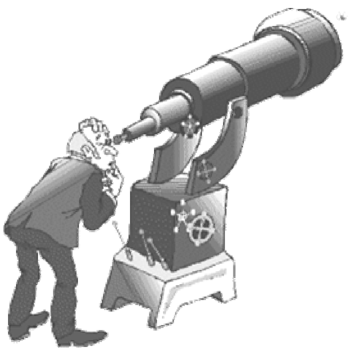
I BOUGHT A TELESCOPE

....WHAT NOW?

Packed with hints, tips, suggestions & ideas with tons of illustrated non-technical articles to help the beginner get started in amateur astronomy

THIS MANUAL IS A MUST FOR ANYONE WHO OWNS A TELESCOPE AND HAS NO IDEA WHAT TO DO WITH IT!



I BOUGHT A TELESCOPE… <u>What Now?</u>

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<u>BASIC ASTRONOMY</u>

Astronomy is the oldest science in the world, evolving ever since the first humans looked up at the night sky and wondered what those lights in the sky were, what the Moon (and during the day, the Sun) were and then started to map and use them for everyday purposes such as time, seasons, farming, navigating and so on. Everyone at some time must look up and think about what is up there and wonder if there is any life out there etc.

You don't even need any equipment to be interested in astronomy. With just your eyes you can learn the main constellations, learn the names of the bright stars, see five planets, spot artificial satellites, pick out star clusters, see the Andromeda galaxy, the Orion nebula, and the list goes on. (Some people I've met don't even know you can see planets with just your eyes).

To start off I would recommend getting hold of a basic night sky guide and learning a few of the main constellations such as Orion (the saucepan) and The Southern Cross which are always visible in the southern hemisphere. You can use these as pointers to other constellations such as Sagittarius and Scorpio etc.

Once you know a few constellations you can try to remember the names of the main stars in those constellations. Next time your at a BBQ for example you can amaze everyone by pointing out Orion and saying "...and the stars are called Betelgeuse, Bellatrix, Rigel, Sieph and the stars in the belt are Alnilam, Alnitak & Mintaka". To which you will either be shunned as a weirdo or asked "Well what's that other really bright star called there", to which you will reply "Ah, that's Sirius, the brightest star in the sky, also known as the dog star, also known as "The Scorching One" in the constellation of Canis Major or The Great Dog". Impressive eh?. (Oh, and Betelgeuse was known as 'The armpit of the central one' to the Arabs).

You can observe the colours of the stars as these give an indication of the temperature of the star, blue-white stars being hottest, and orange-red coolest. We'll cover all this ground again throughout this bulletin.

HOW TO START RIGHT IN ASTRONOMY

Comrades of the night. Astronomy can acquire new dimensions for those who find a good club. Here is what is waiting for anyone with an enquiring mind and a good telescope or binoculars. You don't need to know anything at first. Just get out there under the stars and the Universe will show itself to you.

The letter to an astronomy magazine began. "I am 20 years old and new to astronomy. I have always been fascinated with the stars and universe. What would you suggest my first step be to get into the hobby, so I might get the most enjoyment out of it?"

It's a good question, and it deserves better answers than most beginners find. Many newcomers to astronomy call us in exasperation after blundering down some wrong trail that leaves them lost and frustrated. Such experiences, widely shared, create a general public impression that astronomy is a tough hobby to get into. But this impression is altogether wrong and unnecessary.

Many other hobbies that have magazines, conventions, and vigorous club scenes have developed effective ways to welcome and orient beginners. Why can't we? For starters, novice astronomers would have more success if a few simple, well-chosen direction signs were posted for them at the beginning of the trail. What advice would help beginners the most? Astronomy magazine editors brainstormed this question. Pooling thoughts from nearly 100 years of collective experience answering the phone and mail, they came up with a list of pointers to help newcomers past the pitfalls and onto the straightest route to success.

1. Ransack your public library. Astronomy is a learning hobby. Its joys come from intellectual discovery and knowledge of the cryptic night sky. But you have to make these discoveries, and gain this knowledge, by yourself. In other words, you need to become self-taught.

The public library is the beginner's most important astronomical tool. Comb through the astronomy shelf for beginner's guides. Look for aids to learning the stars you see in the evening sky.

One of the best is the big foldout sky map in every month's Sky & Telescope, or similar magazine like Sky &Space which are available at most newsagents. When a topic interests you, follow it up in further books.

You'll certainly find lots of information on the Web. But the Web is a hodgepodge. What you need right now are well-edited, coherent works that pull the entire picture together, so you gain an overall mental framework into which you can place the scraps of knowledge you'll run into later. In other words, you need books.

Some people's first impulse, judging from the phone calls, is to look for someone else to handle their education -- an evening course offering or a planetarium program. These can be stimulating and helpful. But almost never do they present what you need to know right now, and you waste time commuting when you should be observing. Self-education is something you do yourself, with books, using the library.

2. Learn the sky with the naked eye. Astronomy is an outdoor nature hobby. Go into the night and learn the starry names and patterns overhead. Other books and materials will fill in the lore and mythology of the constellations the map shows, and how the stars change through the night and the seasons. Even if you go no further, the ability to look up and say "There's Arcturus!" will provide pleasure, and perhaps a sense of place in the cosmos, for the rest of your life.

3. Don't rush to buy a telescope. Many hobbies require a big cash outlay up front. But astronomy, being a learning hobby, has no such entrance fee. Conversely, paying a fee will not buy your way in.

Thinking otherwise is the most common beginner's mistake. Half the people who call for help ask, "How do I see anything with this %@&*# telescope?!" They assumed that making a big purchase was the essential first step.

It doesn't work that way. To put a telescope to rewarding use, you first need to know some of the constellations as seen with the naked eye, be able to find things among them with sky charts, know something of what a telescope will and will not do, and know enough about the objects you're seeking to recognize and appreciate them.

The most successful, lifelong amateur astronomers are often the ones who began with the least equipment. What they lacked in gear they had to make up for in study, sky knowledge, map use, and fine-tuning their observing eyes. These skills stood them in good stead when the gear came later.

Is there a shortcut? You can buy computerized, robotic scopes that point at astronomical objects automatically. Once properly set up, a computerized scope is a lot faster than learning the sky and using a map -- assuming you know what's worth telling it to point at. But opinions about computerized scopes are divided. For beginners, at least, there is some consensus that a computerized scope can be a crutch that prevents you from learning to get around by yourself and will leave you helpless if anything goes wrong.

Some compare it to driving through a forest instead of hiking. You cover more ground and the trees are the same, but they don't quite mean as much.

At star parties beneath gorgeous black, star-sprinkled skies, I have seen beginners struggling to program electronics when they should have been sweeping the heavens overhead. Is this just the carping of old fogeys? The jury is still out.

4. Start with binoculars. A pair of binoculars is the ideal "first telescope," for several reasons. Binoculars show you a wide field, making it easy to find your way around. (A higher-power telescope magnifies only a tiny, hard-to-locate spot of sky). Binoculars give you a view that's right-side up and straight in front of you, making it easy to see where you're pointing. (An astronomical telescope's view is generally upside down, often mirror-imaged as well, and usually presented at right angles to the line of sight.) Binoculars are also fairly inexpensive, widely available, and a breeze to carry and store.

And their performance is surprisingly respectable. Ordinary 7- to 10-power binoculars improve on the naked-eye view about as much as a good amateur telescope improves on the binoculars. In other words they get you halfway there for something like a tenth to a quarter of the price -- an excellent cost-benefit ratio.

For astronomy, the larger the front lenses are the better. High optical quality is important too. But *any* binocular that's already knocking around the back of your closet is enough to launch an amateur-astronomy career.

5. Get serious about maps and guidebooks. Once you have the binoculars, what do you do with them? You can have fun looking at the Moon and sweeping the star fields of the Milky Way, but that will wear thin pretty soon. However, if you've learned the constellations and obtained detailed sky maps, binoculars can keep you busy for a lifetime.

They'll reveal most of the 110 "Messier objects," the star clusters, galaxies, and nebulae catalogued by Charles Messier in the late 18th century. Binoculars will show the ever-changing positions of Jupiter's satellites and the crescent phase of Venus. On the Moon you can learn dozens of craters, plains, and mountain ranges by name. You can split scores of colorful double stars and spend years following the fadings and brightenings of variable stars. *If* you know what to look for.

A sailor of the seas needs top-notch charts, and so does a sailor of the stars. Fine maps bring the fascination of hunting out faint secrets in hidden sky realms. Many reference books describe what's to be hunted and the nature of the objects you find. Moreover, the skills you'll develop using maps and reference books with binoculars are exactly the skills you'll need to put a telescope to good use.

6. Find other amateurs. Self-education is fine as far as it goes, but there's nothing like sharing an interest with others. There are more than 400 astronomy clubs in North America alone and Australia has new ones springing up all the time. Call or e-mail the clubs near you. Maybe you'll get invited to monthly meetings or night-time star parties and make new friends. Clubs do vary -- from tiny to huge, from sleepy to vital, from cliquish to enthusiastically welcoming. You have to check them out for yourself. But none would have published a contact unless they hoped to hear from you.

Computer networks offer another way to contact other amateurs. Try the CompuServe Astronomy Forum, the AOL Astronomy Club, Yahoo clubs, or the newsgroup sci.astro.amateur. You may encounter the inevitable flamers and the overly opinionated, but by and large these communities offer interesting news and chat by friendly amateurs who are quick to offer help, opinions, and advice.

7. When it's time for a telescope, plunge in deep. Eventually you'll know you're ready. You'll have spent hours poring over books and ad brochures. You'll know the different kinds of telescopes, what you can expect of them, and what you'll do with the one you pick.

This is no time to scrimp on quality; shun the flimsy, semi-toy "department store" scopes that may have caught your eye. The telescope you want has two essentials. One is a solid, steady, smoothly working mount. The other is high-quality optics -- "diffraction-limited" or better. You'll also be eager for large aperture (size), but don't forget portability and convenience.

The telescope shouldn't be so heavy that you can't tote it outdoors, set it up, and take it down reasonably easily. The old saying is true: "*The best telescope for you is the one you'll use the most."*

Can't afford it? Save up until you can. Another year of using binoculars while building up a telescope fund will be time you'll never regret. It's foolish to blow half-accumulated telescope money on something second-rate that will disappoint. Or consider building the scope yourself, an activity that some clubs support.

8. Lose your ego. Astronomy teaches patience and humility -- and you'd better be prepared to learn them. There's nothing you can do about the clouds blocking your view, the extreme distance and faintness of the objects you desire most, or the timing of the long-anticipated event for which you got all set up one minute late. The universe will not bend to your wishes; you must take it on its own terms.

Most of the objects within reach of any telescope, no matter how large or small it is, are *barely* within its reach. Most of the time you'll be hunting for things that appear very dim, small, or both. If flashy visuals are what you're after, go watch TV.

Worthiness" is the term entering the amateur language for the humble perseverance that brings the rewards in this hobby. The term was coined by Ken Fulton, author of *The Light-Hearted Astronomer* -- a book describing the hobby as a jungle full of snares, quicksand, and wild beasts that only those with the spiritual skills of a martial artist can traverse unmauled. It's really not that bad -- but there are definitely times when a Zen calmness will help you through.

9. Relax and have fun. Part of losing your ego is not getting upset at your telescope because it's less than perfect. Perfection doesn't exist, no matter what you paid. Don't be compulsive about things like cleaning lenses and mirrors or the organization of your observing notebook.

And don't feel compelled to do "useful work." Ultimately, the most rewarding branches of amateur astronomy involve scientific data collecting -- venturing into the nightly wilderness to bring home a few actual bits of data that will advance humanity's knowledge of the universe in some tiny but real way. Such a project often marks the transformation from "beginner" to "advanced amateur," from casual sightseer to cosmic fanatic. But it only works for some people, and only when they're good and ready.

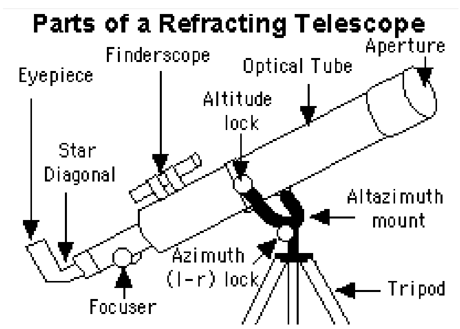
Amateur astronomy should be calming and fun. If you find yourself getting wound up over your eyepiece's aberrations or Pluto's invisibility, take a deep breath and remember that you're doing this because you enjoy it. Take it only as fast or as slow, as intense or as easy, as is right for you.

HOW TO STUDY THE SKY:

A Quick Beginner's Guide

In order to learn about the night sky, we need to cover some of the ways you can view it. First, there is the simplest and easiest way possible, with your own eyes. With your bare eyes you should be able to see things such as the Southern Cross, the Moon, and the Milky Way. Not bad for free. Best of all, you do this wherever you can see the night sky. The best way to view the night sky with your eyes is to close them. Yes, close them. By keeping them closed for about 10 minutes, your eyes adjust better to the dark, and you can see details that you might have otherwise missed.

The next step up from using your naked eyes is to use binoculars. It may seem that this would not give you very much detail of what there is to see in the sky. But did you know that Jupiter, Saturn, and their moons were found with a telescope that had about the same power magnification? With binoculars, you should be able to notice quite a few craters on the Moon, and get a closer look at nearby planets. If you look with your bare eyes where there appear to be no stars in the dark sky and then point your binoculars there, you may be amazed at the stars just waiting to be seen.



Even more details and celestial objects can be noted with a refractor telescope. This is what was used by Galileo hundreds of years ago, which is why this is sometimes referred to as a Galilean telescope.

It is simply a long tube with a lens to collect light at one end, which focuses the light towards the eyepiece lens at the opposite end, where you look through. Of course, there are many different types of these telescopes, but the basis is the same. With this, the rings of Saturn are visible, as are some details of Mars. An advantage of this telescope over others is that it gives better clarity and can also be used for viewing things here on Earth during the daytime.

The second type of telescope that you can buy is called a reflector telescope. This telescope is much larger in diameter than a refractor telescope, and has the eyepiece on the side instead of at the end. The light enters the large opening at the top and hits the bottom of the telescope. Here it reflects off of a large curved, or parabolic, mirror at the base, which focuses the light onto a smaller mirror back up the telescope. The light is then sent to the eyepiece lens, which is where you look through. This telescope can collect more light, and as a result see further objects. Reflector telescopes are used by most amateurs today because they are simply less expensive to buy.

What objects can you see with your eyes and optical aids? Before you have learned very much about the night sky there are things that will be immediately noticeable. The easiest to find and observe is the Moon. While the full Moon shows the entire near side, the details are not readily noticeable. The best time to look at the Moon is when it's a week or so either before or after the full Moon. This way, the Sun highlights the craters with shadows, giving them a better contrast.

What you see will of course depend on where you live, as it is with most of the methods mentioned here. If you live in or near an urban area, the surrounding lights will limit what you may see. But don't worry; there are usually a few areas even in a large city where you can view the stars.

As with all of the differing methods mentioned, a cold night will give better viewing than a warm night. This is because the warm air moves more, distorting the light that must travel through it. This can be best noticed on pavement on a hot day. Cold air, however, does not move or shift so much, giving better clarity to the starry sky

BEGINNERS TIPS & TERMS

A pair of binoculars is all you need to explore the night sky, and even the old naked eye can perform pretty well. Some basic information to help you begin: But, some basic information to help you begin.

Apparent Brightness

The brightness of stars and other celestial objects is measured on a scale of apparent brightness. Smaller numbers are brighter (negative numbers are the brightest).

Degrees : Astronomers use degrees to measure the apparent size of objects in the sky and the distances between them.

An easy way to estimate the size of a single degree is to begin by visualizing the full Moon. It's half a degree across, so two full Moons edge-to-edge equal a degree. The tip of your pinkie finger may just be about the right size when viewed along your outstretched arm.

To measure greater spans in the sky use your outstretched fist. From thumb to little finger, the average fist covers about 10 degrees. So by using this method you will be able to calculate, and understand, the degrees mentioned on star maps and in books a little more easily.

Sense of scale, scope and movement

If you have dark skies, you've probably seen stars that are thousands of light-years away. Others are less than 10 light-years away. A light-year is the distance light travels in one year, moving at 300,000kms per second.

Our Milky Way Galaxy is more than 100,000 light-years across. It contains billions of stars, but the most adept skywatchers can see no more than 6,000 of them without a telescope.

Skywatching can teach you about celestial mechanics. By watching the movement of the planets and stars between, say, dinner and bedtime, you can observe how the Earth spins on its axis.

The Moon, planets, and stars traverse the night sky (and the Sun the day sky) from east to west because the Earth rotates from west to east.

By noting the changing positions of stars and planets over the course of two or more nights, you can witness how the Earth's yearly motion around the Sun alters the positions of objects in the night sky. Stars near the sky's equator rise (and set) four minutes earlier each night,

There's some nifty magic to the math here: Stars rise (and set) two hours earlier each month, and 24 hours earlier each year -- when the Earth has completed one orbit around the Sun.

The four-minute rule works for the planets Jupiter and Saturn, and often for Mars . Mercury and Venus orbit the Sun relatively quickly, though, and their paths are more complicated. Overseas the Stars near the sky's north pole remain above the horizon throughout the year, & the Nth.Star stays in the same position, above the North Pole of the Earth.

Viewing Tips

The best viewing is always under the darkest skies. But even in a city, with a decent amateur telescope, you can see Saturn's rings, find Jupiter's moons, or explore the craters of our own Moon.

Whether you view the night sky with your naked eye, binoculars, or a telescope, here are a few tips to enhance the experience:

No matter how much light surrounds you, more is always worse. Turn off any lights you can. Also, allow 15 minutes or more for your eyes to adapt to the darkness.

One thing you can't control is the atmosphere. Even a cloud-free night isn't always great for viewing. When you look directly overhead, you're peering through about 7 miles of the troposphere, the densest portion of Earth's atmosphere; the light from an object nearer the horizon filters through dozens of miles of the troposphere. The result can be blurry stars.

Turbulent air, something you can't see or predict, can have an effect, too. It makes objects appear to jump around or twinkle. The bottom line: Telescopes will typically yield better results when a target is higher in the sky and when the atmosphere is calm.

Only experience will tell you which nights are best for viewing.

THE ART OF USING A TELESCOPE

Once you've obtained an astronomical telescope, what can you expect of it? Both less and more than many new owners realize.

One of the most fun parts of being an amateur astronomer is showing off the heavens to others. The "oohs" and "aahs" at a public star party as people get their first good look at the Moon or Saturn are a pleasant reward for the proud telescope owner. Naturally, you will have aimed the scope at the most spectacular object above the horizon. Sometimes there's a temptation to show people more typical objects -- ghostly, barely visible apparitions with obscure catalogue numbers -- "to give them an idea of *real* astronomy." The reactions then are not so encouraging, even when viewers are told they're looking at a recently recovered comet or a galaxy 40 million light-years away.

The truth is, most of the thousands of objects visible in amateur instruments are not the least bit spectacular. Anyone who gets a telescope expecting dramatic visual thrills is in the wrong hobby.

The riches that astronomy offers are of a different sort. Visual observing outdoors in the dark usually means working to detect something that's extremely faint, tiny, hard to find, or all three. The more difficult the task, however, the greater the rewards of success. The excitement lies in finding and seeing first-hand remote marvels far beyond our planet -- and in gaining skills and knowledge as an amateur scientist.

Too many people buy a telescope as if it were a TV, expecting it to show pictures all by itself. It's more like a piano, which gives back only as much value as the work you put into it. Learning to use a telescope well is a lot easier than learning a musical instrument, however. If you're reasonably persistent and careful and are willing to practice the techniques described here, you'll soon master the skies.

Know Your Equipment

Naturally, everyone first tries out a new telescope in the daytime. This is when to become familiar with its motions, pointing, focusing, different eyepieces, and magnifying powers, so you can then do everything in the dark.

The Finder. Most telescopes have a finderscope attached to the side to help aim it. You need a finder because the main telescope has such a tiny field of view -- that is, it shows such a tiny piece of sky -- that you can't tell exactly where it's pointed just by looking.

The higher the power, the *smaller* the field of view. For example, at 50 power you're looking at a magnified piece of sky about as small as your little fingernail covers when held at arm's length. An 8× finderscope, on the other hand, displays about as much sky as a golf ball covers at arm's length.

This is big enough to aim at something you see with the naked eye and get it in the finderscope's view. Once it's there, you centre it in the finder's crosshairs. That should be a precise enough aim for the object to appear in the view of the main telescope.

First things first: you'll need to adjust the finder's mounting screws so it's aimed parallel to the main telescope. In daylight, point the main scope at something at least several hundred feet away using the lowest-power eyepiece. (But *not the Sun!* Never look through a telescope that might get aimed at the Sun or you could blind yourself.) A distant treetop is ideal. Centre it in your view.

Never mind if it appears upside down.

Now look in the finder. See the treetop? Is it centred in the crosshairs? Adjust the screws holding the finder until the crosshairs line up on the target. Now check back in the main telescope to make sure it hasn't moved. Then switch to a high-power eyepiece in the main telescope, and repeat the operation until the finder is locked in position with perfect aim.

And why, you ask, is the treetop upside down or oriented at some other weird angle? The answer is that this is an *astronomical* telescope, and after all, there's no up or down in space. So it doesn't matter how the field is oriented. Turning the image right-side up would require extra optical parts, adding to the expense and complication of the instrument and probably degrading its performance slightly. Therefore, "image erecting" lenses are used only in terrestrial telescopes, those intended for looking at things on Earth.

Next let's turn to the mounting.

Telescope mounts come in two basic types: equatorial and altazimuth.

An equatorial mount allows the telescope to swing only in the directions of celestial north-south and east-west. The altazimuth goes up-down (moving in *altitude)* and side to side *(azimuth).* An altazimuth mount at least has the virtue of simplicity. An equatorial mount is ultimately more helpful, but it takes some getting used to.

The Equatorial Mount. If this is what you have, find its polar axis (the rotating part that's more toward the base and maybe has a setting circle showing right ascension). Outdoors, place the telescope so the polar axis points roughly to where you know Polaris, the North Star, will be located after dark. The telescope's motion around this axis now traces the paths taken by celestial bodies across the sky as the Earth turns.

Sweep the telescope around its polar axis from the eastern horizon across the sky to the west to visualize nightly star paths. At first the mount's motions will seem awkward and unpredictable. But remember that no matter where the telescope is pointed, it will move only toward or away from Polaris (celestial north-south) and at right angles to this direction (celestial east-west). The orientation of these varies in different parts of the sky, but with some practice swinging the telescope around in daytime you'll get used to them.

THE FINE ART OF OBSERVING

The challenge of astronomy is that we must view most of the universe from *extremely* far away. When you're trying to see something well on Earth your instinct is to move closer for a better look. But when it comes to distant stars and galaxies, we're stuck where we are. So, ever since the dawn of telescopic astronomy, the art of observing has been the art of using your eye to the utmost of its ability.

Using telescopes takes a little time..soon you will be able to go out and look through your scope and see things you missed just the night before, you'll become accustomed to the telescope and your eyes will quickly adapt to this ‘new’ way of seeing. Everyone goes through this and everyone I know remarks on how easy it is to pick up the skill!

Viewing tips.

When looking through the telescope, focus and refocus with care. A good observer is always fiddling with the focus, trying to get it just a hair sharper. Many people find it best to keep both eyes open, since squinting strains the working eye. You can cover the "off" eye with one hand.

Don't expect to see right away everything an astronomical object has to offer.

The first look always shows less than comes out with continued scrutiny. This is true whether your subject is a dim galaxy that can hardly be told from the blackness of space, or detail on the Moon or a planet where the light is almost blindingly bright.

One reason it takes time to see detail is the unsteadiness of the Earth's atmosphere. Celestial objects constantly shimmer and boil when viewed at high power, due to weak but ever-present heat waves in the air around and above us. The severity of this shimmering -- called the *atmospheric seeing* -- varies from night to night and often from minute to minute.

As you watch an object quiver and churn, unsuspected detail will flicker into view during quick moments of stability when the view sharpens up, only to fade out again before you know it. The skilled observer learns to remember these good moments and ignore the rest. The quality of the atmospheric seeing is most important when viewing bright objects at high power, but it can influence the visibility of faint ones too.

The main reason it takes time to see detail, however, has to do not with the atmosphere but with the eye and mind. Wringing everything possible out of very distant views means learning new visual skills that involve active, concentrated effort.

You'll discover that the eye's picture of a difficult object builds up rather slowly. First one detail is noticed and fixed, and you think there's nothing more to be seen. But after a few minutes another detail becomes evident, then another.

To convince yourself of this, look at a piece of sky with the naked eye and try to spot faint stars. Some will be visible right away; others take a few seconds to come out. When no more appear, most people would quit trying. But keep at it for a few minutes. Chances are some more will glimmer into view in places you would have sworn were blank. After a while you're seeing at least half a magnitude fainter than at first.

The planet Mars is another classic example of this effect. For the beginner taking a first look with a small telescope, Mars ranks as the most disappointing object in the sky. It's just a tiny, featureless, orange fuzzball. The beginner steps aside to let an experienced Mars observer look in the eyepiece. Silence. "There's the north polar cap.... That big dark area in the south must be Mare Erythraeum. Okay, I've got Sinus Meridiani.... There's a cloud patch on the western limb...."

The beginner looks again. Nothing but a fuzzball. Well, maybe there *is* a bit of brightness at the north edge crawling around in the poor seeing, and the fuzziness isn't a *perfectly* uniform orange, but these hardly seem like things worth noticing. Nevertheless, the next time the beginner looks he or she won't be quite a beginner, and the bright spot and dark area will come into view more readily.

An excellent way to train yourself to see better is to make sketches. These don't have to be works of art; the idea is just to record details in your notebook more directly than you can with words. Star fields require no artistic talent whatsoever, but by sketching a field that contains a faint asteroid or outer planet, you can identify the intruder be checking back in the next few days or weeks and seeing which one changes position.

For practice sketching planets, try drawing the Moon with the naked eye. If you have reasonably sharp or well-corrected vision, the Moon shows much more detail to the naked eye than any planet will in a telescope! Make a semicircle a couple of inches in diameter by tracing some round object and then draw the terminator exactly as you see it on the Moon. Carefully add the major dark areas with pencil shading, then look for finer markings. By now you'll be seeing much more detail on the Moon's face than you ever thought possible without optical aid.

The lesson is clear," wrote the British author James Muirden in *The Amateur Astronomer's Handbook,* long a classic: "No opportunity should be lost to train the eye to work with the telescope; to observe the same object with different powers so as to see the effect of magnification; to try to see faint stars; and to draw planetary markings.

In the beginning, to be sure, this may all seem to be wasted effort; the observing book will fill up with valueless sketches and brief notes of failure. But this apparently empty labor is absolutely essential; for, as the weeks pass, a steady change will be taking place. Objects considered difficult or impossible to see will now be discerned at first glance, and fainter spectres will have taken their place. Indeed, these former features will now be so glaringly obvious that the observer may suppose that some radical improvement has occurred in the observing conditions. But the credit belongs entirely to the eye."

Life's Little Comforts

Naturally, this sort of concentration will be spoiled by any undue discomfort or inconvenience at the telescope. You'll need a table right at hand to hold charts, red flashlight, eyepieces, notebook, pencil, and other gear. The perfect solution for one observer has been a cheap cardboard card table with fold-up metal legs. It's big, very light, and easy to carry and store. He got it for $4 in a second-hand shop 20 years ago.

Nothing ruins your ability to see like having to twist and strain to look through the eyepiece. A rotating tube, which can turn in its cradle to orient the eyepiece more where you prefer, is therefore a nice plus in a small reflector and almost mandatory in a large equatorially mounted one. If you can find or make an adjustable-height observing chair, your telescope may start showing new worlds. I've used an assortment of seats from a milk crate to a stepladder.

Any jerkiness and backlash in the mount's motions can also spell doom, especially if you lack a clock drive. Make sure the telescope is balanced properly by adjusting any counterweights; it shouldn't move in one direction more easily than in another. Don't be afraid to take a mount apart and lubricate it, or return it to the manufacturer if it's truly unsatisfactory. The mount I bought for my 6-inch reflector years ago was originally quite jerky. After trying various lubricants, I settled on candle wax rubbed onto all the bearing surfaces. The mount's "clamps" were merely bolts that tightened head-on against the shafts; I epoxied small pieces of leather to the bolt ends, impregnated these with graphite powder and a little oil, and thus gained adjustable tension. The improvement was enormous. At high power I could follow the stars with a smooth, continuous motion just by touching the side of my nose against the eyepiece.

In wintertime, you can either heed the astronomer's standard advice to dress for 20°F to 30°F colder than the actual temperature, or you can learn the hard way. As for the summer, it remains a mystery how successful observations were performed before the invention of mosquito repellent.

In short: Anything that makes your observing easier, surer, or more relaxed, no matter how much trouble it takes beforehand, is worth the effort.

SO.. HOW DO I FIND ALL THIS STUFF?

You use a 'Star Chart'

Whether you're navigating to a specific galaxy in Virgo or just sightseeing along the celestial highway and want to know where you've been, you need a star chart. Just as no single road map serves all situations, so too are star charts available with different levels of detail.

One "chart" that every observer needs -- from the beginning naked-eye sky-watcher to the seasoned big-telescope user -- is a planisphere (sometimes called a star wheel). These inexpensive and "interactive" maps are very easy to use: a simple spin of the planisphere's circular dial sets the date and time to reveal at a glance what stars are overhead. In theory a planisphere is accurate only for use at a specific latitude on Earth, but in practice it covers a range of latitudes.

In the extensive article which follows 'star charts' or 'planispheres will be covered in greater detail, expanding and recounting what you are about to read:

Most planispheres show only the brighter stars and major constellations. Indeed, planispheres are one of the best tools for learning to locate and identify the constellations, since they are to the sky what a classroom globe is to the Earth. If, however, you're looking for a specific star cluster or nebula, you'll want a more detailed chart.

Beginners should select <u>*charts*</u> that include stars at least as faint as 6th magnitude -- the typical naked-eye limit for a rural sky. The higher the magnitude number, the fainter the star, with each whole-number increment representing a brightness change of 2.5 times. Thus, a 6th-magnitude star is 2.5 times fainter than one of 5th magnitude.

Certainly the most enduring naked-eye charts are those in *Norton's Star Atlas and Reference Handbook*, first published in 1910 and now in its 19th edition. Plotting some 8,800 stars and many hundreds of deep-sky objects, Norton's is excellent for people probing the sky with binoculars and small telescopes.

Hunting down fainter stars and nebulae calls for yet more detailed charts, such as those in *Sky Atlas 2000.0* -- the sky's equivalent of the *Rand McNally Road Atlas*. With more than 81,000 stars and thousands of deep-sky objects plotted on 26 charts covering 48 square feet of paper, this detailed atlas will satisfy the needs of most people with telescopes as large as 6 or 8 inches in aperture. Indeed, if you have more than a passing interest in sky watching and are limited to owning a single atlas, this is the best one to consider.

Atlases with even more detail exist, with the three-volume *Millennium Star Atlas* being the reigning king of the mountain, but they are better suited to serious deep-sky observing and are not recommended for learning your way around the sky.

The best views of the heavens, whether with the naked eye or binoculars and telescopes, happen after your eyes have had a few minutes to adapt to the darkness.

To preserve this so-called dark adaptation, you should avoid bright incandescent and fluorescent lights. A special-purpose "astronomer's flashlight," which shines dim red, will provide enough illumination for consulting star charts while still preserving dark adaptation. Or you can simply put red cellophane over any household flashlight…or even paint the globe with red nail polish!

Star-hopping is an excellent way to learn telescopic observing. You began at a bright, easily identified star and hop to nearby interesting targets using faint adjacent stars to guide the way. Alan MacRobert frequently describes star-hops in the pages of *Sky & Telescope*. More than a dozen of these celestial excursions are collected in his aptly titled book *Star-Hopping for Backyard Astronomers*, along with much sound advice for the beginning observer and interesting information about the stars, nebulae, and galaxies visible in the eyepiece of a small telescope.

Astronomy,Sky & Telescope and Sky & Space magazines are a valuable resource for beginning backyard observers, with their monthly finder charts and information on the visibility of planets, comets, meteor showers, and other fascinating ephemeral sights.

As countless amateur astronomers already know, the starry sky serves as an endless source of wonderment, which can be enjoyed on any clear night.

Note : If you can, try and locate an Adult Education College or astronomical society in your area. Here you may be able to take up a basic astronomy course at relatively small cost with the aid of knowledgeable instructors to assist you along the way..you'll meet others too, just like you, so it's worth thinking about huh?

MAPS & CHARTS

Starfinding With a Planisphere

Above: With a planisphere, or star wheel, you turn a disk to set your time against your date. The edge of the star map then represents the horizon all around you at that time. Some planispheres come with extra features. David Kennedal's Precision Planet and Star Locator, shown here, includes settings to build in corrections for daylight saving time and your longitude, as well as a marker on the sky map that can be dialled to any right ascension and declination.

The most important aspect of a planisphere, however, is the clarity and realism of its star map. Among the many devices on the market, the Precision Planet and Star Locator and The Night Sky by David Chandler Is an example.

Using a Planisphere

In principle nothing could be simpler. You turn a wheel to put your time next to your date, and presto, there's a custom-made map of the stars that are above your horizon for that moment. The edge of the oval star map represents the horizon all around you, as you would see if you were standing in an open field and turned around in a complete circle.

The part of the map at the oval's centre represents the sky overhead, much like the all-sky constellation maps in the centre of each month's major Astronomy magazines.
In practice, several complications can throw beginners off.

The worst is that a planisphere's map is necessarily small and distorted. It compresses the entire celestial hemisphere above and around you into a little thing you hold in your hand. So star patterns appear *much* bigger in real life than on the map.

Moving your eyes just a little way across the map corresponds to swinging your gaze across a huge sweep of sky. The east and west horizons may look close together on a planisphere, but of course when east is in front of you west is behind your back. Glancing from the map's edge to centre corresponds to craning your gaze from horizontal to straight up.

There's only one way to get to know a map like this. Hold it out in front of you as you face the horizon. *Twist it around* so the map edge labelled with the direction you're facing is *down.* The correct horizon on the map will now appear horizontal and match the horizon in front of you. Now you can compare stars above the horizon on the map with those you're facing in the sky.

Then there's the distortion issue. On a planisphere designed for use in the Northern Hemisphere, constellations in the southern part of the sky are stretched sideways, taffy-like, making it hard to compare them with real star patterns. This problem does not exist on a well-designed map for fixed dates and times, Some planisphere designers have come up with a partial solution.

David Chandler's planisphere *The Night Sky* presents two maps, one on each side. One minimizes distortion north of the celestial equator, the other south of it. Just flip it over for the best view.

A further complication is that a planisphere works correctly for only one latitude on Earth. Most today are made in several editions, each for a particular latitude. Then there's the matter of daylight saving time. When this is in effect, remember to "fall back" to standard time by subtracting an hour from what your clock says before you set the planisphere's dial.

Actually, planispheres don't employ standard time either, but rather local mean time. The difference, which depends on where you live in your time zone, can amount to a half hour or more. Fortunately, even a half hour one way or the other doesn't really matter for most star finding.

In fact, if you just want to know which constellations are up and where they are, a planisphere's limitations can largely be overlooked. It's remarkable that such a simple working model of the sky can work so well.

BASIC ASTRONOMY OBSERVING FROM THE CITY

Light pollution is the bane of amateur astronomy -- but you can see a lot even through the worst of it. For amateur astronomers these are the best of times and the worst of times. Never have such large and sophisticated telescopes and such powerful accessories been so readily available at moderate prices. Never has so much celestial information been available at the flip of a page or click of a mouse. But never have so many people lived under such awful skies. Many readers can follow the motion of Pluto in 3000 A.D. on a screen, but cannot step outdoors and find Polaris through the light pollution.

This paradox will grow ever more extreme as equipment improves and dark skies retreat. The future of amateur astronomy is, perhaps, a microcosm of the rest of the world's future: better technology in a poorer environment.

Which of these two trends will outrun the other and become dominant is anyone's guess, in amateur astronomy as in the larger world. One result, however, is already becoming clear. The environment is public -- but equipment ownership is private. The stars belong to everyone, but *access* to them is becoming privatised. Many once-common celestial sights already require expensive instruments or the money and time to travel to distant, unspoiled locations.

No matter what the future holds, however, some observers will never let anything stop them.

These are people who set up telescopes in city lots and observe with blankets draped over their heads to block streetlights, while keeping an ear out for muggers. These are people who spend a year examining bleary star images through an apartment window and come away with a sheaf of variable-star light curves. These are people who time the instants when stars are occulted by skyscraper walls and determine the rate of precession of the Earth's axis.

"Normal" observers who have (or travel to) decent skies tend to regard such enthusiasts as crankish inhabitants of an unimportant amateur-astronomy backwater. They are wrong. As the world grows more densely populated, urbanized, and brightly lit, city observers are the vanguard exploring trails to our future.

Nebula Filters

City and suburban observers gained a new claim to the deep sky when nebula filters were developed in the late 1970s. These function on a straightforward principle. Emission nebulae give off light at narrow wavelengths that differ from those of sodium- and mercury-vapour streetlights. By using a multilayer interference filter, the spectrum of visible light can be cut finely enough to separate these wavelengths. The result is a much darker sky, somewhat dimmer stars and galaxies, and only slightly dimmer planetary and emission nebulae. This enhanced contrast can, in many circumstances, more than make up for the relatively small amount of light lost from the nebula, and so it stands out more clearly.

These filters do not bring country skies to the city, but they do help. One technique for detecting nebulae, especially tiny planetaries, is "blinking" with the filter. Hold it at the eye and move it rapidly in and out of the line of sight; a nebula will blink relative to the surrounding stars. Alternatively, blinking can be done by tilting the filter back and forth while looking through it, since it loses its effectiveness when at an angle.

Several nebula (or "light pollution") filter designs are available. They use somewhat different strategies for different types of objects and conditions. A detailed review of them is in the July 1995 *Sky & Telescope.*

Duck and Cover

"Light pollution" is the glow in the sky itself. It should not be confused with *local lights* that shine directly into the observer's eyes.

Local lights are more aggravating but easier to defeat. Many observers have cooperative neighbours who turn off outdoor lights on request. A good way to break the ice on this issue is to offer views through your telescope.

If you can't observe in the shade of trees or walls, you might rig a tarpaulin to shield your site. Max Wyssbrod lives in Lucerne, Switzerland, which he calls "the brightest country in Europe." His "cloth observatory" consists of four aluminium poles 10 feet long that fit into tubes cemented into the ground in a 10-foot square. The four walls are black cloth; guy ropes add stability. The whole rig, along with an 8-inch Schmidt-Cassegrain telescope, takes 15 minutes to set up.

Another strategy is to shield only your eye and the back end of the telescope. An old-fashioned photographer's black cloth or equivalent, or a cape that can be thrown up over your head, does the trick. Any telescope in bright local lights should also have a long dew cap or side shield to keep the light out of the tube. Eyepieces should have rubber eyecups.

"I use a black hood, and blinders I made from cardboard fitted to each side of my face," writes Charles Haun of Morristown, Tennessee. "This works quite well."

Hiding under cloth and wearing blinders may seem an ignominious way to experience the glories of the cosmos. But such is the garb that amateur astronomers shall increasingly wear as they march bravely into the future.

BEATING THE 'SEEING' - TIPS FOR SUCCESSFUL VIEWING

NASA spent $2.1 billion to escape from poor atmospheric seeing; that's what it cost to put the Hubble Space Telescope above the atmosphere. Backyard observers on a smaller budget, however, need not despair of improving their fuzzy, shimmering views. You can avoid the worst effects of atmospheric turbulence by understanding its nature and learning a few tricks.

Viewed at high power from the bottom of our ocean of air, a star is a living thing. It jumps, quivers, and ripples tirelessly, or swells into a ball of steady fuzz. Rare is the night (at most sites) when any telescope, no matter how large its aperture or perfect its optics, can resolve details finer than 1 arc second. More typical at ordinary locations is 2- or 3-arcsecond seeing, or worse.

It's not hard to understand why. The usual definition of a "good" telescope is one that keeps all parts of a light wave entering it nicely squared up to within ¼ wavelength accuracy by the time the wave comes to focus. But that same light wave, in traversing just six feet of air inside a telescope tube, is retarded by about *800 wavelengths* compared to where it would be if the telescope contained a vacuum. Clearly the air is an important optical element, and it had better affect every part of a light wave equally. If the refractive power of the air down one part of the telescope tube differs from the rest by more than just one part in 3,200, the ¼-wave tolerance will be breached. Such a change results from a temperature difference of just 0.1° Celsius. Add the *miles* of air that the light wave traverses before it even gets to the telescope, and it's a wonder that we can see any detail beyond the atmosphere at all.

The air's light-bending power, or refractive index, depends on its density and therefore its temperature. Wherever air masses with different temperatures meet, the boundary layer between them breaks up into swirling ripples and eddies that act as weak lenses. You can see this where hot air from a fire or a sunbaked road mixes with cooler air; the heat waves are astronomers' poor seeing writ large. Our windy, weather-ridden atmosphere is almost always full of slight temperature irregularities, and when you look through a telescope you see their effect magnified. Much of the problem, however, arises surprisingly close to the telescope, where you can take control of it to reduce it.

Inside the Scope

Seeing problems are often at their worst a fraction of an inch from the objective lens or mirror. If the objective is not at air temperature, it will surround itself with a wavy, irregular, slowly shifting envelope of air slightly warmer or colder than the ambient night. So will every other telescope part. Therefore, give the telescope time to come to equilibrium with its surroundings. Amateurs soon learn that the view sharpens within about a half hour after bringing a telescope outdoors. The full cool-down time for a large, heavy instrument may be much longer. It pays to set up early.

Usually the telescope is too warm, especially if it is stored indoors to prevent destructive dampness from condensing inside it during weather changes. But sometimes the opposite happens. Whenever a telescope begins to collect dew or frost, you know that it has grown *colder* than the air via *radiational* cooling. In this case gentle heat not only prevents dew but also keeps the scope closer to the air temperature -- and thus may sharpen its resolution.

"Tube currents" of warm and cool air in a telescope are real performance killers. Reflectors are notorious for tube currents, but closed-tube Schmidt-Cassegrains and refractors can get them too. Any open-ended tube, amateurs these days tend to agree, should be ventilated as well as possible. Suspending a fan behind a reflector's mirror has become a popular way to speed cooling and blow out mixed-temperature air. It's easy to check whether tube currents trouble your images. Turn a very bright star far out of focus until it's a big, uniform disk of light. Tube currents will show as thin lines of light and shadow slowly looping and curling across the bright disk.

Near the Scope

Some seeing problems arise just a few feet in front of the telescope. Obviously, try to keep your breath and body heat out of the light path. This is one reason to put a cloth shroud around an open-framework tube.
A telescope's immediate surroundings should have low heat capacity so they don't store up the warmth of the day. Grass and shrubbery are better than pavement. The flatter and more uniform the greenery the better. Heated buildings are disasters of poor seeing, especially if you find yourself looking over a chimney.

If you build an observatory, make it of thin materials that cool quickly: plywood or sheet metal, not masonry. Paint it white or a very light colour to reflect solar heat, and ventilate it very well. A thick rug belongs on the floor. A roll-off roof that opens the whole room to the sky provides quicker cooling and better seeing than a dome with its chimney like slit.

If you insist on a dome, it's a good idea to install a large fan in one wall to suck air down through the slit past the telescope, just as professional observatories do. It's widely considered a poor idea to attach an observatory to a heated house unless you resign yourself to low-power work. At least put it on the upwind side. Much poor seeing hugs the ground, so an elevated observing platform is a good idea if you can manage it. A scope is likely to show the stars and planets more sharply if you can get it up just a few feet closer to them.

High-Altitude Seeing

Now we come to the unavoidable heart of the problem. There's not much you can do about the air thousands of feet up. But you may be able to predict when and where it will be smoothest. Telescope users recognize two types of seeing: "slow" and "fast." Slow seeing makes stars and planets wiggle and wobble; fast seeing turns them into hazy balls that hardly move. You can look right through slow seeing to see sharp details as they dance around, because the eye does a wonderful job of following a moving object. But fast seeing outraces the eye's response time.

An old piece of amateur folklore is that you can judge the seeing with the naked eye by checking how much stars twinkle. This often really does work. Most of the turbulence responsible for twinkling originates fairly near the ground, as does much poor seeing. But high-altitude fast seeing escapes this test. If the star is scintillating faster than your eye's time resolution (about 0.1 second), it will appear to shine steadily even if a telescope shows it as a hazy fuzz ball.

Astronomers often talk of "seeing cells," air-eddy lenses ranging in size from millimetres to a few meters wide that swarm through the sky. These eddies originate wherever air masses rub past each other -- either horizontally in winds, vertically by convection, or both. Sometimes, when watching an extended object like the Moon or a planet, you can focus on a horizontal layer of "shear turbulence" a few thousand feet high.

The ripples sharpen up when you turn the focuser slightly to the outside of infinity focus (eyepiece farther from the objective). This is the signature of an inversion layer in which a mass of warm air flows across cooler air below. The actual temperature difference may be very slight. Large or slow-moving eddies cause slow seeing, but they don't stay large forever. No matter what size the eddies are when they originate, they break up into smaller and smaller ones. When these become as small as roughly millimetre-scale, they finally die out and dissipate their energy as heat via the air's fluid friction (viscosity).

This complex situation belies an often-repeated piece of astronomer's lore: that seeing cells are 10 centimetres (4 inches) in size. In fact they come in all sizes. But cells in this middle range do have an important property: they affect a large telescope more seriously than a small one. If you have a 4-inch scope, 4-inch and larger cells passing through its line of sight will make an image shift around while staying relatively intact. The same cells passing in front of a 12-inch aperture will superpose multiple images at once, making a fuzzy mess. This fact has led to another piece of folklore: that when the seeing is bad, a large telescope shows less detail than a small one. Therefore, supposedly, you can improve the view by stopping down a large aperture with a cardboard mask.

Technically there is a bit of truth in this, as mathematical analysis of seeing has shown, but in practical terms the improvement is slight to nonexistent. I have never seen an improvement by stopping down a telescope when the problem was poor seeing. The most that can usually be said is that on a really rotten night, large- and small-aperture views will be equally poor. Even then, if you constrict the aperture you miss the chance for the momentary high-resolution views that the full aperture will provide if the air briefly steadies.

There are unrelated reasons why you may indeed see more in a stopped-down telescope, most of them bad. Maybe your eye was dazzled by a too-bright planet; in that case an eyepiece filter would solve the problem better. Maybe the aperture stop is masking optical errors in a flawed objective, or maybe it's just allowing a mediocre eyepiece to perform better by increasing the telescope's f/ratio. Poor collimation is also less damaging when the f/ratio is increased. On a reflector or Schmidt-Cassegrain, an off-axis mask does give you the advantage of a clear aperture. A clear aperture, mathematical analyses have shown, is slightly less affected by atmospheric turbulence than an obstructed one.

In Search of Steady Air

The seeing quality depends on the weather, but not by simple rules that apply everywhere. Poor seeing does seem more likely shortly before or after a change in the weather, in partial cloudiness, in wind, and in unseasonable cold. Any weather pattern that brings shearing air masses into your sky is bad news. Good seeing, some observers claim, is most likely when a high-pressure system settles in to bring clear skies for several days running. Keep a seeing-versus-weather log for your locality, and you may discover correlations that will become your key to sharp viewing.

Seasonal patterns are more predictable. The seeing is often mediocre in the cold months over the northern United States and southern Canada, when the high-altitude jet stream flows above these latitudes. The very best seeing often comes on still, muggy summer nights when the air is heavy with humidity and the sky looks unpromisingly milky with haze. Some astronomers claim that a blanket of industrial smog steadies the air as effectively as summer humidity -- or rather that it accompanies the same tranquil air masses that are conducive to fine seeing.

Time of night also plays a role, but again there are few universal rules. Right after sunset the seeing is apt to be excellent, so start your planetary observing as soon as you can find a planet in twilight. The seeing is apt to deteriorate before dusk fades out. Some observers find that their seeing improves after midnight; others say it goes to pieces. This depends largely on local topography; observers in valleys might get worse seeing as the night goes on and cold air pools in the valley. Late dawn may be another excellent time.
For observing the Sun (use an astronomer's solar filter!), the best time is early morning before the Sun heats the landscape. The very worst seeing of the 24-hour cycle comes in the afternoon.

Geography is critical. Smooth, laminar airflow is the ideal sought by observatory siting committees worldwide. The best sites on Earth are mountaintops facing into prevailing winds that have crossed thousands of miles of flat, cool ocean. You don't want to be downwind of a mountain; the airstream breaks up into turbulent swirls after crossing the peak. Nor do you want to be downwind of varied terrain that absorbs solar heat differently from one spot to the next. Flat, uniform plains or gently rolling hills extending far upwind can be almost as good as an ocean for providing laminar airflow. You may learn to predict which wind direction brings you the smoothest air.

One easy countermeasure when observing bright objects like the Moon and planets is to use a colour filter. Different colours seem to shimmer out of phase with each other in the seeing (the reason stars twinkle in colours), and in a telescope this contributes to the general fuzzing up. The blue image of a planet may align with the yellow image one instant and separate from it the next. If you isolate just the yellow light, for instance, the planet will often appear to quiet down noticeably, at least in a small aperture.

A colour filter is especially useful when you're aiming at altitudes lower than 45° above the horizon. The seeing is always worse at low altitudes because you're looking through more air. In addition, you face more *atmospheric dispersion.* This is the smearing out of a celestial image into a short spectrum with blue on top and red on the bottom. Even as high as 60° up, the blue component of an image appears 0.9" above the red. The difference is 1.5" at 45°, 2.5" at 30°, and 5" at 15°. Your eye is fairly insensitive to light at the extreme ends of the spectrum, so dispersion really doesn't look quite as bad as this. Still, filtering out all but one colour in a swarm of chromatic aberration will sharpen your view. In the summer of 1994 I found a yellow or orange filter invaluable for following the comet-crash spots on Jupiter as the planet sank each evening toward the horizon.

Atmospheric problems get worse the lower you look. A star 15° above the horizon will be enlarged twice as much by atmospheric turbulence as one at the zenith, regardless of whether the seeing is good (defined here as 1" star images overhead) or poor (4"). Atmospheric dispersion elongates a star into a colourful little spectrum; at very low altitudes this overtakes even poor seeing as a cause of blurry images

Mostly, though, beating the seeing is just a matter of patience. Keep watching, and intermittent good moments may surprise you. One reason why experienced observers see more on the planets than beginners is that they simply watch longer, ignoring all but the steadiest moments. Moreover, the seeing can change as radically from minute to minute as it does from second to second. When that perfect minute comes along, the dedicated observer is the one most likely to be there at the eyepiece to catch it.

KEEPING WARM AT THE TELESCOPE

The deep blue sky of a frigid late afternoon in winter sets an astronomer's pulse to running -- or so it always has mine. Night comes early. The air shows no sign of haze or humidity, promising the darkest skies of the year. Studding the icy blackness will be such bright riches as Orion, Canis Major, Gemini, Auriga, Perseus, and Cassiopeia.

And yet I hear amateurs say their scopes are "in storage;" that this is the season one reads about astronomy rather than practices it. Do these people shiver too hard to keep a steady eye? Do they think the Southern Cross can be viewed only through the pain of frozen fingers and toes? In fact you can enjoy winter nights comfortably for hours on end if you dress properly and heed a few cold-weather tips that everyone should know.

Clothing

The first principle of cold-weather dressing is to trap layers of warm air near your body. Studies by the U.S. Army have found that "dead air space," air held in place by tiny fibres, is the only effective body insulator. It doesn't really matter what the fibres are, whether thrift-shop cotton, finest goose down, or exotic synthetics -- only how many inches you put on.

Of course some insulators are lighter than others, per inch of dead air space provided, and have other desirable properties. Vigorous hikers and skiers need light, flexible materials that wick perspiration away from the skin so it can evaporate without leaving a clammy, cold feeling. Special winter outfits are designed for these needs. Skywatching, on the other hand, is hardly athletic. So you can do fine by piling on layers of ordinary clothes that are already around the house.

What matters is how you wear them. Many thin layers are often better than a single thick one. Remember, you want to trap air. The outermost layer should be windproof to keep cold air out. It should also have elastics or ties to close off the waist, sleeves, and the face of a parka hood.

The second principle is to cover your whole body evenly. Three sweaters and a down parka won't keep you warm if there's nothing on your legs but blue jeans. Long underwear and an extra pair of pants -- perhaps heavy wool hunter's pants or insulated snow overalls -- are just as important as a coat. Pyjama pants make good "long underwear." Two pairs of pyjama pants are better. Your neck and head are major areas of heat loss, so a thick, warm hat and scarf or a thick parka hood are essential.

Where different items of clothing meet at ankles and wrists, prevent bare spots by interleaving the layers. Pull your inner socks up over the legs of long underwear, your pants down over the socks, and your outer socks up over the pants. Whenever it's mildly chilly it helps just to tuck your pant cuffs into the tops of your socks to keep cold air from blowing up your legs.

The third principle is to protect your extremities. Fingers, ears, toes, and nose freeze first. Good footgear is crucial. Your boots should be heavily insulated, but since you won't be scrambling up rockslides they needn't be rugged. Many observers swear by the large, puffy snow boots ("Moon boots") used by snowmobilers. Much warmth is lost from the feet to the ground by conduction through the soles of ordinary boots, so an insulated bottom liner or insole will help. Boots should be large enough to allow you to wear heavy wool socks over your regular socks without any feeling of tightness. Circulation to hands and feet must be kept completely free; anything that feels tight will soon feel frozen.

Protecting fingers is a problem because you have to manipulate eyepieces, charts, pencils (pens freeze up), and so on. One strategy is to wear thin skier's gloves inside loose, more heavily insulated mittens. The mittens can come off briefly as needed. My little finger is always the first to turn painful unless I keep it in the same finger of a glove as my ring finger; then it's no problem. Better alternatives are shooter's mittens with flap-covered slots that allow you to stick your fingers out. You might make cuts in the fingertips of an old pair of gloves.

A ski mask with holes for your eyes and mouth protects the face, if you don't mind looking like a terrorist. Don't use the kind with no mouth hole; your humid breath will come out the eyeholes and fog the eyepiece.

Since you'll be standing still, dress for 20° to 30° Fahrenheit colder than the actual temperature. Studies for Canada's National Research Council indicate that this is the clothing-requirement difference between walking briskly (what most people normally do outdoors in winter) and standing still for long periods.

Eat, Drink, and Act Merry

You can prolong your time in the cold by eating a good meal beforehand and by nibbling carbohydrates, which raise blood sugar and provide heat energy. Hard candy is convenient, but too many sweets can cause a sudden jump in blood sugar followed by an equally abrupt crash. A sandwich gives a steadier lift.

A thermos of hot coffee may feel comforting, but caffeine restricts circulation in the extremities. So does tobacco. A thermos of hot cider or other sweet drink will be better for you. Avoid alcohol; it not only reduces night vision but makes you lose heat by dilating capillaries in the skin.

Once any part of you gets cold, warming it is very hard without an external heat source. So as soon as something begins to feel chilled, run in place for a while or do some jumping jacks. You produce several times more heat during mild exercise than at rest, and good circulation will carry this heat all the way to your toes and fingertips.

Elderly and very thin people have lower metabolism (production of body heat) and are especially vulnerable to cold. Women produce less heat on average than men. People with good muscle tone generate more, even at rest.

Vigorous exercise raises anyone's metabolism for up to six hours afterward, so late afternoon or early evening would be a good time for a workout. Beware of exhaustion, however, which leaves you prone to rapid chilling.

A little-known cause of chills, headaches, and ill feeling in winter is dehydration. You lose a lot of water breathing dry winter air, while cold depresses the thirst mechanism so you don't drink enough. When the body runs low on water it conserves fluid by reducing circulation to the extremities, which means your hands and feet freeze quicker. Guzzle water before going out under the stars.

Safety

Cold can kill. If you observe from a remote, lonely site in winter, think through the entire chain of events that will happen if your car won't start. Have you told someone where to come looking for you if you don't show up by breakfast? How will you keep warm until then?

Car batteries lose power in the cold. Even if you normally run your equipment off the car battery and have enough juice left to start the engine, don't assume you can do this in unusually low temperatures. If in doubt, run the engine for five or 10 minutes per hour while observing. This is a good reason to power your equipment from a separate 12-volt battery -- which in an emergency might recharge the car battery enough to get you started.

Any car that is driven in cold rural areas should carry certain emergency items under the seat: extra old sweaters or blankets, an extra hat or two, hard candy, matches, and candles. A candle in a car will provide much warmth if you huddle over it, but open the window a crack. If the engine will start but the car won't move, check the gas gauge. Conserve gasoline by running the engine and heater only 10 minutes or so out of each half hour or hour. If the area is snowy, check that the tailpipe is clear so exhaust won't be trapped under the car. Police report that exhaust poisoning is a major cause of death for motorists whose cars get stranded in deep snow.

No matter how thirsty you get, never eat snow when in danger from cold. Snow requires so much body heat to melt that rapid hypothermia can result. Instead, melt it in a hubcap over your candle. Times like these make a cellular phone or mobile ham radio look mighty good.

Another piece of advice from cold-weather state police: don't leave your car. It provides by far the driest, most windproof, most comfortable shelter you could possibly devise in the wilds. It's also highly visible. Poor judgment leading to gross stupidity is a classic effect of oncoming hypothermia. When things look bad it would be very easy to walk a half mile down the road from your car at 3 a.m. in hopes of finding the house that you think maybe you passed, become disoriented, and forget to turn around. If you stay in your car, sooner or later -- whether in hours or days -- someone will always come.

Such emergencies, of course, are unlikely. With a little planning and common sense, winter nights under the stars will be as pleasant as any -- as well as darker and more exciting

DEALING WITH DEW

The most common equipment hassle that observers face at night is water on the telescope, which comes as a surprise to newcomers who expect things to stay dry in clear weather. Unfortunately, the steadiest, sharpest telescopic views are often had under precisely the atmospheric conditions that cause dew to form. At the eyepiece you first notice dim stars and galaxies becoming harder to see, then bright stars develop fuzzy halos -- and a check with the flashlight reveals wet haze coating the optics. In severe cases the whole telescope may be soaked. Wiping never helps; more water condenses the moment you stop. At this point many observers pack up, defeated. However, you *can* keep your lenses and mirrors crystal clear in even the heaviest dewing conditions. You just need to understand the enemy and take effective countermeasures.

Dew does not "fall" from the sky. It condenses from the surrounding air onto any object that's colder than the air's *dew point.* The dew point, often mentioned in weather broadcasts, depends on both temperature and humidity. When the humidity is 100 percent, the dew point is the same as the air temperature. At lower humidity, the dew point is below the air temperature. If it's below freezing, you get frost instead of liquid water.

An example of dew physics occurs when you take a bottle out of the refrigerator. If the bottle is colder than the air's dew point, it drips with condensation. Your telescope is the bottle. "But my telescope *can't* get colder than the air!" a new Schmidt-Cassegrain owner once remarked. "It was *warmer* than the air when I brought it outdoors. The Second Law of Thermodynamics says that can't happen!"

If only life were so simple. Objects do try to come to the same temperature as their environment and then stay there, as the Second Law says. But they don't exchange heat just with the air around them. They also exchange heat with objects at a distance by radiation. That's why the Sun can feel warm on your skin even though it's 93 million miles away. At night the heat flow goes in the opposite direction. The effective temperature of the dark night sky is just a few degrees above absolute zero, and a telescope in an open field is exposed to a whole celestial hemisphere of this cosmic chill.

The first line of defence against dew, therefore, is to shield your optics from as much exposure to the night sky as is feasible. The traditional dew cap extending beyond a refractor's lens often serves this purpose well enough to keep the lens dry. The longer the dew cap, the more likely it is to work. One of the nice things about a Newtonian reflector is that its entire tube acts as a dew cap to shield the mirror in the bottom. An open-tube reflector, however, needs a cloth shroud around its open framework to gain this benefit. The cloth itself, of course, will get wet on its sky-facing side.

The worst dew problems appear on exposed parts that are thin (or have low heat capacity) and rapidly radiate away their warmth. Schmidt-Cassegrain corrector plates are notorious for dewing; so are Telrad sights with their exposed glass. A dew shield is reportedly the first accessory that Schmidt-Cassegrain owners most often come back to buy.

You can easily make your own. A piece of tough 5/8-inch foam rubber, the kind sold in sporting-goods stores to go under sleeping bags, makes a dew shield that's cheap, durable, and very lightweight. The foam is an excellent insulator, for maximum effectiveness. If you're concerned that the cap might vignette the image (block some starlight near the edges of the field of view), you can cut the foam so it flares open at a very slight angle. A 3° opening angle should allow a 3° unvignetted field of view.

As a rule of thumb, a dew cap should be at least 1½ times as long as the aperture is wide. A side benefit is that the cap also cuts down on stray light getting into the telescope.
Eyepieces too are prone to dewing. Warm radiation from your face slows the process, but humidity from your eyeball and breath speeds it up. A tall rubber eyecup, the kind that extends above the eye lens all around, not only blocks stray light while you're observing but acts as a miniature dew cap when you're looking away.

The same principle works on large scales. Early on a clear morning, have you noticed grass in the middle of a field white with frost or dew while grass near a tree has none? The tree is a giant dew cap, and it can work for you too. If you'll be looking at only one part of the sky, it's nice to have trees around and behind you. Not just your telescope but your charts and accessories will stay dry longer.
Trees also reduce wind problems, but a slight breeze is a good thing. Radiational cooling is slow and inefficient compared to heat transfer with the surrounding air, so even the mildest breeze will keep your telescope nearly up to air temperature.

Then there's the observing umbrella, not a widely known accessory but one that works. A beach umbrella blocks the chill of absolute zero the same way it blocks the heat of the Sun. It can help shield all your gear and keep the chill off you too. On a still night a thermometer under an umbrella can read more than 10° Fahrenheit higher than when it is exposed to the open sky.

The Heat is On

There will be times and places where none of this is enough. You then have no choice but to warm your optics, usually electrically. A 120-volt hair dryer, used gently from a distance so it doesn't overheat the glass and warp it, will blow off dew for perhaps five minutes. Then you have to use it again, and again! A 12-volt auto windshield defogger gun is somewhat less effective. A better way is to apply a little heat continuously. Heated dew caps that run off a 12-volt battery are advertised in magazines or with just a little electrical know-how you can make an anti-dew heater to any size, shape, and specification you want.

Warmed optics can have unexpected benefits. Dew works its first subtle evils before you notice anything. The late Walter Scott Houston used electric warmers on both the objective and eyepiece holder of his 4-inch refractor. When he turned off the power, the telescope could lose a whole magnitude of light grasp before the objective actually looked dewy.

"Even on nights when dewing is not noticeable," Houston wrote, "the star images seem better with the heaters on than without them!" This may be because, contrary to what you might think, gentle heating keeps a telescope close to the temperature of the surrounding air. After all, the whole idea is to stop it from growing *colder* than the air.

Not-So-Cold Storage

The most destructive dewing happens when a telescope is in storage. No telescope should be closed up and put away until it is thoroughly dry. Water with nowhere to escape, or condensation that forms and evaporates repeatedly in a sealed environment over months and years, may attack optical coatings and ultimately etch the glass itself.

How, you may ask, does water get into an airtight space that was dry when you sealed it? The answer is it was there all along. Air contains water vapour, and if your telescope gets colder than what the dew point was *when the air was sealed in,* water will condense. This is why so many puzzled telescope owners discover water stains on the *inside* surfaces of their corrector plates and refractor lenses.
Several approaches can prevent this. Don't move a sealed telescope from warm to cold storage. In fact, sealing may be a bad idea altogether. The best telescope covering is cloth, which will "breathe." It keeps dust off but lets water vapour out. And you might want to leave the eyepiece holder covered only with cloth, just enough to keep dust and spiders out.

The worst problems occur when a warm front of humid air blows in after cold weather, as often happens in early spring. Everything cold gets drenched. A cloth wrap may be the best defence here too; it will greatly reduce the amount of humid air that can flow over cold parts.

The usual advice is to store a telescope at the outdoor temperature to minimize tube currents when you set it up. But this old rule may need modification. Keeping the telescope a *little* warmer will tend to thwart condensation. An enclosed porch or attached garage may provide the extra few degrees you need. And really long-term storage should probably be inside your living space. Never leave a telescope in a damp basement or garage or, as a rule of thumb, any place where tools grow rusty.

You can take active countermeasures too. A 4- or 7-watt light bulb inserted into a blanketed telescope makes a nice low-power heater. Position it just below or right next to the glass, or else you may merely drive off water from other parts of the tube that will condense onto the cold optics. Running the bulb continuously will cost about a dollar per watt per year. You might turn it on only in the damp season, or attach it to a humidistat switch.

Silica gel desiccant will dehumidify the air in a tightly sealed enclosure. One amateur keeps a ¾-pound bag in plastic webbing attached to the inside of one of the tube caps of his 12.5-inch reflector. Every month or two when the bag's indicator slip turns from blue to pink, he heats the bag in a toaster oven in his kitchen to drive off the collected moisture. The more tightly you seal your tube or storage case, the less often you'll have to do this. Silica gel is available from many sources Water can be an insidious enemy for astronomers, but a little knowledge will keep it permanently at bay.

CARING FOR OPTICS

Big-time optical cleaning. "We don't use the word `scrubbing,'" says Robert P. Thicksten, superintendent of the 200-inch Hale Telescope mirror on Palomar Mountain. "First we pat the old aluminium mirror coating and then gently rub it with soap to loosen soil, using true animal sponges that have been pounded with wooden mallets and washed several times." The 200-inch mirror is cleaned and realuminised every two or three years.

When cleaning lenses and mirrors, the most important rule is that of the doctor's Hippocratic Oath: "First, do no harm." Any telescope or binocular used for astronomy is a scientific instrument and should be treated as such. Even the humblest one deserves care, since you'll be using it right at the limit of its capabilities trying to see faint objects or fine detail. In such critical work, little problems can make a big difference.

Then again an observer's life is full of imperfections, and there's no point fretting about them. The right attitude toward optics means knowing when to be vigilant about care and when to relax.

Every optical instrument gets dirty. Dirt on lenses or mirrors scatters light and reduces contrast. It makes dark skies less dark and bright objects less crisp.

The first tactic against dirt is defensive -- and here's where to be vigilant. Keep the lens caps on when the instrument is not in use. If none are available, make your own, such as shower caps or cloth over the ends of a Newtonian reflector. A plastic Kodak film canister makes a convenient plug for a telescope's 1 1/4-inch eyepiece holder.

I store my two reflectors positioned so both their main and secondary mirrors face slightly down. That way dust can't settle on them. Eyepieces and Barlow lenses should be capped on both ends, or kept in plastic sandwich bags or small food containers.

Never touch the surface of a lens or mirror. The acids in skin oil can attack optical coatings over time, so if you do leave a fingerprint on, say, a binocular objective, clean it off promptly using the method described below.

So much for vigilance. Now to relax. Dirt happens, and in moderate amounts it has remarkably little effect on performance. In his book *Star Testing Astronomical Telescopes*, Harold Richard Suiter analyses the effects of dirty optics mathematically. His conclusion? "The maximum amount of dirt [that a perfectionist] should tolerate on the optics is about 1/1000 of the surface area, [which is] the size of a single obstruction about 1/30 of the diameter." In other words, on a 10-inch mirror this is the equivalent of a completely opaque dirt blot 1/3 inch across. That's quite a pile of crud before there's any detectable effect on contrast.

"Don't decide to clean mirrors on the basis of shining a light down the tube at night," advises Suiter. "All mirrors fail such a harsh inspection." After you've done what you can to prevent dust, ignore it.

Cleaning Optics

There's a good reason to ignore dirt aside from maintaining peace of mind. A dirty lens or mirror can always be made clean, but a scratched one is scratched forever. Cleaning causes tiny scratches ("sleeks") if you don't do it exactly right, and maybe even if you do. So clean optics rarely. One well known amateur said I've washed the main mirror of my trusty 6-inch reflector twice in 30 years, and the mirror of my 12-inch reflector twice in nine years. I've never cleaned the secondary mirrors at all, aside from blowing off dust, and they still look fine -- because I've been careful about clean storage.

Actually, the surface you are cleaning is usually not glass but an optical coating that is softer and more vulnerable. The basic antireflection lens coating is magnesium fluoride, which can be very soft if the manufacturer applied it at too low a temperature. Good magnesium fluoride coatings are usually made quite hard. The newer, better multi-coatings tend to be softer but are also being hardened up by manufacturers.

Cleaning a mirror. Ordinary house dust contains bits of rock powder carried in on the wind. Sleeks are caused by rubbing this stuff against glass. So when a cleaning finally must be done, the first and most important step is to remove all grit. The safest way to remove grit is to blast the surface with tap water. That may be all you need to do.

If dirt remains, swish the surface very lightly with clean cotton in lukewarm water and detergent. Rinse with tap water, do a final rinse with distilled water, and set up on edge to dry.
Mirrors (and disassembled lens elements) can be completely immersed in water for thorough cleaning. You'll need the kitchen sink, two towels, liquid detergent, a bottle of distilled or demineralized (deionized) water (available in drugstores), and a package of sterile cotton. (If it's sterile it's more likely to be grit-free.)
Wash out the sink, rinse it well, and lay a folded towel on the bottom. Take off any jewellery from your hands and wrists. Put the mirror face-up on the towel, and with the drain open, blast the mirror's surface with room-temperature water for a few minutes. This will remove most dust and grit safely. Do not shock a mirror's metal coating with hot or cold water.

Turn off the tap and give the mirror a final rinse with distilled or demineralized water. This will leave no mineral deposits when it dries. Stand the mirror on edge (on a folded towel to prevent slipping) and let it dry completely. You can draw off stubborn water droplets carefully with the corner of a paper towel.
If the mirror looks reasonably clean, quit while you're ahead! You can't scratch a mirror you haven't touched.

If it's still cruddy, plug the sink, put the mirror back in on the towel, and fill the sink half full with lukewarm water. Add a teaspoon of liquid detergent and let the mirror soak for five or 10 minutes. Then, holding it underwater, swirl it around for a last chance at rinsing off remaining grit.

Take a wad of cotton and, starting at one edge, swab the mirror in one direction, applying no pressure but the weight of the cotton itself. Grit is less abrasive wet than dry, so do this underwater.
Turn the cotton over in a backward-rolling motion as you go, so that as soon as a part of it rubs the surface, that part is carried up and away from the glass. Throw out the wad when it has been turned completely. The job may take a lot

of cotton. .It's a good idea to work in complete silence. If you make sleeks, you may actually hear them! If so, stop and proceed to the rinse.

Drain the sink and run lukewarm water over the mirror for at least a minute. Finish with a rinse of distilled water and tilt the mirror on edge to dry.

EYEPIECES AND SMALL LENSES.

For dusting eyepieces, a quick and safe first step is to lay a finger across the eye end (without touching the glass!) and suck air under it past the lens while flipping your finger away. The sudden pulse of air removes much dust. This takes about one second at the telescope.

The traditional method for dusting optics is to brush very lightly with a camel's-hair brush. These brushes, sold in camera shops, have soft bristles with minimum tendency to scrape grit against a lens. The bristles should be untrimmed ("natural end"). Brush very lightly in one direction, while turning the brush in a backward-rolling movement so that as bristles pick up dust they are flicked away from the glass. Seal the brush in its container or in a plastic bag when not in use.

Camera shops also sell cans of compressed gas for blowing dust off lenses. Be careful with the kind that use liquid propellants; these have a reputation for spitting onto the glass and leaving a residue, if the can is tipped or shaken in use. Your own breath is likely to leave spit too.

For tougher dirt or stains on the surface of a lens, various lens-cleaning solutions are available. Among the simplest and most effective are pure isopropyl alcohol or methyl alcohol (methanol), available in drug stores and hardware stores, respectively. Standard isopropyl rubbing alcohol works well too and is easier to find, but avoid alcohol preparations with other ingredients that may leave stains. If you dilute a cleaning solution, use distilled or demineralized water. Camera shops sell lens-cleaning fluids such as Crystal Clear, which is ultra-pure methanol.

You'll need a soft, grit-free wipe. A well-washed piece of pure cotton cloth works well. So does a cotton swab or piece of clean cotton. Moisten it with the fluid and swirl the fluid gently across the lens, applying no pressure. If necessary, rub dry with a fresh piece very gently.
Don't drop liquid directly onto the glass. It's liable to seep into the edge of the lens cell and carry dissolved grime onto interior surfaces, staining them.

Eyelash and fingerprint oil will stain coatings permanently if left on long enough. So will moisture condensation sealed in after observing sessions. (Blow-dry your eyepieces if necessary before capping them.) But such stains are only cosmetic, eyepiece manufacturers insist. They should have no noticeable effect on performance.

An eyepiece's field lens will probably stay clean by itself. Leave it alone except perhaps for an occasional air blast or camel's-hair dusting. If problems develop inside the eyepiece, don't try to take it apart. You are almost certain to tilt and jam ("cock") a lens element. Send the eyepiece back to the manufacturer for disassembly and cleaning, which some makers will do at little or no cost.

Refractor objectives and the corrector plates of catadioptric telescopes should not be taken out of their cells except by an expert. (If you ever do take a refractor lens apart, make sure you will be able to collimate it after putting it back together ‹ an art known to few. Make sure that on the outside rim of each element is a pencilled indication of which sides face each other, which face the sky, and the orientation with which the elements are to be reassembled so that the same points around their edges match up again.)

They can be cleaned the same way as small lenses by using more time and fluid. It's okay to put drops of fluid directly onto the glass as long as none gets into the edge of the cell. Resist any urge to hurry the job.
Dew Hazards

When a lens or mirror gets colder than the dew point of the surrounding air, water or frost will condense on it. A dirty surface will dew up much faster than a clean one. Never wipe a dewed lens or it may sleek -- and more dew will immediately condense on it anyway. Instead, warm the glass slightly with an electric hair dryer. An eyepiece can be warmed in your hand, then dried by sucking air in across the eye lens or by waving your hand just in front of it.

Dewing can be reduced or stopped by shielding the glass from exposure to most of the open sky. Exposure to the chill of space is usually what causes things to dew up at night. If a basic dew cap doesn't do the job, you can add commercial or homemade ant-dew heaters. (See "Dealing With Dew,".)

If you get rid of dew reasonably soon, it has no effect on the optics. Stains and worse problems arise when dampness remains, or forms, on optics in storage.

A cold telescope can become dripping wet on being brought into a warm house. Don't cover or seal the telescope until it's completely dry. One school of thought says that sealing is a bad idea altogether. When a telescope is in storage, the humidity in the air that was sealed in can condense onto the optics if the temperature of the glass drops. Dust covers should probably "breathe" a little to let water vapour out during changes of temperature. Cloth might be a better cover than plastic, at least over the eyepiece tube. Of course, avoid a storage site that shows signs of being prone to dampness.

Be vigilant to prevent dirty lenses and mirrors -- and then forget about them. Perfectionists are never happy, but astronomy should be fun. After all, what matters is not what you see on your telescope, but what you see through it.

THE SETTING CIRCLES ON YOUR TELESCOPE

Nearly every telescope on an equatorial mount comes with setting circles. In theory, they show the right ascension and declination to which the telescope is pointed, making it simple to aim at any object whose coordinates you look up. In practice, experienced observers generally regard setting circles as decorations to help sell telescopes, as a source of false hope for beginners, and possibly useful as makeshift frisbees.

We're talking here about traditional mechanical setting circles: rings engraved with lines and numbers on the telescope's two axes. More recent "digital setting circles," electronic readouts that tell where a telescope is pointed, can be vastly more accurate and useful; they're described at the end of this article.

Conventional setting circles are no substitute for learning to find your way around the sky by looking with your eyes. But having absorbed this lesson, many observers scorn their setting circles forever after, even in situations when they might be quite helpful.

The problem is that many adjustments and alignments have to be done very precisely before the circles will display right ascension and declination accurately enough to find objects "blind." Rarely are all of these adjustments made.

But if you have some knowledge of the sky, you can use the circles for less demanding tasks that have looser accuracy requirements. We will discuss this simpler type of use first, then go on to the more exacting applications.

Offsetting from Stars

Their inherent inaccuracies give less trouble if you use setting circles only to measure your way a few degrees across the sky rather than all around the celestial sphere. This is the *offsetting* method of finding objects from a known star.

This method works even with the oldest-style setting circles that only read hour angle from the celestial meridian instead of right ascension. (These are identified by their 0 to ±12 hour markings that can't be set to anything but 0 when the scope is pointed at the meridian.)

First check that the telescope is polar-aligned moderately well. The polar axis of the mounting should be aimed at the celestial pole to within a couple of degrees. (Instructions for polar alignment come with most equatorial scopes.)

Look up the coordinates of your target object and any fairly bright star within 10° or so of it. Subtract the right ascension and declination of the star from those of the object. The result tells you how far from the star to swing in declination going north (or south if the value is negative), and how far in right ascension going east (or west if negative).

Most setting circles have rulings every 1° in declination and every 5 minutes of time in right ascension. So express your declination offset in degrees and right ascension in minutes. Try to read the declination dial to a tenth of a degree and the right ascension dial to one minute or better.

Offsetting can be very useful if the normal method of finding objects -- star-hopping with the aid of a good map -- isn't working. Perhaps you don't have a map that shows enough stars for you to home in on the exact point. Perhaps your finderscope is too small or the light pollution too bad, or you've repeatedly gotten lost in a difficult field and want to try a new tack.

Offsetting is especially efficient when you plan to survey many objects in a small area of sky. Work out your offsets indoors beforehand, and write them in your observing notebook.

All-Sky Use

If you want to find objects anywhere in the sky by dialling their coordinates, you should understand the many precise adjustments required to your telescope.

Suppose your lowest-power, widest-field eyepiece gives a 1° true field of view, typical of amateur instruments. If the telescope is pointed ½° wrong, your object will be on the edge of the field where it will go unnoticed. Merely to place it closer to the centre than to the edge, you have to aim with ¼° accuracy.

What are the adjustments?

The axis of the telescope's optical system should be made truly perpendicular to the mount's declination axis. This in turn should be perpendicular to the mount's polar axis. The polar axis must be accurately aligned on the celestial pole. The circles themselves must be positioned just right. Last, you must *read* the circles accurately -- usually to a small fraction of their finest gradation.

Some of these adjustments have two degrees of freedom, such as in altitude *and* azimuth when aligning on the celestial pole. So all told, there are eight variables where error can creep in.

Based on the way simple random errors add up, each of these eight adjustments must be good to 0°.09 accuracy to achieve an *average* total error of 0°.25 in where the telescope is pointed. Half the time the errors will add up to be better than this, half the time worse. To make them fall consistently on the better side, you should strive for even finer accuracy -- say 0°.05 -- in each adjustment.

No wonder setting circles have a reputation for never working.

We'll deal with each adjustment in turn.

First, make sure that the *optics* of the telescope are collimated (aligned) as best you can. Collimation on a reflector is usually just a matter of turning the adjustment screws behind the primary mirror to make a slightly out-of-focus-star image perfectly round when centered. On a Schmidt-Cassegrain telescope, you make tiny adjustments to the screws on the secondary mirror mount. Refractors rarely need collimation. Instructions for collimating a telescope usually come with it.

If you use a star diagonal, such as on a Schmidt-Cassegrain, be sure it too is collimated if it has adjustment screws on its back. Using high power, centre the scope on an object while viewing "straight through" without the diagonal. Then insert the diagonal and see if the object is still centered. If it's not, turn the diagonal's adjustment screws until it is.

The reason for getting collimation all squared away first is that when you collimate a telescope, you change its aim point -- that is, the direction of its optical axis with respect to the tube. After you collimate you will have to realign the finderscope to match the main telescope's new aim.

Now swing the tube to about 90° declination. While looking through your lowest power eyepiece, swing the mount back and forth in right ascension by turning the polar axis. You will see the field slowly turning. Make slight adjustments to the declination so the motion of the field is minimized when you turn the scope.

Ideally, you will find a declination position where the stars rotate around the exact centre of the field. This happy state of affairs means you have gotten the optical axis truly parallel to the mount's polar axis.

Don't expect it to happen. Instead, you will only be able to find a place where the field motion is minimized, not reduced to zero. The point of sky around which the field appears to rotate will be off to one side, perhaps out of view entirely.

You want to shim the telescope tube in its cradle, or adjust the fork arms if the scope has a fork mount, to bring this point to the centre of view. While turning the scope in right ascension, form a mental image of where the field's centre of rotation lies. Nudge the scope that way to judge which side of the cradle needs to be shimmed, or which fork arm raised.

You can use strips of brass or plastic or folded-up aluminium foil for shimming. Adjust a fork arm on a Schmidt-Cassegrain scope by loosening the bolts that hold it to the drive base and sliding the arm slightly up or down. (This may be limited by the size of the bolt holes) The adjustment may take quite a bit of trial and error, but it's a job you'll only have to do once.

If your telescope tube can rotate in its cradle (a convenience on many reflectors), you may find you can get closer to the ideal after rotating the tube by some amount. Try this first, then do the shimming. Just remember that in actual use, you may need to rotate the tube back to the position it's in right now before the setting circles will work well. Mark the tube so you can do this if the circles later give problems.

Once you've done the best you can, loosen the declination circle, turn it to read precisely 90°, and retighten it permanently.

Now a confession: we've skipped a step. In the case of a German equatorial mount we haven't checked that the declination axis is perpendicular to the polar axis, and with a fork mount we aren't sure if the optical axis is perpendicular to the declination axis. That's because there is little or nothing you can do about it. *Trust the manufacturer and cross your fingers.*

The next step is accurate alignment on the celestial pole. Some telescopes come with pole-finding reticles for their finderscopes. Another method that is especially precise is described in the article "Accurate Polar Alignment."

Now, at last, the setting circles are ready for their intended use!

The declination circle need never be touched again. But the right ascension circle does have to be repositioned at the start of each observing session, because the sky is always moving.

Aim at a bright star whose right ascension you know. (It's handy to keep the right ascensions of a dozen bright stars on the inside cover of your observing notebook.) Slide the right ascension circle to read the correct value for that star.

On a German equatorial mount, the star should be on the same side of the mount as the objects you'll be looking for.

Now you can dial in the right ascension and declination of any object in the sky. Look in your lowest-power eyepiece, and there it should be.

If your right ascension circle is driven by your telescope's clock drive, as is the case with all Schmidt-Cassegrains we know about and many reflectors, you can dial in object after object all night without touching it again. If the circle is not driven, reposition it to the right ascension of the current object just before swinging to the next.

Technology to the Rescue

New ways have recently been invented to circumvent the problems that make setting circles so error-prone. These methods revolve around the "digital setting circle."

In its simplest form, this is nothing more than a readout in little red numbers of what an ordinary setting circle tells you with a dial and pointer. But once this data is electronically encoded, a computer chip can begin to work miracles with it.

In some versions you can simply "initialise" the circles by setting on two or three bright stars at the beginning of a session, and the chip corrects for misalignments of many kinds -- even failure to polar-align at all.

The next step up in sophistication is automatically correcting for lack of perpendicularity in the mount's axes -- compensating for imperfect mechanics by smart electronics.

Team up good digital setting circles with a computerized data base of celestial objects, and you gain the astounding finding capabilities of a "computer assisted" or "robotic" telescope. These are currently working a revolution in high-end amateur astronomy, finally fulfilling the promise of what many people thought setting circles were supposed to do all along.

SKY PHOTOGRAPHY WITH JUST A CAMERA

ADAPTED FROM AN ARTICLE BY A STAFF REPORTER IN *A* POPULAR *TELESCOPE'* MAGAZINE

The $1,000 modern still/video camera and 40-year-old $2 Kodak box camera may seem worlds apart technologically, but both are suitable for astro-photography since they can make time exposures. (Today's popular point-and-shoot cameras generally cannot.) If the box camera seems like a joke, consider its surprisingly good star images as revealed in many amateur photos submitted to astronomy magazines over the years.

'SHOOT PICTURES' of astronomical objects without a telescope? The prospect might not seem very thrilling. After all, how many photographs of star trails can you take?

Such were my thoughts as a teenager starting out with no astronomical friends and slim pickings at the local library. My immediate solution was to turn to amateur telescope making instead, but that's another story. More than 25 years have since passed, and I'm well settled in as an astrophotographer, every year adding hundreds of hours of exposures to my collection. As a teenager I never would have dreamed that most of these pictures would be made with no telescope.

Camera-only astrophotography can be surprisingly easy and satisfying. It was mainly my lack of teenage imagination that prevented me from seeing its potential. Furthermore, hardly a year goes by that I don't hear of new ways to make dramatic celestial photographs with an ordinary 35-mm single-lens-reflex camera.

First the Hardware

A few years ago I could say that no 35-mm camera was too simple or too complex for astrophotography. That's no longer so. Cameras of the automatic point-and-shoot variety, the most widely sold today, are not suited for astrophotography. None that I know has a provision for keeping the shutter open for a time exposure. However, the ability to hold the shutter open is such a creative option that it's bound to be on future point-and-shoots, which become a bit more like their sophisticated single-lens reflex forebears with each new product generation.

With point-and-shoots temporarily excepted, just about any other camera will work for astrophotography. To prove a point, consider the two pictured at the beginning of this article. The Hasselblad is fitted with a wide-angle lens and other accessories that boost its suggested retail price to over $7,000. The circa-1948 Kodak box camera cost $2 at a flea market. Its sole feature is the ability to make a time exposure!

Most people probably already own a camera that falls somewhere between the $2 and $7,000 extremes. If you don't and you're in the market for one to point skyward, there are a few things you should look for. The first is manual time exposure that functions independently of the camera's battery. This has become very rare in today's electronic cameras.

The problem with a totally electronic shutter is that it drains the camera's expensive battery during time exposures. Furthermore, nighttime cool or winter cold places extra demand on a battery. The result is often shutter failure that magically corrects itself after the camera is brought back into a warm house.

You may have a tough time finding a camera body that's simple and straightforward enough to take a time exposure.

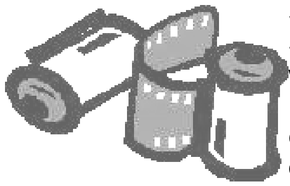
As of the time of writing, however, the venerable Pentax K-1000 is still available. This camera is completely manual, and it's an excellent choice for astrophotography. My wife has one dating from the mid-1970s, and its modest 50-mm f/2 lens delivers very good star images even when used at full aperture. (Most lenses need to be stopped down a bit to deliver their best images in the corners of the frame.) What's particularly appealing about the K-1000 is its very modest price.

An even cheaper source to consider is the used-camera shelf of your local photo store. There are some very good deals to be had on used equipment, much of it traded by people "upgrading" to automatic equipment. Nikon, Minolta, Olympus, Pentax, Canon, and others have all made fine manual cameras in the past.

Most of today's cameras have some form of electronic display in the viewfinder. These often include light-emitting diodes (LEDs). It is important that the LEDs be off during a time exposure. Not only will a lit display contribute to battery drain, but often the light will leak onto the film and fog the picture. Such was the case with my old Minolta XD-11. That camera allowed manual time exposures, however, so I simply removed the battery.

The only other hardware that is especially helpful for simple astrophotography is a sturdy tripod and a shutter-release cable. In a pinch, however, I've done without either, resting cameras on rocks, fence posts, and even the ice on a frozen birdbath while gently holding the shutter release down with my finger.

Next the Film



Selecting film for astrophotography has become increasingly complicated for the beginner. Scores of different films line the wall of any large camera store. Hardly a month passes when one of the major film manufacturers doesn't release a new or improved emulsion. Nevertheless, I've seen beautiful celestial photographs made on just about every commercial film, even ones that seemed inappropriate for the subject (like an aurora shot on Kodak's old High Contrast Copy film that had an extremely slow ISO rating of 6).

A good starting point would be an ISO 400 emulsion. It has fairly fine grain yet enough speed to record faint stars. Whether you choose a print or slide film is up to you. In recent years I've been leaning more to negative (print) films because of their wider exposure latitude. This goes for both colour and black and white. But getting the most out of a negative film often requires having a custom print made at a photo lab, and this can become expensive. Then again, I have seen some very good colour prints come from one-hour processing shops. Negative films also open the door to many enhancement techniques. But these *will* require work in a custom lab or home darkroom.

It's a good idea to begin each roll with at least one shot made by daylight or flash. This will give the technician in the darkroom a reference frame. Otherwise it is difficult to find the edges of frames against the dark backgrounds of most astronomical images. The results can be disastrous when the film is cut into short lengths for packaging or, in the case of slides, for mounting. To be safe I always ask that my processed film be returned uncut and then do it myself.

Finally the Subjects

So what do we shoot? Constellations are a good start. But aiming a camera in the dark has never been easy. Usually only the brightest stars are visible in the viewfinder. But here's a trick I have always found to work. Once your eyes are dark-adapted it's possible to see your hand silhouetted against the sky when looking through the camera. To check where you are aimed, look through the viewfinder and move your hand in front of the lens until it reaches the edge of the field. Now lift your eye just enough to look over the camera and see where your hand is projected against the sky. This is the approximate edge of the field being photographed. You can repeat the procedure for each side of the frame.

With the lens set to its widest aperture (lowest f/number), make a series of exposures from 15 seconds to 2 minutes long, each being double the time of the previous one. The diurnal motion of the sky will, of course, cause the stars to trail on the film. The length of these trails depends on several factors, some of which you can control. What matters is your personal tolerance for how long a trailed image can be before it appears objectionable. The length l of a star's trail on the film in millimetres can be calculated from the formula

$l = [tF \cos (\text{delta})]/13{,}750$, where t is the exposure time in seconds, F the focal length of the lens in millimetres, and delta is the north or south declination of the star.

Stars near the celestial equator (delta = 0) appear to move the most, those near the celestial poles the least. Telephoto lenses increase the length of the trails, since they effectively magnify the sky's motion on the film, while wide-angle lenses diminish it. What seems like a very tiny trail on the film becomes significantly larger when the negative is enlarged to a print or the slide is projected onto a wall or screen.

Nevertheless, the pictures show that interesting scenes are possible even when stars are visibly trailed.

If you *want* long trails, the limiting factor for exposure time is often the sky brightness. Moonlight, airglow, and especially local light pollution are highly variable.

Making a few test exposures is the best way to learn what your skies will permit. From my home on the outskirts of Boston's dome of light pollution, the naked eye can see stars of magnitude 5 on a good night.

My rule of thumb is that these conditions permit a 1-hour exposure on ISO 1,000 film with a lens set at f/11. To record the same image, higher-speed film would need a smaller lens opening (higher f/number), while slower film would need a larger one.

Likewise, a shorter exposure could use a larger lens opening, thereby gathering more light per minute, without sky fog becoming a problem. (A word of warning when doing this, however: a larger lens opening will reduce the maximum exposure time more than the lower f/number alone would suggest. This is because a phenomenon known as reciprocity failure causes the film to record light with poorer efficiency during long exposures.)

The CCD

The biggest promise that technology holds out -- for those who can afford it in both money and time -- is the CCD camera. By 2000, CCD (charge-coupled device) cameras had taken over and vastly expanded high-end amateur astronomy, and their prices are declining every year. A CCD camera has two enormous strengths. First, the CCD chip is many times more sensitive to light than either your eye or photographic film. Second, it feeds a digitally recorded image from the telescope directly into your computer, where the image can be enhanced, analysed, measured, and manipulated.

The most important manipulation is the ability to subtract away an extremely light-polluted background, as if by magic, with hardly any loss of data. An 8-inch telescope can now record 15th- or even 16th-magnitude stars in the worst city light pollution or moonlight. This is several times fainter than the same telescope can show stars to the eye under black, mountaintop conditions!

Drawbacks to CCDs include the very small field of view, the difficulty of aiming this field where you want, and problems of focusing. The equipment may be temperamental; the telescope mounting must be as rigid and controllable as for long-exposure astrophotography. And, of course, you're looking at a computer screen, not stars. It has been said that CCD astronomy is about working with equipment and computers, not sky gazing.

The most important advance that CCDs represent is the science that can be done with the recorded images. For much of the 19th century, amateurs were almost on a par with professional astronomers in terms of the useful science they could do. Then amateurs fell very, very far behind -- but now CCD cameras in dedicated hands are making up some of this lost ground. Amateurs are discovering asteroids in great numbers, performing professional-quality variable-star studies, detecting the 19th-magnitude optical afterglows of gamma-ray bursts near the limits of the observable universe, taking spectra of stars and galaxies, imaging the planets more finely than was once thought possible, and much more. No machine, however, will ever replace the simplicity and delight of examining the stars directly, as a part of living nature.

Of the tens of thousands of astronomical pictures I've taken, one in particular stands out. In the late 1970's I mounted a camera firmly in a window and, without moving it, made an exposure of the Sun once a week at the same time of day every week for a year -- on the same piece of film. The resulting image of the analemma was first published in *Sky & Telescope*'s June 1979 issue. Since then it has appeared in more than a hundred publications with captions in something like a dozen languages. The image hangs in museums and art galleries. It even found a spot in Peter Turner's recent revision of his *History of Photography.* I can't say I could have made the picture as a teenager; it required more photographic and astronomical knowledge than I then possessed. But all the camera equipment I needed rested in my father's closet not 10 feet from where I sat pondering my limited potential for astrophotography without a telescope.

YOUR EYE VERSUS THE ASTROPHOTO

"What happened to M42?? There's no more colour!" This is a direct quote from a friend of mine who had joined me during an observing session recently. It was his first look at a deep sky object through a telescope and he was surprised at the grey-green spectacle presented in my eyepiece. He had seen pictures of M42 in books and magazines, and he was perplexed by the lack of brilliant reds and blues. Some of the detail seemed to be drastically different to his eye as well. In fact, his next question was "Is there something wrong with your scope?" This is a very common experience among new backyard astronomers looking through their telescope for the first time, and it can be a rude introduction to the difference between photographic and visual astronomy!

First, the pictures you see in books are *time lapse* photos. In a sense, all pictures are time lapse. When you take a snapshot of your family or your cat or whatever on a bright sunny day, basically all that is happening is the camera's shutter opens for a very fast period of time to allow light to strike and "build up" on the film. This is exactly what is happening with astrophotos, except the shutter is held open to expose the film for anywhere between several seconds and several hours (some Hubble Space Telescope pictures were exposed over the course of days!). This allows the astrophotographer to record detail in an object that would otherwise be imperceptible to the human eye, because the faint light gathers up on the film to form a brighter and brighter image as the exposure progresses. The human eye is designed to continuously interpret light as it hits the retina; it doesn't gather light over time like film. Therefore, we have a more difficult time seeing faint detail and colour when we look into a telescope in "real time". (Our eye's inability to store light is not always a disadvantage, as we'll see later!)

There's a little bit more to the explanation to fully understand the difference between what you see in the scope and in pictures. The retina in your eye is made up of a central region filled with sensors called "cones" and a peripheral ring of sensors called "rods". Cones are excellent for seeing colour and resolving fine detail, but unfortunately they are terrible at seeing in dim light. Rods are exactly the opposite; they sense dim light better than cones, but they essentially ignore colour and cannot resolve fine detail. This set up evolved to work very well in our natural habitat (the brightly sunlit world), but it's less efficient when it comes to the dim light encountered in astronomy! Our natural tendency is to look directly at something to see it best. Looking straight at something means using the cone filled central region of the retina, revealing lots of colour and detail in a bright environment. But look straight at a dim celestial object and those cones lose their effectiveness. That's why many observers use a technique called *averted vision*, which essentially maximizes your eye's potential to glimpse faint detail by using the zone in your eye where rods and cones overlap.

To make a long story short, our eyes can't store light like photographic film does, plus they aren't specifically made to view colour and detail in the dark anyway. This is why your view through the telescope will almost never match a photo. But as I mentioned above, this isn't always a disadvantage! In order to record faint details on photographic film, brighter areas end up overexposed. Look at a picture of M42 and you'll notice that you can't see one of its most interesting features, the Trapezium! The same thing happens with comets. There was a wealth of detail to be seen in Comet Hale-Bopp's head through a telescope, while most photographs will show the head as an overexposed patch. Also, many double stars are difficult to photograph, but easily seen visually.

So, if you are shocked by the lack of splashy colour in the eyepiece the first time you look at an object, remember that there is nothing wrong with your eyes or your telescope! It's just the most obvious difference between visual and photographic astronomy!

FIXING COMMON TELESCOPE PROBLEMS

- Reprinted from the internet site with permission Fraser Farell

Cleaning telescope optics

This section describes simple maintenance you can do successfully at home if you are careful. If the telescope (or binoculars) are extremely dirty, stained, peeling, mouldy or corroded; you should send them to a specialist for refurbishment (eg: the Binocular and Telescope Service Centre or the Binocular and Telescope Shop).

"The optics" are the various mirrors, lenses, prisms or eyepieces which are used to form the image. These are all precision components which need to be looked after with care. Protecting the optics from airborne debris will make a big difference to their longevity. Use covers on the ends of the telescope tube, and return eyepieces to their storage containers when not in use.
However, you should never cover the optics if they have dew, ice or condensation on them. Moisture plus confined air encourages fungal growth. Place the telescope indoors (or use a hair dryer on LOW heat) until it is dry - and don't touch the wet optics. Telescope optics will collect dirt and pollutants every time they are exposed to air, and will eventually look grotty. But when should you clean them?

First of all, be lazy. Think of something else to do instead of cleaning your telescope. Many professional telescopes are only cleaned once or twice a year, because it does take quite a lot of accumulated debris to noticeably affect performance. So don't panic over a few bits of lint on your primary mirror. If you are seeing smeared-looking or blurry images; first check your eyepieces for fingerprints, sweat, dew, mascara or other deposits. Your eyepieces are the components most likely to get grotty in normal use.
Here's what your cleaning kit should contain:

1. A few litres of distilled or deionised water, plus a small spray container.

2. Isopropyl alcohol (available from pharmacies and chemical suppliers) or medical grade methylated spirits. Ordinary methylated spirits from your supermarket will leave a residue when it dries.

3. Plenty of sterile cotton wool (available from pharmacies).

4. Lanolin-free dishwashing detergent. Anything advertised as "kind to hands" or "softens your skin while you wash" is likely to contain lanolin. Lanolin does horrible things to optical surfaces.

5. A blower brush or lens brush (available from camera shops) for dust removal.

6. A very clean kitchen sink with draining board.

You may also need some clean screwdrivers, spanners, etc for minor dismantling.

Dantronix are now selling a product called "OptiClean Polymer" which claims to remove dirt and grot down to the molecular level -- without harming the optics. I haven't tried it so I won't comment on its effectiveness.

NEVER, EVER, USE HOUSEHOLD WINDOW OR MIRROR CLEANERS ON TELESCOPE OPTICS. These products often contain ammonia and/or sodium hydroxide which are deadly to astronomical mirrors and most lens coatings. Similarly, towels and paper tissues should be kept away from optics, because most of them will cause scratches.

You should only need to clean an eyepiece's outer lens surface - the glass nearest to your eye. This is the surface most likely to be dirty or stained in normal use. Never dismantle eyepieces unless you know exactly what you are doing. The internal surfaces should never need cleaning, unless moisture or liquid has got past the outer lens. If this has happened, get the eyepiece cleaned by a specialist.

To clean the outer lens surface of an eyepiece:

- Blow off any loose dust using the blower brush.
- Mix equal volumes of isopropyl alcohol and distilled water to make up about 1/2 cup of "stain remover." If using methylated spirits, mix 1 volume of spirits with 2 volumes of distilled water.
- Soak a fresh ball of cotton wool in this mixture, and dab (don't wipe) the lens surface with the cotton wool ball. If the ball becomes stained, discard it and get a fresh ball.
- When the lens surface looks clean, spray the surface with distilled water to remove the alcohol.
- Place the eyepiece on its side to dry naturally.

Refractors and Schmidt-Cassegrains both get dirty at the top end (for cleaning purposes, Maksutov = Schmidt-Cassegrain). The refractor's objective lens (the big one at the top of the tube) and the Schmidt-Cassegrain's corrector plate (the window-like covering at the top end) can be cleaned as follows:

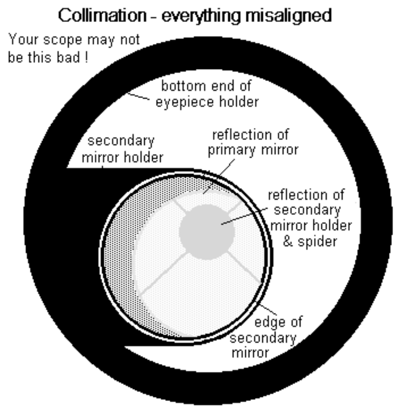
- If possible, lay the telescope on the draining board so that the corrector plate (or objective lens) is vertical, and facing the sink. Alternatively, turn the telescope on its mounting so that it is aimed slightly downwards.
- Cover any electronic components so that they cannot get wet.
- Blow off any loose dust using the blower brush. For refractors, also blow out any loose dust inside the dewcap (the short "tube extension" in front of the objective).
- Spray the corrector plate (or objective) with distilled water to wash away any remaining dust, and allow it to dry.
- If there are fingerprints or other stains, mix up about 1 cup of "stain remover". To see any stains on a refractor objective, shine a torch into the tube from the eyepiece end.
- Soak a fresh ball of cotton wool in this mixture, and dab (don't wipe) the stain with the cotton wool ball. If the ball becomes dirty or stained, discard it and get a fresh ball.
- When the corrector plate (or objective) looks clean, spray the surface with distilled water to remove the alcohol.
- Leave the corrector plate (or objective) in the vertical position to dry.
- For Schmidt-Cassegrains; if any liquid has got inside the corrector plate, leave the telescope's front cover off, and allow to dry naturally. NEVER remove the corrector plate - or the primary mirror - unless you know exactly what you are doing. The optical components of commercial Schmidt-Cassegrains are assembled - and tested - in a specific relationship to each other, at the factory.
  Similarly, if liquid has got inside a refractor's objective lens, allow it to dry out naturally.
- If internal stains on a corrector plate or objective lens are evident, then the telescope optics should be cleaned by a specialist, or returned to the manufacturer.

To clean the mirrors of a reflector:

- You will need to remove the primary mirror (the big one at the bottom of the tube) from the telescope. Most reflectors use a mirror cell, attached to the end of the tube, to support the primary mirror. All good mirror cells have large and obvious screws (or bolts) on the back side, to adjust the tilt of the primary (see alignment below). You do NOT need to undo these -- look instead for screws or bolts at the sides or edges of the mirror cell. In general:
    - Reflectors less than 150mm aperture use three screws (or bolts) through the sides of the tube into the mirror cell.
    - Reflectors over 250mm aperture with cylindrical tubes use six or more bolts through the sides of the tube into the mirror cell.
    - The mirror cell in many square-tubed reflectors (eg: some Dobsonians) is built into the panel which closes the bottom end of the tube. Remove this panel.
- If possible, the telescope should be aimed upwards when removing the mirror cell. As you remove the cell, the telescope tube will suddenly become top-heavy; so take precautions against it moving.
- It is advisable to remove the primary mirror from its cell before washing, because this will keep liquids out of the cell assembly. However, you can begin cleaning before mirror removal. Place the cell (with mirror) on a clean surface (such as the kitchen sink draining board), with the mirror facing upwards. Then use the blower brush to blow off any loose dust.
- You will see some restraining device(s) around the edge of the mirror's upper surface. Typically, these are small padded metal plates which are held in place by screws attaching to the mirror cell. Some mirror cells may use a padded ring, or spring-steel "fingers". Carefully remove the restraining device(s) from the mirror. A magnetic screwdriver is helpful!
- Some large Dobsonian mirrors are restrained by a sling or girdle which is hung between two strong supports on the side of the mirror cell. The sling supports the weight of the mirror when the scope is aimed low in the sky. Be sure to replace the mirror and cell "right way up" when you're finished.
- You should now be able to lift the primary mirror out of the mirror cell. Small mirrors may be resting directly on the padded metal surface of the cell. Larger mirrors are supported underneath by an arrangement of balanced metal plates -- be careful not to disturb these, because their positioning is important to your mirror's optical performance. Good mirror cells will feature alignment studs and holes which "automatically" reposition these plates when the mirror is replaced.
- Place the mirror (facing upwards) in the kitchen sink, then fill the sink with warm (NOT hot) water until the water is about 10mm deep over the mirror. Running the water across the mirror's surface will help loosen the dust.
- Add 2 or 3 drops of lanolin-free dishwashing liquid.
- Gently swirl a wet ball of fresh cotton wool over the mirror. If the ball becomes stained, discard it and get a fresh ball. Repeat this process until the mirror is clean. If the mirror is really filthy you may need to refill the sink and continue this step. Then empty the sink.
- If there are fingerprints or other stains, mix up about 1 cup of "stain remover". Soak a fresh ball of cotton wool in this mixture, and dab (don't wipe) the stain with the cotton wool ball. If the ball becomes stained, discard it and get a fresh ball.
- Mirrors used near the sea, or sources of industrial pollution, will tarnish within a few years. Tarnish -- typically a brown or dirty yellow patina on the mirror -- CAN'T be removed by this cleaning procedure. If tarnishing is severe then your mirror needs to be re-aluminised. This is a task for a specialist.
- Rinse the mirror with warm tap water, then spray with distilled water.
- Stand the mirror on edge and allow it to dry naturally. Place some folded towels or other padding around it, in case it falls over!
- Replace the mirror in its cell, replace the restraining device(s), then refit the mirror cell to the telescope.
- The secondary mirror (the small one at the top of the tube) is usually glued onto a cylindrical holder of some kind, which is typically attached to the spider with a central bolt. The spider is another cylinder held in the tube's centre with a 3 or 4-vaned support structure. The other 3 (or 4) smaller bolts around the edge of the spider are used to adjust the tilt of the secondary mirror.
- To remove the secondary mirror, undo the central bolt until the mirror holder is free. Do NOT try to remove the mirror from its holder, and don't accidentally drop it down the tube!
- The secondary mirror can be cleaned using the procedure for eyepieces (see above). Be aware that liquid may get between the mirror and its holder, so be sure everything IS dry before replacing the mirror holder on the spider.
- Your optics should now be clean, but you will now need to realign them. Read the next section!

Optical alignment

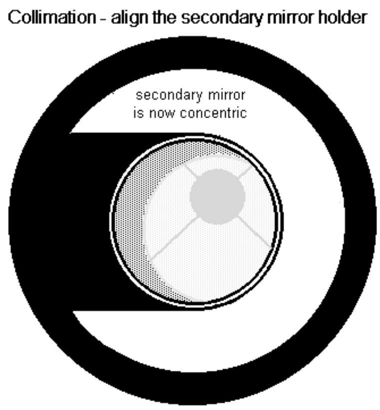
If you have an ordinary reflector, you can adjust or *collimate* the optics yourself using simple tools. First of all, remove the eyepiece and look down the eyepiece holder into the telescope. You should be able to see the secondary mirror, a reflection of the primary mirror in the secondary mirror, and a (reflected) reflection of the secondary mirror holder and spider in the primary mirror.



If your telescope is properly aligned, all of these components should be concentric with the central axis of the eyepiece holder; but you probably aren't that lucky and instead you may see something resembling this first diagram, or one of the diagrams below. If things are really bad all you may see is a view of the inside of the tube in the secondary mirror. But don't panic; even this can be cured ;-) Note that if you see something resembling one of the later diagrams, then skip to that part of the procedure! For ease of identification I have colour-coded the components in these diagrams.

Throughout the collimation process, it is important to do your checks while looking down the central axis of the eyepiece holder. Various "collimating aids" are commercially available, but if you have the standard 32mm (1.25 inch) eyepiece holder then an empty 35mm film canister can be used instead. Drill a 3mm hole through the exact centre of the canister's lid, and cut a 20 to 25mm hole through the centre of the canister's base. Don't just cut off the canister base -- many canisters lose rigidity if this is done.
Then insert the canister (base first) into the eyepiece holder, wind the focuser all the way out, and look through the 3mm hole in the lid. The telescope should be pointed towards the daytime sky (not the Sun!) or similar bright, diffuse light source. You should be able to see the bottom edge of the eyepiece holder and the secondary mirror hardware.

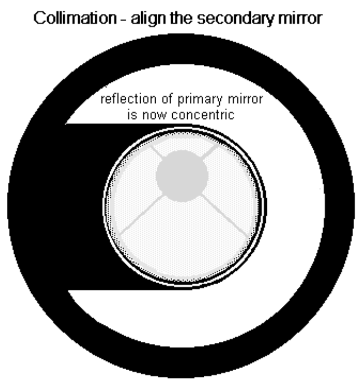
The first step in collimation is to get the secondary mirror holder into the right position. For reflectors, this is such that the secondary mirror is concentric with the bottom edge of the eyepiece holder. Don't worry about the mirror's tilt (if any) just yet; we fix this in a moment.



Secondary mirror holders are held in place by the spider -- typically this consists of 3 or 4 thin arms (or metal strips) radiating from the mirror holder to the telescope tube. These arms often pass through slots in the tube and are held in place by nuts.

Loosen the nuts to allow the spider assembly (with secondary mirror) to be slid along the tube slots so that the secondary mirror reaches the right position. Occasionally there may be no slots, in which case you will have to do this adjustment simultaneously with the secondary mirror alignment described next.
Some small reflectors use a single arm to support the secondary mirror holder. This design works well, provided the support arm is able to be adjusted within the tube, and is strongly built. My 150mm reflector's support arm is a 20mm by 5mm thick aluminium strip, bent into an L shape and held to the tube by bolts passing through slots in the plate.

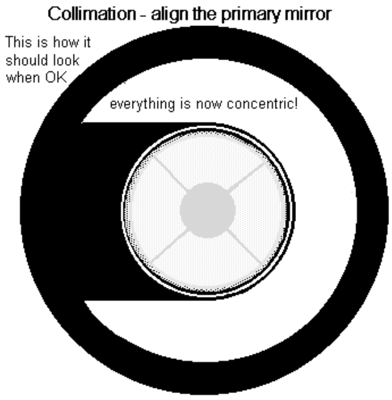
Now take a look at the secondary mirror holder. A few simply consist of a metal (or plastic) block solidly fused to the spider assembly. These have to be adjusted by moving the entire spider assembly (a real nuisance). Some compound the problem by using a single plastic arm, instead of a spider, for support. Plastic tends to deform in warm climates.



Better holders are held onto a spider by a relatively large central bolt, surrounded by 3 smaller screws (or bolts). These work antagonistically on the holder's base. The big bolt "pulls", the screws all "push", and together they hold the secondary mirror holder firmly in place. The tilt of the secondary mirror is adjusted using these screws. If you have a non-adjustable spider, then the position of the secondary mirror is also controlled by these screws and the bolt. To save a lot of time, I suggest that you loosen the central bolt a couple of turns (but don't let it fall out) and hold the secondary mirror holder against the adjusting screws by hand -- but don't touch the surface of the mirror! Grip the holder's sides instead. Rotate the holder if necessary to achieve correct secondary mirror positioning. Use your other hand (with the screwdriver) to turn the screws as needed; then retighten the central bolt. The secondary mirror is correctly positioned when the reflection of the primary mirror is concentric with the edge of the secondary mirror AND concentric with the eyepiece holder. The final step in collimation is to get the reflected image of the secondary holder concentric with the image of the primary mirror. To do this you adjust the tilt of the primary mirror using some large and obvious bolts (or screws) on the bottom of the telescope tube. Don't confuse these with the fasteners holding the mirror cell in the tube!

Many commercial reflectors use three antagonistic pairs of bolts spaced 120 degrees apart. In each pair, one bolt "pushes" against the mirror cell, and the other bolt "pulls" upon the mirror cell. These can get very exasperating because the bolts must be adjusted a little bit at a time, while you check and re-check the view through the telescope. An assistant may be helpful.

Some reflectors replace the "push" bolts with strong springs (between the mirror cell and the back of the tube); through which the "pull" bolts pass. The springs are partly compressed by the tension on the bolt, thereby forming a rigid support which is also easy to adjust. If you are building your own telescope then I recommend this design. The valve springs from old engines are ideal, and readily available from car wreckers.



When your telescope is properly collimated, the view should resemble this final diagram. However, short-focus (f/5 or smaller) reflectors should have the image of the primary mirror displaced slightly down the tube ie: deliberately off-centre towards the primary.

You will get good views of stars at this stage, but for perfect images you will need to test star images on a perfect night. Or you can use a laser collimator installed in the eyepiece holder. Only slight adjustments of the primary mirror's tilt should be necessary.

For safety reasons, a laser collimator should not be used until the telescope is close to perfect adjustment. Shining a laser down a misaligned telescope can be hazardous to you and any bystanders.

If you have a Schmidt-Cassegrain you can collimate them by adjusting the tilt of the secondary mirror and (sometimes) the primary mirror. There will be three collimation screws on the secondary mirror holder (the "disc" in the middle of the corrector plate), possibly hidden under a plastic cover. There may also be a fourth screw or bolt in the centre of the secondary mirror holder -- DON'T TOUCH this one on a Schmidt-Cassegrain!

Aim the scope at the daytime sky or other bright, diffuse light source; and replace the eyepiece diagonal (if any) with your 35mm film canister or collimating tool. The view will be similar to the reflector diagrams above, except that you won't see the secondary mirror holder.

You don't need to worry about centering the secondary mirror or its holder, so skip to the secondary mirror tilting adjustments. This is a very sensitive adjustment on a Schmidt-Cassegrain so proceed carefully -- you should not need to do more than 2 turns on any screw. If a screw appears to "stick" it has reached the end of its thread; try adjusting the other two screws instead.

DON'T TOUCH the centre screw/bolt (if there is one) or the secondary mirror may fall off inside the tube. You also have to avoid touching the corrector plate accidentally! Adjust the collimation screws until the reflection of the primary mirror is concentric with the edge of the secondary mirror AND concentric with the eyepiece holder.

Do not adjust the primary mirror without the manufacturer's explicit instructions, unless you know exactly what to do. Designs vary, even among telescopes from the same manufacturer; so what you think are the primary mirror's collimation screws may in fact be the screws that hold the mirror cell in place! Commercial Schmidt-Cassegrains are focused by moving the primary mirror; so there's a lot of hardware in there.

If you have a refractor or a Maksutov; do NOT attempt to do any optical alignment (or disassembly) at home, unless you are an optical expert and have the appropriate equipment. These telescopes are pre-aligned by the manufacturer and the relative orientations of the optical components are NOT random. In fact, better-quality specimens will have individually matched and tested components.

Before you send away one of these telescopes for expert attention, check that its "misalignment" is not in fact a faulty eyepiece or diagonal.

COMMON OPTICAL PROBLEMS

This section could easily expand into a collection of weird and wonderful stories so I'm going to restrain myself to a checklist for now :-)

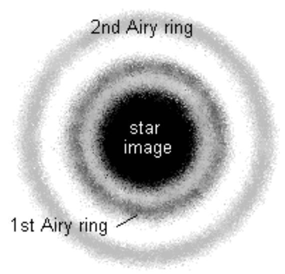
- **I can't see anything!**

  - Is it a clear night? Telescopes can't see through clouds you dimwit... ;-)
  - Have you removed the telescope's protective covers? I saw someone take nearly 100 photos of the October 1976 total solar eclipse through his telescope before he noticed that its front cover was still on. Totality ended about five seconds later....
  - Is the telescope properly collimated? A 120mm reflector was GIVEN to me as a "useless broken piece of junk" by someone who had tried unsuccessfully to use it for five years. The only fault was a badly misaligned secondary mirror -- which I fixed in 2 minutes. My children now use this telescope.
  - Is the telescope aimed at something visible? Some parts of the sky are devoid of bright objects. Try looking at the Moon (if it's up).
  - And finally, are YOU dark-adapted? Don't expect to see much if you have just come outside from a brightly-lit room, or if you are badly afflicted by light pollution. For more information on light pollution and what you can do to stop it, visit the International Dark-Sky Association (IDA) home page.
  - Outdoor lighting in Australia is controlled by three Standards. AS1158 is for public lighting, AS2560 is for outdoor sports lighting, and AS4282 is for all other outdoor lighting.

- **I can't find anything or it keeps moving out of view**. First of all, telescopes -- even at low magnification -- view only a SMALL piece of the sky. At high magnification you view a TINY piece of the sky. Try looking along the telescope tube at your target to get aimed approximately. If you have no experience aiming a telescope, practice with the Moon first, using your LOWEST magnification! When you can find the Moon easily -- and you are accustomed to your telescope's movements -- you can then try the harder task of finding specific stars and planets.

  Secondly, all experienced observers find targets using a low magnification; then they centre the target in their view, THEN they change to a higher magnification. All "computer controlled" telescopes expect you to find some "known" stars as part of their initialisation procedure - read the instructions. And don't expect a finder scope to be properly aligned (or to stay aligned).

  Unless your telescope has a tracking motor that can counteract the Earth's rotation, anything in the view will soon move out of the view, and new objects will come into view instead. At high magnifications this can happen in a few seconds, but it takes longer at lower magnifications. You can use this movement to find astronomical east and west in your field of view -- objects come in from the east and "move" to the west if the telescope is kept motionless.



  However you should check that the telescope itself doesn't consistently move up (or down) whenever you aim at something and let go of the telescope. This is a symptom of poor tube balance or a mechanically inferior mounting. *Department Store Telescopes* are often afflicted with both of these problems.

- **Everything's blurry or everything's just a big blob.**
  - Are you focused? Stars should focus down to POINTS of light, not discs!
  - Are the optics clean? Check the eyepieces first.
  - You may have a defective eyepiece. Try a known good eyepiece.
- **Bright objects have rings or spikes or coloured haloes**.
  - A faint blue (or violet) halo is normal for refractors and simply indicates that blue light is not being focused to exactly the same point as the other colours. You can see this phenomenon best by looking at Venus or the bright edge of the Moon. You should NEVER see this phenomenon in a reflector or Schmidt-Cassegrain and it will be very difficult to detect in the best refractors.
  - **Tiny faint rings around bright stars are normal** -- these are known as *Airy Rings* and are an example of *diffraction*. Diffraction is a fundamental optical phenomenon caused by the wave-like nature of light, and you cannot stop it happening. This image shows a highly magnified view through a refractor.

Other telescope types show similar (but usually brighter) Airy Rings, which in reflectors may be accompanied by diffraction spikes radiating from the star. The spikes are caused by the spider arms. Each arm generates TWO diffraction spikes 180 degrees apart, so 3 arms will generate six spikes and 4 arms will generate eight spikes. However with 4 arms exactly 90 degrees apart, four of the spikes will overlap the other four spikes and be "hidden" from view. Some reflectors may use curved spider arms to eliminate the spikes, by spreading the diffracted light around the image. Diffraction also causes the rings (and spikes) around bright stars on astronomical photos.

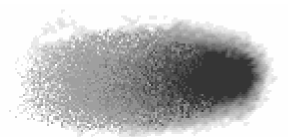
- **Multicoloured haloes** (or any halo) may be caused by a poor-quality eyepiece or objective lens, dirty or greasy optics, or high cloud. Contact lens wearers may see pearly-looking haloes around bright objects if their contact lenses are not clean.

- **Bright objects have "ghosts"**
  - Your eyepiece may not have anti-reflection coatings on its internal surfaces. Get a better eyepiece.
  - Some junk telescopes suffer from internal reflections inside their tubes, because the manufacturer didn't bother to paint the inside of the tube black.
- **Everything's upside down and/or back-to-front!**
  - Upside down (ie: field rotation) is NORMAL for an astronomical telescope. If this bothers you (or you bought the scope for birdwatching) then you can get erecting prisms for many telescopes. Or buy the equivalent "terrestrial" or "spotting" scope model. However by doing this you will lose some light (to absorption) within the additional optical components.

    If your view is upside-down -- or sideways -- when compared to a standard starchart; don't worry, just rotate the chart to match what you're seeing. The real difficulty is with back-to-front views....

  - **Back-to-front** (a.k.a. reversed or "mirror image") is also normal for telescopes with an ODD number of reflections; such as Schmidt-Cassegrains (primary mirror + secondary mirror + eyepiece diagonal) and most refractors (eyepiece diagonal). This can be very confusing for beginners when they try to match the eyepiece view to a (non-back-to-front) standard star chart. Many computer star atlases can print charts any way you want
  -
- **Stars near the edge of the field have tiny "tails" or stars change shape when I focus.**

  The tiny tails are caused by *coma*, which becomes increasingly obvious at shorter focal ratios (f/4 or below).

  A severe case of coma (greatly magnified)

  Coma correcting accessories are available (but they are expensive).
  The shape change vs focus is most likely caused by *astigmatism* -- one or more optical components are not perfectly symmetrical. You will see the image's direction of elongation change as you move from one side of "focus" to the other. The offending component can be identified by rotating it about its centre, whereupon the astigmatic image will rotate too. In practice, the eyepiece is the most easily tested component -- just spin it while it's in the eyepiece holder.

  A mild astigmatism may be caused by excessive pressure on the optical components. If it's a reflector, check that mirror retaining devices are not pressing hard upon the mirrors, and that the primary mirror cell is evenly supporting the mirror's weight. If astigmatism is severe then the offending component(s) should be replaced. If a new telescope is astigmatic, you should return it and demand a refund.
  The whole field doesn't come into focus at the same instant or there seems to be a "ring" of best focus.

  Your telescope mirror has *spherical aberration* -- the same problem that crippled the Hubble Space Telescope. The only real cure is replacement of the optics. If this is a mirror you have made, you will have to return to your "optical figuring" stage. If a new telescope has spherical aberration, you should return it and demand a refund.

Harold Suiter's book Star Testing Astronomical Telescopes is an excellent reference for diagnosing and fixing all sorts of optical problems. So you still want to read about some weird telescope problems? Let's see...a large spider constructed its egg sac upon the secondary mirror of one of my telescopes.

One of my friends found her cat asleep inside her telescope tube one night. And I know of one amateur observatory that was wrecked by a mouse plague. The mice chewed through just about every non-metallic object (including the insulation on electrical wiring), and mouse urine proved to be devastatingly corrosive to optical and electronic components. Yuck!

Improving a Department Store Telescope

If you have bought one of these things -- or got it as a gift from some well-meaning relative -- then you will probably have to modify it to avoid disappointment. Ignore the manufacturer's claims of the scope's maximum magnification!

The typical manufacturer ruins these scopes by supplying cheap dodgey eyepieces, and putting it on a flimsy wobbly mounting. However, a surprisingly large number of *Department Store Telescopes* do contain some reasonably good primary/secondary mirrors, or a decent achromatic objective lens. Some "telescopes" are best used to support tomato bushes; but many others can be resurrected by doing a few things that the cost-cutting manufacturer didn't.

The first upgrade is some decent eyepieces. If your scope can accept 32mm (1.25 inch) diameter eyepieces, then you have a huge selection of aftermarket eyepieces to choose from. If you're stuck with 25mm (0.96 inch) diameter eyepieces, then your choice is more limited -- but you can certainly get better eyepieces than the ones supplied with the telescope!

Even the traditional Orthoscopic or Plossl-type eyepieces will noticeably improve the typical *Department Store Telescope*. These eyepieces are available in both 25mm and 32mm diameters from most dealers and will probably cost you $Aust70-130 each. You can try more exotic (and expensive) eyepiece designs but you're unlikely to get a correspondingly better image.

The second upgrade is a steady mounting. One quick fix is to suspend a few kilograms underneath the telescope, between the legs of the tripod. This lowers the scope's center of gravity (improving stability) and holds the legs more firmly onto the ground (reducing vibration). A couple of bricks is sufficient. Don't overdo this remedy. I saw one owner try this with a concrete paving slab, which promptly collapsed the mounting and bent the tripod legs!

Even a stable tripod is unhelpful if the parts connecting it to the telescope tube are badly designed (or built). For example, some tubes are held by a single bolt passing through a flange on the underside of the tube. This is inherently wobbly, because the tube is supported at a single point which isn't at its centre of gravity. It's also exasperating to aim at anything. Other sources of wobbles are the thin-walled tubing used for construction, and the lack of control over mechanical backlash.

Another solution is to build an entirely new mounting. Reflectors can be converted to a Dobsonian mounting. A modified mini-Dobsonian can be used to support a refractor. If you're good with tools you can try building a German equatorial mounting for your telescope, using stronger and larger components than the original. For example, galvanized water pipe fittings have been used for decades in home-made telescope mountings.

Some general rules for mounting design include:

- The telescope tube must be balanced between its points of support.
- All rotating sub-assemblies must be balanced around their axes of motion.
- All moving, swinging, rotating components should be able to be clamped into position easily. Alternatively, sufficient friction should be built into the mounting to prevent the telescope moving suddenly in a breeze.
- The telescope should be difficult to knock over.
- You should be able to look through the eyepiece no matter where the telescope is pointed.

BUILDING AN ALTAZIMUTH OR DOBSONIAN MOUNTING: You can download for a reflector and a refractor mounting. These diagrams include plenty of notes. I deliberately haven't included dimensions, because they are dependent upon your telescope tube size and the materials you have for construction. Use these schematics to help you prepare some actual plans for your telescope. **Mel Bartels** has an excellent web description of How To Motorise A Dobsonian; as well as links to amateur telescope-making sites.

OK…WHAT DO I LOOK AT ?

MOST CELESTIAL OBJECTS THAT ARE OF INTEREST TO AMATEUR ASTRONOMERS FALL INTO THE FOLLOWING CATEGORIES:

Double Stars

These are the easiest objects to find, and may be only visually close together or may actually be part of an gravitationally interacting binary system. Albireo pictured at the left is most spectacular related to the contrasting colours. Use low power eyepieces to locate double stars, but higher powers will resolve their colours and separation (splitting a double star).

Open Clusters

Located within our galaxy, open clusters are brilliant communities of stars clustered in tight formations. These stars are usually of the same age and are born of the same stellar nurseries. Use low power eyepieces to locate and admire these spectacular formations.

Globular Clusters

Globular clusters are a densely packed collection of stars that are the oldest known objects in our galaxy's halo. There may be millions of stars packed together so close that night and day would not exist if our solar system were located inside. Medium and high power eyepieces are of greatest value.

Nebula

Also located within our galaxy, these giant pockets of gas and dust form the birth place of stars. They may reflect light from nearby stars (reflection nebula) or may emit their own light (emission nebula). Medium power eyepieces in larger aperture scopes yield best results. Smaller scopes (<6") may benefit from nebula filters ignored to increase the contrast between these nebula and the surrounding blackness of space.

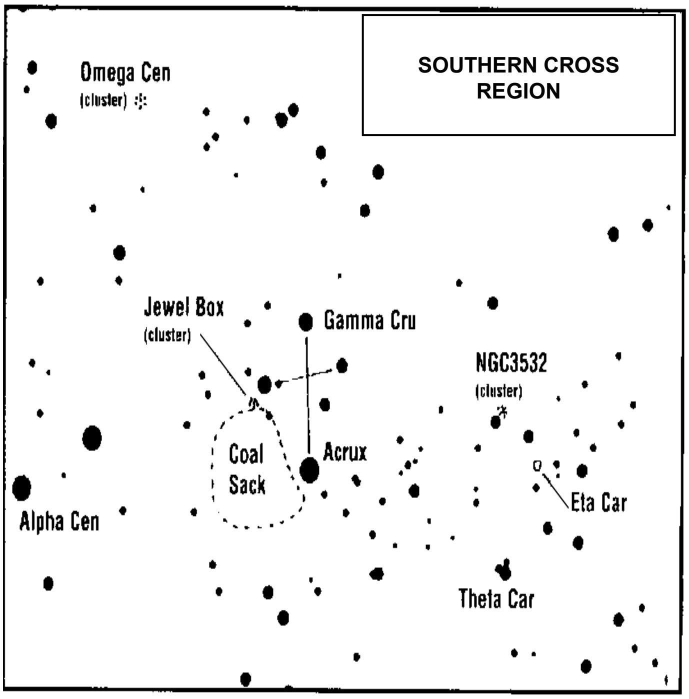
Planetary Nebula

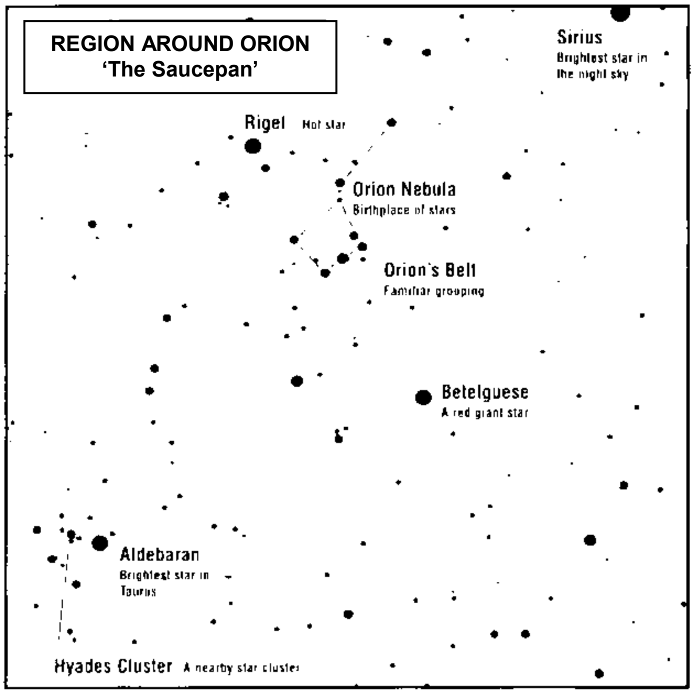
Planetary nebula are the remnants of the final moments of a star's death. When a star is in its final moments it ejects its outermost layer in a massive explosion (supernovae, for example). These nebula are the left over dust and gas that are expanding away from the site of the explosion. Low to high powered eyepieces in medium (6") to large (10") scopes are best. All scopes benefit from an OIII filter.

Spiral Galaxies

This is mankind standing outside looking in as it related to the structure of our own Milky Way galaxy. Many of these galaxies are similar. Very distant, and generally dim related to their top down perspective. Big aperture scopes (8"+) rule when searching for and observing these objects. Low to medium power eyepieces are best, only photography/ CCD imaging will reveal subtle details.

USE THESE MAPS TO FIND THESE EASY LOCATABLE OBJECTS



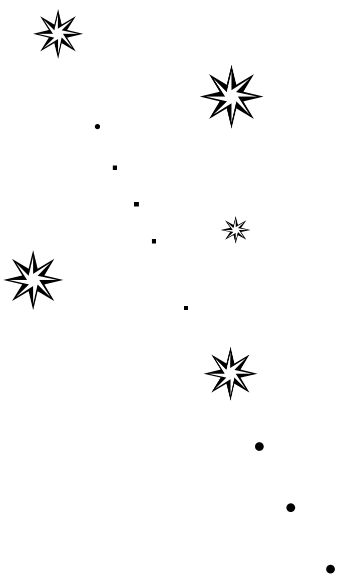


LATER IN THE YEAR Look for the double star Alpha Centauri, the bottom star of the two 'pointers' our closest star (a magnificent double) – Star Cluster NGC3532 – The Eta Carina nebula – The darkish Coal Sack – The 'Jewel Box' star cluster – all Southern sky marvels!

EARLY IN THE YEAR Look for The amazing nebula in the handle of the 'saucepan' – The huge red Giant star Betelguese – Rigel, the brightest star in Orion – The Hyades star cluster – Sirius, our brightest star – the 3 stars in line in Orions belt – all good telescope objects and easy to locate

THE SOUTHERN CROSS

How To Find South



Once you have located the Southern Cross it can be used to find true south. Simply extend the longer axis of the Southern Cross from top to bottom by 4.5 its length and you will reach the south celestial pole. Then, drop a line straight down to the ground to find south, and you'll never get lost again!

Come down 4.5 times length

SOUTH (straight down)