophotography for the Amateur*. This book will tell you everything you need to know to get you going. I can't possibly adequately cover the complex techniques of successful celestial picture taking in just a few pages, but, if you've schooled yourself in the basics of the practice with Covington's book or other sources, I *can* tell you how to go about deep sky photography *in the city.*

In the city, it all comes down to the *speed of your telescope*—it's focal ratio. As we know, a scope with a "slow," large focal ratio produces bigger, more magnified images with a given eyepiece than a fast, small focal ratio telescope. In fact, a large *f*/ratio scope produces bigger images even *without* an eyepiece, during prime focus photography when the camera's film takes the place of the eyepiece. A small focal ratio scope projects a smaller, brighter image of a nebula or galaxy onto the film. Due to the smaller, brighter image, the picture builds up more quickly, *faster* in a "fast" small focal ratio scope than in a telescope with a larger focal ratio, one that projects *larger*, dimmer objects on the film. A large image builds up *slowly* on film. A large focal ratio scope is a "slow" scope. Normally, deep sky photographers want to use a fast telescope, one with a focal ratio of *f*/8 or *f*/6 or even faster. Not in the city. Using a relatively slow scope, one with a focal ratio larger than *f*/8, maybe one as slow as *f*/10, is the key to getting decent pictures.

The problem in the city for astrophotographers, just as it is for visual observers, is sky glow. In a fast telescope, an image builds up in a hurry. But so does evidence of light pollution. This comes in the form of "sky fog," as seen in Plate 22. I took this image, a 10 minutes exposure, through an 80-mm *f*/5 refractor from the heavily light-polluted site shown in Plate 1. Sure, you can make out the Orion Nebula and the stars of Orion's sword, but the background is bright and milky in appearance and obscures even medium bright stars.

What can you do? One approach is to reduce exposure time. That can help, but it's not the answer. The problem with shorter exposures is that it becomes very difficult to capture dimmer objects. The Orion Nebula is incredibly bright at an integrated magnitude of 4.0, so even a short exposure with a high-speed scope like an *f*/5 allows a recognizable image to build up on the film. Most DSOs are not nearly so bright, and exposures short enough to reduce the film-fogging effects of light pollution will not adequately record the object of interest.

Another problem with fast telescopes, especially those with small apertures like the 80-mm, is that they produce small images. That is OK for large galaxies like M31 or emission nebulae like M42, but becomes a problem when you're trying to record small galaxies and planetary nebulae. You can enlarge the image in the darkroom or computer, but there won't be much detail visible no matter how much you blow up the negative. The image scale was too small for good resolution.

Is there any way to image dimmer objects in the city while preserving image scale and preventing sky fog due to light pollution? Yes. The way to achieve good-looking deep sky photos in the city is to image with a slow, large focal ratio scope. How does a larger focal ratio with its longer focal length help in the city? For one thing, it *spreads* *out* the sky glow, reducing its intensity, allowing much longer exposures before sky fog becomes apparent. This is similar to our technique of reducing the intensity of the bright sky background visually by using higher magnification eyepieces.

Plate 23 is a 15-minnute shot at $f/10$ (with an 8-inch Schmidt Cassegrain). While there is some obvious fogging from sky glow, I don't feel it hurts the picture much, and what little there is could be easily removed by scanning the picture into a computer and "processing" the image with a program like *Adobe Photoshop*. Another benefit of larger focal ratios is that even big objects like the Andromeda Galaxy show off more detail when you take advantage of all the resolution capabilities of your film by enlarging your pictures in the camera using more focal length.

What's the maximum length of time you can expose an image in light pollution before fogging becomes unbearable? This depends on the focal ratio of the scope, the speed of the film (its ISO/ASA number), and the condition of the sky. The larger the focal ratio of the telescope, the longer you can go. So why not go to go an $f/15$ or larger focal ratio? Because any telescope eventually reaches a point of diminishing returns.

The larger the focal ratio and the longer the scope's focal length, the bigger and dimmer the image at prime focus gets. With an $f/15$ scope you can expose considerably longer than 15 minutes, even from the worst urban settings. Unfortunately, the images become so large in scale that it will be difficult to properly frame anything other than the smallest objects. The Orion Nebula will spill off the negative's edges. Why take a picture of M42 if you can only get the innermost core of the nebula into the shot?

More importantly, the larger the focal ratio and longer the resulting focal length, the longer it takes to build up an acceptable image on the negative. At $f/10$, it's possible to go as long as 30 minutes in medium-heavy light pollution. Even 30 minutes, though, is not long enough to adequately record the dimmest Messiers at this focal ratio. They become too big and too dim at $f/10$. Go to really slow scope, an $f/15$, with its even bigger and dimmer images, and only the brightest sky objects can be properly recorded with reasonable length exposures. Sure, exposures of 1 hour may be possible at $f/15$ and higher focal ratios, but, even after an hour, most objects will be dim and disappointing on the negatives. The DSO is too big and spread out to look good, even after a marathon exposure.

Another variable is film. The speed of the film will affect the length of your exposures. I prefer a medium-speed emulsion in the ISO 200 range with good red sensitivity for nebulae. A 200 speed film is fast enough for most deep sky work, and it helps keep the sky fog down. Go to ISO 800, even with an $f/10$ telescope, and your urban shots will fog up in a hurry. Unfortunately, there are few films for the astrophotographer to choose from lately. In the last few years, the major film companies, Fuji and Kodak, have changed the emulsions of many of their films to reduce their red response. This may be good for terrestrial photographers, but it makes a film almost unusable for us. How can you record the beautiful reds of M42 if your film doesn't respond to that part of the spectrum?

The best 35-mm film available today for the astro-imager is Kodak's Elite Chrome 200 transparency ("slide") film. Unfortunately, my tests with it show that the film's spectral response in the red is relatively poor, and that it seems to pick up sky glow more readily than some other films I've used. Compare Plate 23 (Elite Chrome) to Plate 24, which I made of M42 6 years ago from a similarly light-polluted site. The image in Plate 24 was made with the same telescope, camera, and exposure time (20 minutes) as Plate 23, but the film used for Plate 24, Fuji's Super G800, recorded more nebulosity and noticeably less sky fog. Unfortunately, the Fuji film is no longer produced. Kodak and Fuji are both switching over to digital imaging products, and the roster of available films is shrinking every day. The emulsion types useable for deep sky photography are disappearing even more quickly. Elite Chrome is currently the best of a disappointing lot.

Are there any other ways to improve urban images other than increasing scope focal ratios? A few urban astrophotographers report good results from exposing through light-pollution reduction filters. I've tried these filters with cameras, but was disappointed with the results. The most serious limitation in using these filters for photography is the "filter factor." Introducing even a mild filter like the Lumicon Deep Sky or Orion Skyglow into the light path means the light from the target object is badly dimmed before it reaches the film. As with high focal ratio scopes, long exposures are possible through filters, but it will *take* much longer for a suitable image to build up.

Another problem in using LPR filters for picture taking is color shift. Most deep sky astrophotographers are now forced to use color film, since the single black and white emulsion suitable for deep space imaging, Kodak's Tech Pan, has, like so many other films, been discontinued. Use an LPR filter with color film and images will assume a very strong red or green cast depending on the particular filter in use. This "excess color" can be removed by computer processing, but a light-pollution filter often leaves the negative with such a strong color bias that it's difficult to bring it back to "normal."

How do you determine the required exposure for your site, scope, object, and film? The best bet is experimentation. Expose a DSO in 5 min increments. Say 5, 10, 15, and on up to 20 or 30 minutes (at $f/10$, less if you're shooting at faster, smaller focal ratios). Examine the results and decide which exposure gives a good balance between sky fog and detail. One final bit of advice? Make sure the telescope is well shielded from ambient light. Light from nearby sources leaking into your telescopes will make even the shortest exposures with the slowest scopes look horrible.

Piggyback Astrophotography

Do you have to photograph *through* a telescope? If the above sounds too challenging, you can start out with simple piggyback imaging. In piggyback astrophotography, you mount a camera on the scope's tube via an inexpensive bracket and it photographs through its own lens rather than through the telescope. This provides a good introduction to astrophotography without the difficulties associated with precise polar alignment and guiding, and most deep sky imagers have traditionally started out this way. Piggybacking is not only easy, it's a good way to take attractive, wide-angle constellation shots.

If you intend to try piggyback astrophotography, be aware that the fast focal ratios of your camera's "normal" lens—$f/2.0$ or less—mean that sky fog will build up in a tremendous hurry. Go much more than 30 sec of exposure time, and you'll swear the resulting prints were shot in the daytime. Plate 25's shot of Comet Hale Bopp was taken well after dark despite its apparently blue skies. If you want to try piggyback imaging in the city, use a slower telephoto lens. You may find old, "slow" longer focal length lenses with focal ratios of $f/5$ to $f/8$ available for very reasonable prices in your local camera store's used department.

The CCD Alternative

You can get some attractive film images in the city, as I hope my Great Nebula pictures show, but there is no denying that the film astrophotographer is limited by light pollution. Due to sky fog, you must keep your exposures short, even with slow scopes. Forget imaging beautiful but dim objects like the Horsehead Nebula, or even capturing good detail in brighter objects. As many astrophotographers are finding, though, there is a substitute for dark skies when it comes to picture-taking, the CCD camera. The CCD camera and its use, like astrophotography in general, is a subject for an entire book. I do, however, have enough space and experience to talk briefly about why these electronic cameras are of extreme interest to urban astronomers.

The CCD camera is a camera that uses an electronic chip, a "Charge Coupled Device," instead of film. This CCD chip is similar or identical to the one in your video camcorder or your "digital" still camera. The only major difference between an astronomical CCD camera and your digital snap-shooter, in fact, is that an astronomical CCD camera is usually equipped with a device that cools the chip, often to well below zero. One other difference is that most astronomical CCD chips deliver black and white pictures rather than the color images of camcorders and digicams. This is because black and white CCD chips offer better resolution and sensitivity for astronomical subjects.

Why cool a CCD camera? Heat means noise when it comes to digital images, and the longer you expose, the worse it becomes. After just a few seconds, the image produced by an uncooled camera is covered with "snow"—speckles representing thermal noise. For the terrestrial still camera, this is not a problem. You rarely need to exceed a few seconds of exposure time due to the sensitivity of CCD chips. Some of these chips have equivalent ISO/ASA ratings in the thousands. But even with this sensitivity, an astronomer may need to expose a faint nebula or galaxy for 5, 10, 15 minutes or longer. At these exposure times, an uncooled camera's image would be buried by thermal noise. So, long exposure astronomy cameras have a means for cooling them down to defeat thermal noise. This cooling may be provided by water or air, but is most often accomplished by a device called a Peltier chip. The Peltier is a thermoelectric cooler that can chill a CCD to well below freezing without the need for liquid coolants, eliminating most heat-produced noise.

You've got a very sensitive camera capable of exposing for as long as you want to go. But how does this help the urban imager? What makes CCD better than film in the city? The most important benefit for the urban astrophotographer is the chip's sensitivity. You can keep exposures short, even with a relatively slow telescope, but still pick up plenty of details before you see evidence of background sky fog. Another help is the relatively small size of CCD chips. This increases the image scale, just as if you increased your scope's focal length, further suppressing light pollution's effect. Finally, CCD cameras produce digital images with very good *dynamic range*. What that means is that any problem with light pollution can be easily reduced or totally eliminated by standard computer image processing programs. The image in Plate 26 was taken from a light-polluted site even worse than the one I used for the earlier film images, yet shows little or no sky fog.

CCD cameras are not magic, of course. Their biggest drawback is their expense. An entry-level cooled camera with a small chip (about 1/5 the size of a 35-mm film frame) goes for around 1,000 US$. Cooled astronomical cameras will always have a limited market so don't expect prices for entry-level cameras to go down much, though chip-sizes and features at a given price-level will continue to increase. You'll also need to take a laptop computer into the field, as almost all astronomical cameras require a computer to control the camera as well as save and process images. Finally, for those of us brought up with the beauty of film astrophotography, even the most expensive CCD cameras in the most experienced hands have yet to produce pictures with *quite* the beauty and depth of traditional emulsion astrophotography. On the other hand, a CCD user with a medium-sized scope can rather easily record stars of 18–20th magnitude, something that was difficult for professional observatories under the darkest skies and equipped with giant telescopes 30 years ago.

Other Electronic Imaging Alternatives

What if you want to take non-film images in the city and don't think a traditional CCD camera is for you? As of now, there are three methods of image making that improve on photography but which don't demand the financial investment required by "real" integrating astronomical CCD cameras.

Both amateur and professional astronomers have used video to take pictures of the sky for the last 30 years. In the mid-1990s, I was one of a group of amateur astronomers who demonstrated that the newer video camcorders with their relatively sensitive color CCD chips and high definition tape formats (Hi 8 and Super VHS at the time), could take images of the Moon and planets that easily exceeded anything that could be done with film, no matter how large the telescope. While this was a breakthrough for Solar System imagers, it wasn't much help for the deep sky photographer.

Shooting at 1/30 second in color, the family camcorder is unable to produce a good image of even the brightest DSOs. Some amateurs experimented with low-light surveillance cameras, black and white "closed circuit" cameras that are much more sensitive than the average camcorder, and had some success. They would shoot many minutes of footage, download this video to a computer, and combine hundreds of frames into acceptable deep sky images. This was encouraging for video fans, and seemed to work as well in the city as under dark skies, but the pictures produced, though nice, were a long way from the images coming out of the cooled CCD cameras of the time.

Then everything changed. Sony began producing a very sensitive CCD chip intended for use in video cameras, the ICX248AL. This CCD is at least twice as sensitive to light as a conventional chip, including those used in astronomical cameras. The Sony CCD is also surprisingly inexpensive, so it wasn't long before it was being used by several manufacturers in cameras designed for astronomy, notably Adirondack Video Astronomy in the U.S. with their Stellacam and Mintron in the UK.

What makes these cameras innovative is not just the fact that they are incredibly sensitive, it's that they go well beyond what a normal video camera can do. In addition to shooting video sequences, they are able to automatically add frames together internally and thus deliver the equivalent of long exposures. Things have gotten even better recently, with the latest "deep sky video cameras" featuring even more sensitive chips and longer exposure capability.

The pictures produced by these cameras are surprisingly noise free considering the fact that they are uncooled, and are definitely comparable to those taken with entry-level cooled cameras (see Plate 27). They actually have several advantages over conventional CCD setups. Each exposure taken by a Stellacam or Mintron is short, so fewer demands are placed on a telescope mount's ability to track precisely. You don't need a computer, either. While they can be used in conjunction with a computer (equipped with frame-grabber hardware), the images they produce can also be recorded with a simple home VCR. Some users don't even worry about recording the images. They use these cameras for real-time deep sky observing.

Real-time deep sky viewing with a video camera may not be quite as "romantic" as old-fashioned visual observing. On the other hand, the view of a dim object like galaxy M51 on the video monitor in the city is much more detailed than you'll see through an eyepiece under the darkest skies. The spiral arms of this object will be far more clearly seen than they will visually in a scope 3 or 4 times as large as the one the Stellacam or Mintron is imaging through. Since these cameras output large-format real-time video, focusing and framing is much easier than with an integrating CCD camera. At about half the price of a conventional astronomical CCD imager, the Stellacam is well worth a look by the urban imager.

Everybody I know has got a digital still camera these days. The filmless camera is all the rage, and prices are declining while quality and features are increasing at an amazing pace. Naturally, the first thing an amateur astronomer thinks of when getting her hands on one of these new megapixel wonders is, "Can I take astrophotos with it?" Initially, the answer was, "Yes, but only of the Moon and planets." Digicams are uncooled, and the initial products aimed at amateur photographers were not able to take exposures longer than a second or two.

Astrophotographers have never been stopped by conventional wisdom, however, and it wasn't long before they were taking amazingly beautiful *deep sky* pictures—color deep sky pictures—with digicams. How? Using the same technique video imagers had used before them: taking many shots and combining—"stacking"—these frames with PC imaging software like *Adobe Photoshop*. The deep sky pictures coming out of digital cameras just keep getting better. Not only are astrophotographers developing innovative ways around the thermal noise problem, top of the line amateur-grade digicams now offer longer exposures (5 minutes or longer) and built-in noise reduction software. Just like "real" CCD cameras, digicams are relatively immune to skyglow problems.

That said, digital camera still cannot produce images as good as those of dedicated astronomical CCD cameras. They do very well on bright objects, less well on dimmer ones, and noise is still a problem. The average digicam image requires far more processing than that from an integrating astronomical camera. The digital cameras best suited for astronomy work, the digital Single Lens Reflexes, are still fairly expensive, too, though their prices are beginning to come down now. If you're interested in a camera that can take good-looking color images of showpiece DSOs, and also do a wonderful job for terrestrial picture taking, one of the newer digital SLRs might be right for you. I would not, at this time, buy one of these cameras just for astronomy, however.

Don't have a digicam? Don't want to buy a Stellacam? Sure don't want an expensive cooled camera? Still want to take deep sky pictures? A webcam, one of those little video cameras designed for use with PCs for teleconferencing can bring back amazingly good portraits of DSOs. When these devices first became widely available 10 years ago, curious astrophotographers decided to see if they could be used in astronomy. They had one major advantage over video cameras—they are designed to output their images directly into the computer in digital form. No videotape, frame grabber, or other intermediary is required. Initially, as with video, it appeared that the webcam would be useful only for the Moon and planets, due to its inability to shoot video at exposures much longer than about 1/5 second.

Again, amateurs found workarounds. One thing that works is to do the same thing video and digicam users do—stack images. That produces surprisingly nice results. But the webcam crew was not content to stop there. Creative amateurs have found ways to electronically modify webcams to allow longer exposures, and have even added Peltier coolers to them to cut down on thermal noise. Excellent deep sky images are being done in the city—in color—with webcams purchased used for as little as 10 US$.

If you'd like to learn more about webcams in astronomy, the people to talk to are the members of the Internet QCUIAG, the "Quick Cam and Unconventional Imaging Astronomy Group." They can help you select the right webcam. Some are better than others, and many current webcams use CMOS imaging chips rather than the CCD chips that are best for astrophotography. Webcams have gone from producing images that impressed just because they were identifiable pictures of familiar DSOs, to images that can stand up against those produced by much more expensive cooled cameras.

Recently, we've begun to see cameras that blur the boundaries between the integrating astronomical camera and the webcam. The most exciting of these new cameras, the Meade Deep Sky Imager, is about three times the cost of an off-the-shelf webcam, but is capable of long exposures out of the box—no modifications required. The DSI also features a larger chip than most webcams, though its CCD sensor is still smaller than that of most integrating cameras. The DSI normally produces color images, though it can be told to output monochrome instead.

The software included with the DSI is what makes it special. Its innovative "suite" of programs allows it to operate in a manner that combines the best features of the webcam and the integrating camera. It can output near real-time video, making it easy to find and focus objects, but it can also do long exposures of up to 1 hour in duration. It can also guide your telescope if you're taking images with another camera, or guide the telescope between its own exposures, making corrections when it's not taking pictures. The DSI is not actively cooled, but it does have an innovative passive cooling system that appears to drastically reduce thermal noise. The Meade Deep Sky Imager appears to be a big hit with amateurs, so expect to see similar innovative and inexpensive cameras from other manufacturers.

"Five chapters of talk! When do we get to the *good stuff*?" I hope the first part of this book has been helpful regarding the techniques and equipment needed for rewarding urban observing. As you've seen, it's not as simple as just grabbing the telescope and running for the backyard. But now it's time for that good stuff. What comes next is a "walking tour of the cosmos from your bright backyard," a feast of wonders for every season of the year. In the beginning I told you you'd be surprised at what can be seen from the light-polluted city. But "surprised" is not a strong enough word. Prepare to be *amazed*.

Before getting started on the Tours section, you may want to have a look at Appendix 2, which explains directions and distances in the sky, something that is very important for object locating if you're star hopping. You may also find Appendix 3 helpful, as it explains the classifications and "codes" used to describe DSOs in this book and in other resources.

Which telescopes did I use to observe the objects in the Tours part of this book? The City Lights Telescopes (Plate 28) were a 4.25-inch f/11 Newtonian reflector, a 6-inch f/8 Newtonian, an 8-inch f/5 Newtonian, a 12.5-inch f/4.8 Newtonian, an 8-inch SCT, an 11-inch SCT, a 60-mm refractor, and an 80-mm refractor. Which ones got the most use? The 4.25-inch reflector and the 11-inch SCT. I used the small Newtonian whenever possible to try to gauge how small an instrument would reveal chosen targets. The 11-inch Celestron Schmidt Cassegrain brought sky glow defeating aperture and a computerized go-to drive system to my bright sky survey, and conquered the most aggravating faint fuzzies.

What exactly will you find in these tours? All types of DSOs and more. Should double stars be classified as DSOs? I don't know, but they sure are beautiful, so I've included quite a few for your enjoyment. The main course here, though, is those astoundingly beautiful galaxies, nebulae, and star clusters you crave, well over a hundred of them. You'll find a complete list of the objects visited in this book in Appendix 4 along with their vital statistics including their Right Ascensions, declinations, and magnitudes.

Grab those eyepieces, would you? No, you won't need a coat—it's almost always shirtsleeve observing weather down here in sunny southern Alabama. It's time to walk the deep sky.