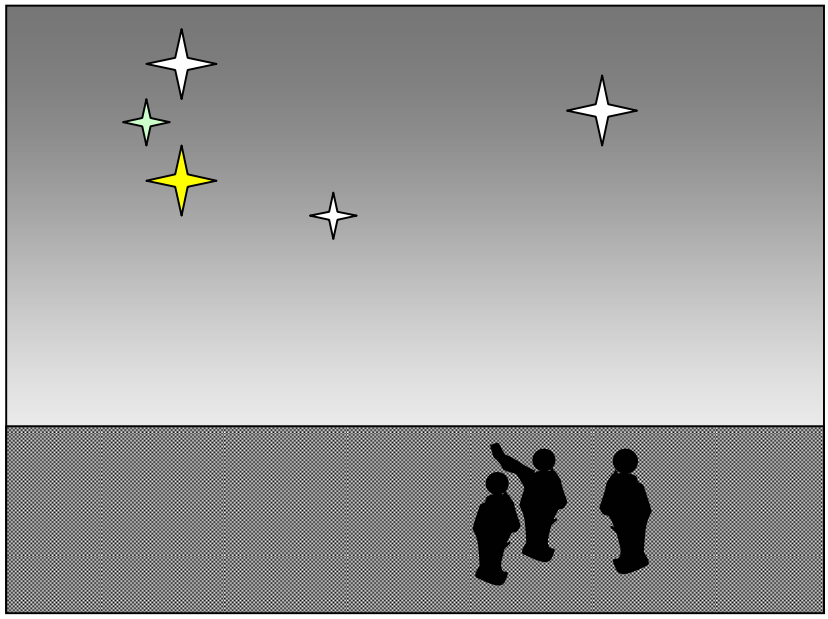
Things are looking up

– observing the sky for everyday folk.



A booklet for beginners.

Written by Bob Kibble,

DARK SKY DISCOVERY

Dark Sky Discovery

This pack was originally written for a project run by the Royal Observatory Edinburgh and the City of Edinburgh Cultural Co-ordinators. Later editions have been produced for the Dark Sky Scotland and Dark Sky Discovery programmes.

This edition has been printed to support the network of Dark Sky Partnerships which have been set up across the UK and Ireland. These partnerships will run activities throughout International Year of Astronomy 2009 and beyond. We are very grateful for funding from the Royal Astronomical Society and the Science and Technology Facilities Council.

For more information, please contact

Dave Chalton
Dark Sky Project Officer
Royal Observatory Edinburgh
0131 668 8343
dsc@roe.ac.uk

www.darkskydiscovery.org.uk

The Dark Sky Discovery partners and funders are:

Contents.

Things are looking up
– observing the sky for everyday folk.

Why should I read this?
A visit to any high street bookshop or a good library will provide you with a host of up to date books on astronomy. Some will have been written for advanced astronomers, some for students on astronomy courses. Others will offer a coffee table overview of space, complete with the latest Hubble telescope photographs in full colour. There are plenty of astronomy books for young people, covering curriculum topics as well as offering 'wow' factor images. This booklet is none of the above.

This booklet is for absolute beginners, many of whom will be parents and/or teachers, beginners who have an interest in knowing a little more about what they can see on a dark night. Such beginners want to increase their confidence in knowing just what it is they are looking at and what they might be able to guide others towards. If you are new to practical astronomy and want to spend a chilly evening looking upwards then this booklet is for you.

What can you expect by the time you have reached half way? I'd guess that by half way you'll be wanting to take others out to the garden to show them some stars and planets, perhaps also you'll be looking twice at the astronomy texts in your local bookshop or dropping hints about binoculars as your birthday approaches. Perhaps you might have invested in some woolly socks and a hat. This booklet should carry a health warning. Astronomy can be addictive.

Sharing with others.
Your friends, family and neighbours will also be interested in the night sky. With a little confidence and experience you will find that you can share your knowledge with others. This booklet could prove helpful to teachers, parents, scout or guiders, community group leaders.

Does this booklet have a structure?
Yes indeed there is a structure. The booklet is presented in eight units. The first five units are devoted to spending time under the night sky. Within these units you will find ideas for twenty practical projects. In general the simplest activities come first. We start with naked eye observing and then move on to projects using instruments. The later units offer a selection of additional practical ideas including daytime observing and some suggestions for sharing your interest with young people.

Note. The star charts drawn here are simply to show approximate locations. Only a few key stars have been shown to give you an idea of where to direct your attention. For accurate star locations you need to refer to a published star chart. However, it is quite possible to use these rough charts to make a start on your journey into space.

Unit 1. Getting Started.

Unfortunately you can't just go out and look up. Well you can, but a little preparation will reap its rewards. You'll need to assemble four key ingredients:

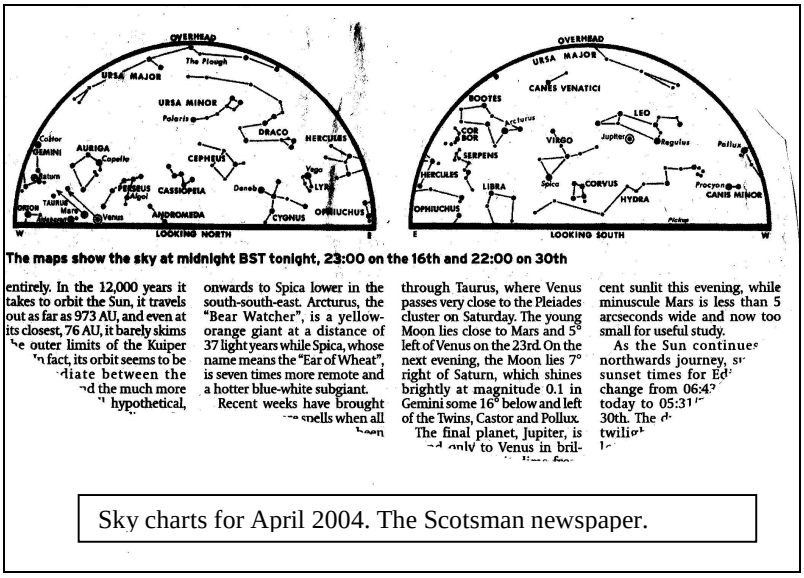
1. **A beginner's star chart**. You can find star charts in astronomy books but a good source is in one of the popular astronomy magazines. I recommend Astronomy Now. This is a monthly British publication and available in good newsagents. It has a section on the night sky and includes a simple star chart. Other sources include the broadsheet newspapers – they usually include a star chart at the end of a month ready for the coming month (you'll need to look out to catch it – it appears only once in the month). You can buy a 'planisphere'. This is usually a plastic disc which shows the night sky throughout the year. By rotating an outer cover you can reveal the sky for the particular month. Avoid the very small planispheres as they become very hard to read at night.

2. **Warm clothing**. An hour spent outdoors at night, especially if the sky is clear, will subject you to lowering temperatures. Gloves, a hat and spare socks are worth investing in.

3. **A dark site.** There is no need to travel miles from home. However, street lights and car headlights do reduce the quality of 'seeing'. Try to move away from a main road and find a location away from bright lights. A garden or a local park might provide you with such a site. Take care. Dark places, away from the safety of your own home, can be dangerous places. Take a friend.

4. **A dark, clear night.** Unfortunately in the UK, our maritime climate offers what might be called interesting or changeable weather. There is no point in observing unless the sky is reasonably clear. Such nights might occur for no more than a quarter of the year. The chances are that it will not be clear. Keep watching for those clouds to clear. You are looking only for an hour's clear sky at this stage. Watch the weather forecast. However, in mid summer the sky doesn't always get dark enough even if it is cloud-free. The 'darkness' of the sky will improve as your eyes 'adapt' to the low light conditions. Adaptation can take about 15 minutes. Be patient, you'll start to see objects which were not apparent when you first looked up.

Extras: If it is dark, how will you read your star chart? A small torch will help. However the light from a small torch will ruin your adapted 'night' vision. Astronomers cover their torch with a piece of red cellophane to reduce the glare.



The maps show the sky at midnight BST tonight, 23:00 on the 16th and 22:00 on 30th

entirely. In the 12,000 years it takes to orbit the Sun, it travels out as far as 973 AU, and even at its closest, 76 AU, it barely skims the outer limits of the Kuiper In fact, its orbit seems to be diate between the d the much more hypothetical,

onwards to Spica lower in the south-south-east. Arcturus, the "Bear Watcher", is a yellow-orange giant at a distance of 37 light years while Spica, whose name means the "Ear of Wheat", is seven times more remote and a hotter blue-white subgiant.

Recent weeks have brought spells when all

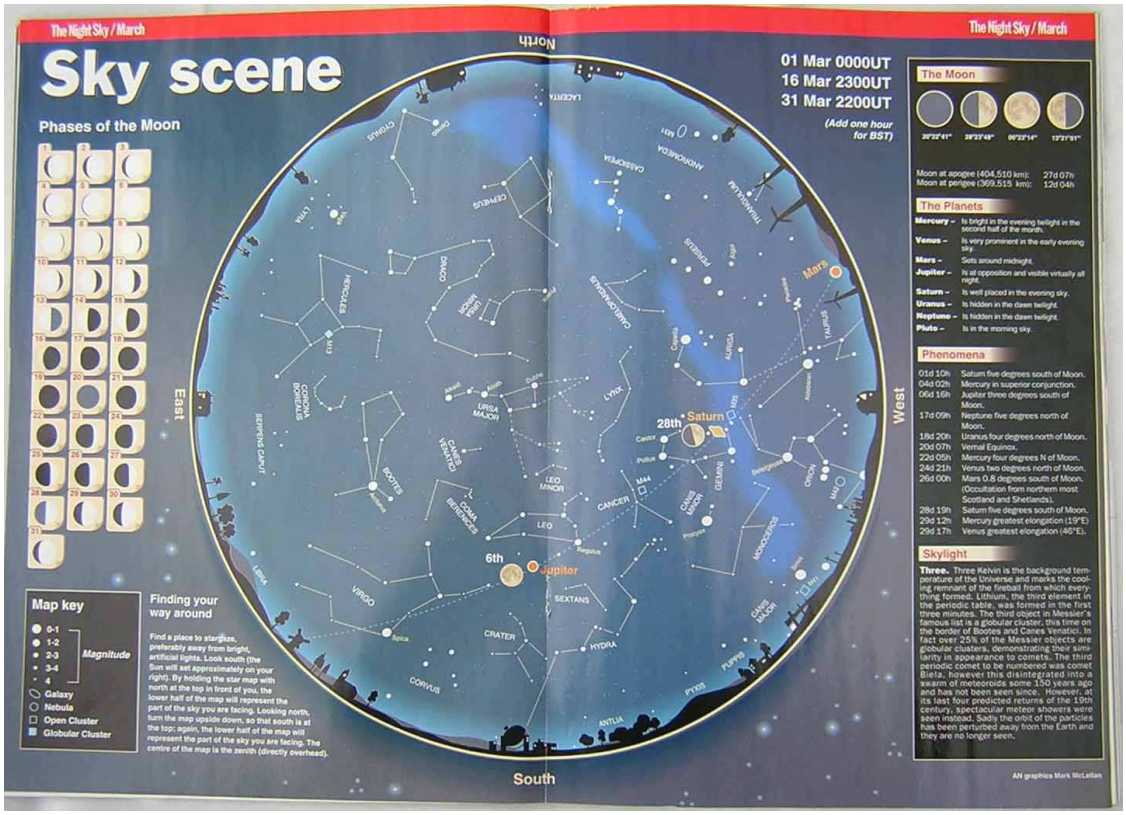
through Taurus, where Venus passes very close to the Pleiades cluster on Saturday. The young Moon lies close to Mars and 5° left of Venus on the 23rd. On the next evening, the Moon lies 7° right of Saturn, which shines brightly at magnitude 0.1 in Gemini some 16° below and left of the Twins, Castor and Pollux.

The final planet, Jupiter, is only to Venus in bril-

cent sunlit this evening, while minuscule Mars is less than 5 arcseconds wide and now too small for useful study.

As the Sun continues northwards journey, s sunset times for Ed change from 06:4 today to 05:31 30th. The d twilig

Sky charts for April 2004. The Scotsman newspaper.



Sky chart from Astronomy Now magazine, March 2004.

With all four elements in place you are ready to venture out to do some real, first time astronomy.

Unit 2. Naked-Eye observing.

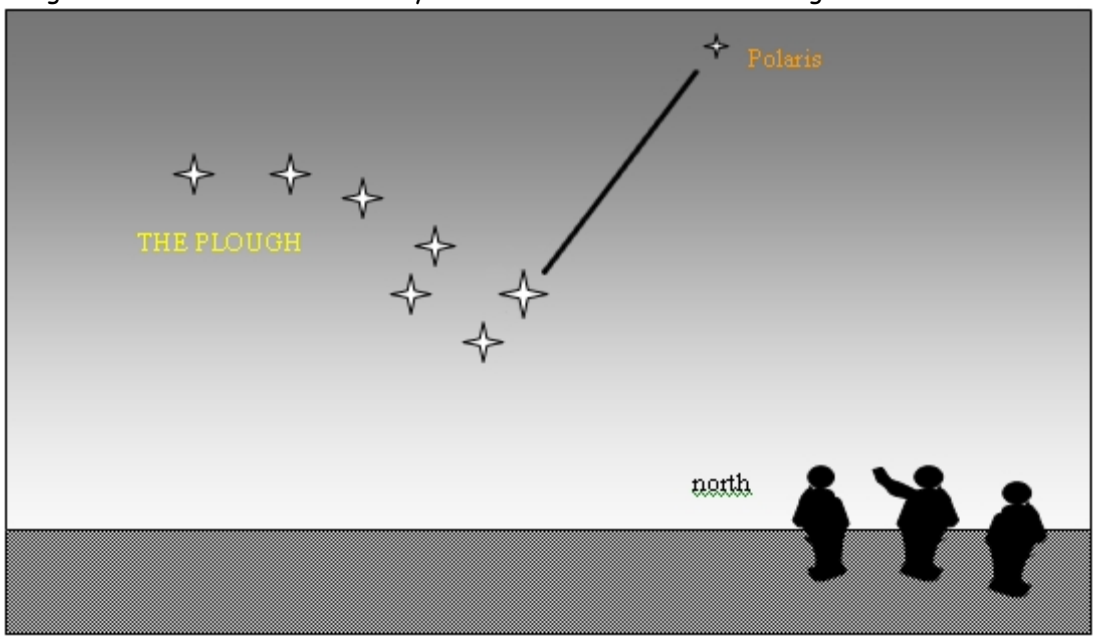
These projects don't require binoculars or a telescope. Just the simple kit outlined above. We call this 'naked eye' observing.

Project 1. **Finding the Plough, Polaris, looking north, the Great Bear.**

(any time of year)

The stars, sun and Moon, in fact everything in the sky appears to move as night follows day. The Sun rises and sets and so do all the stars. (Of course this is an optical illusion. It is really us on Earth doing all the actual moving). However one star seems to remain constant. It is Polaris, the pole star or the north star. Polaris is not particularly bright. However it is the most important star to be able to locate and this is your first challenge.

Assuming you have wrapped up well and prepared yourself, spend some time looking upwards in your location. The target to find is the Plough, part of the constellation Ursa Major (the Great Bear). The seven main stars in the Plough are not particularly bright. However their shape is a distinctive 'saucepan' shape. Depending on the time of year, you may find the Plough to be orientated differently to the sketch shown. It is a large constellation.



Once found, look at the Plough for a while to get a feel for recognising it next time. To find Polaris, use the last two stars in the 'pan'. Use these as pointer stars to guide you to Polaris. (see the sketch). There are no other bright stars near to Polaris, only a few faint ones. If you have trouble you can always use a compass and find north. Polaris will be high in the sky above the northerly horizon. The Canadian singer Joni Mitchell sang: 'I am as constant as the northern star..' This is a reference to the fact that Polaris is the only star in the sky to remain in place through the night.

Additional armchair notes to supplement project 1.

- **How far is Polaris?**

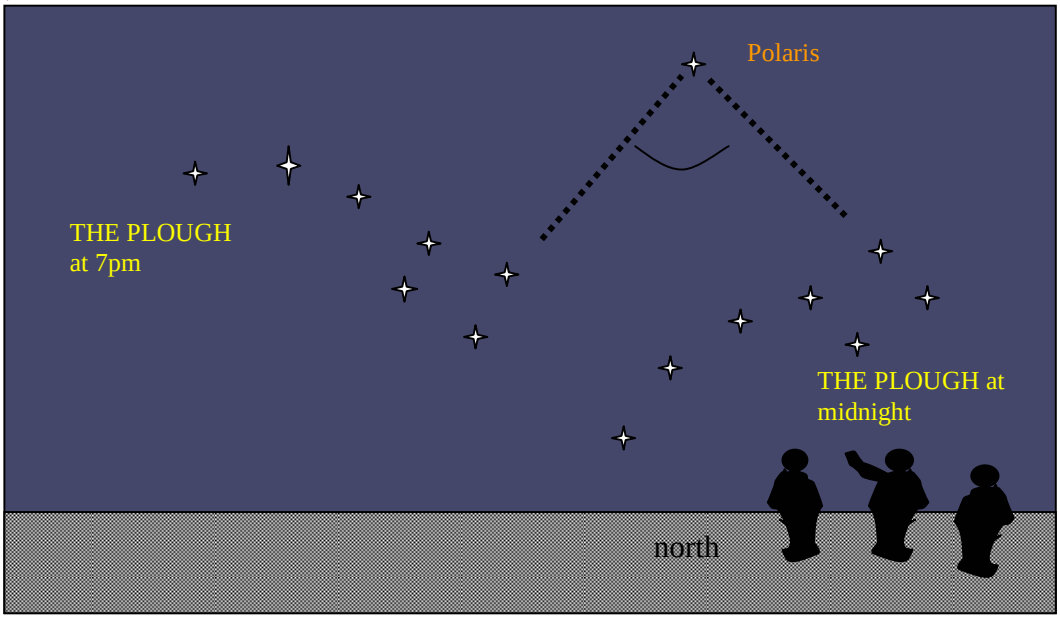
Polaris lies at a distance of 430 light years away. (It takes light 430 years to reach us from Polaris. So when you see it, you are looking at it how it was 430 years ago. Looking back in time to a time when Galileo was alive.) However it is still very much one of the nearby stars in our Milky Way galaxy.

- **Why does Polaris remain in the same place?**

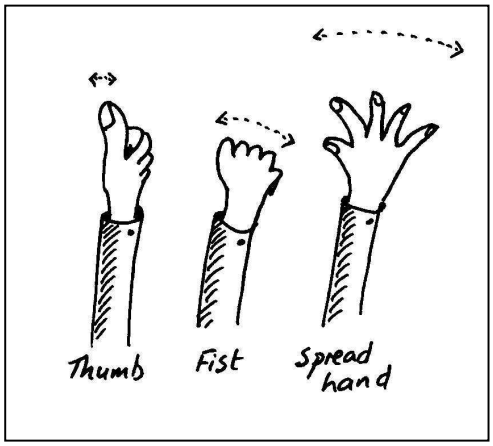
This is a coincidence. Polaris just happens to be in a location directly above the Earth's North Pole. If you imagine the Earth's axis extended into deep space, it would point directly at Polaris. Think about a spinning bicycle wheel. The tyre moves fast but the axle at the centre remains unmoved.

- **Why does the Plough appear in different positions?**

If you watch over a period of an hour or two you'll notice that the Plough appears to move. It moves gradually, slower even than a clock hour hand. As the Earth turns, the stars in the sky appear to move and they appear to move around a single point. Yes, this point is the Pole Star.



Finally, a big challenge for beginners is to be able to transfer a star chart pattern to the real sky. It is often impossible to know just how big a constellation is going to be. As a rough guide we'll use the following helpful rule. Outstretch your hand and hold up first a thumb, then a clenched fist and then an outstretched hand. These three shapes occupy an increasing spread of sky space. We'll use this idea when describing constellations. The Plough is about two full handspans across.

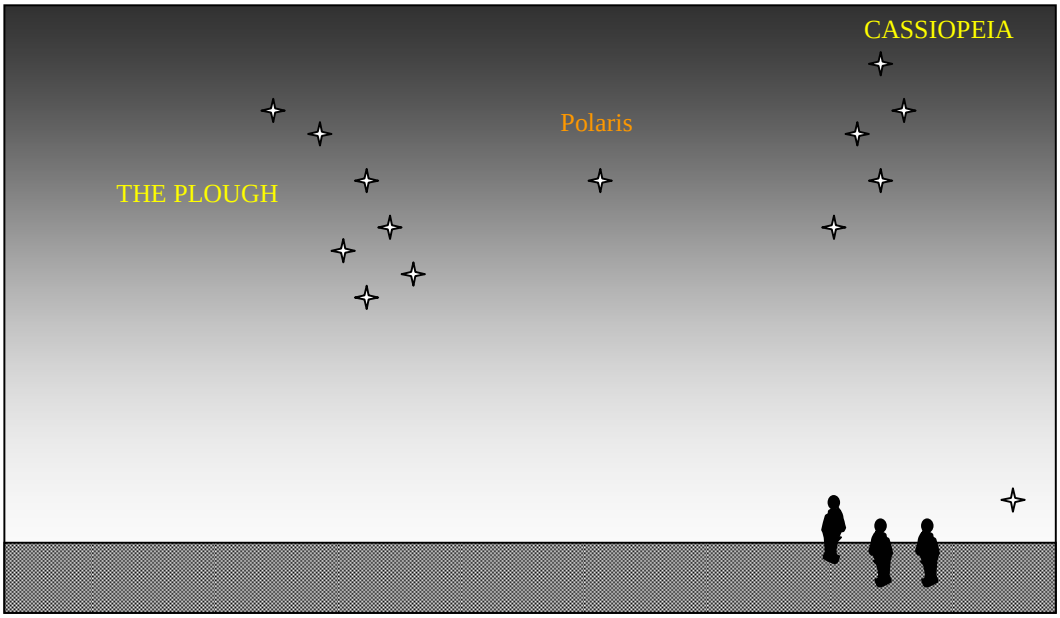


Project 2. Cassiopeia, Draco (the dragon) and Ursa Minor (the Little Bear)

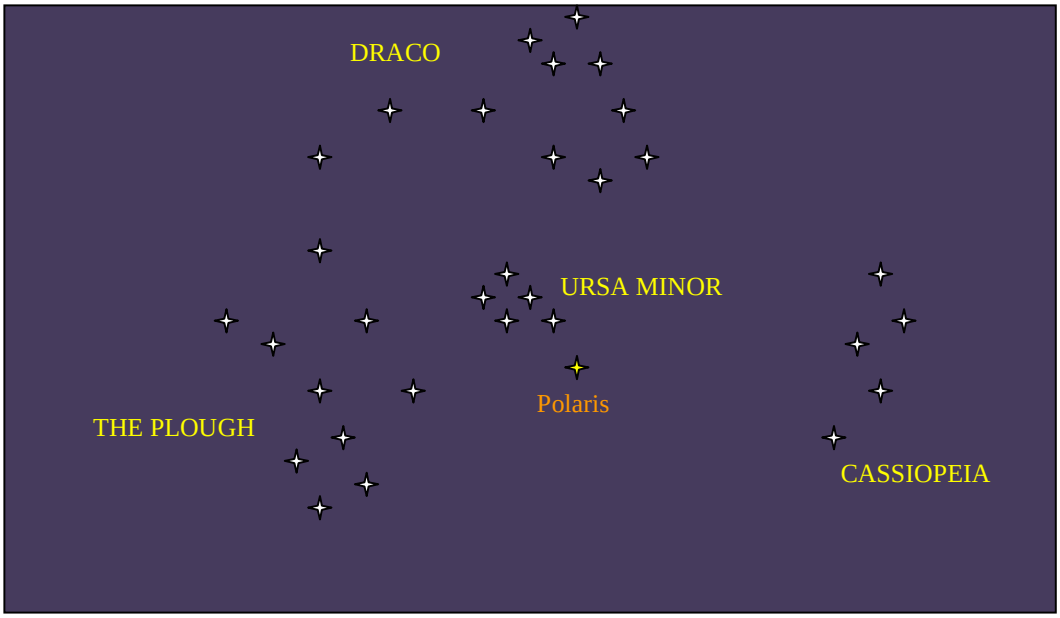
(any time of year)

An important feature of the Plough is that it is visible on a clear night throughout the year. These next constellations are also available to be seen throughout the year. Your starting place is to find the Plough and the pole star (see project 1).

The constellation Cassiopeia is often described as having a 'W' shape. To find it, look to that part of the sky on the far side of Polaris opposite to that where you see the Plough. Cassiopeia is about a full handspan across.



In this area of the sky there are two more challenging constellations. Your star chart might offer some help in locating them. Start with Polaris itself. The pole star is a member of a group of stars which form their own constellation, Ursa Minor, the Little Bear. Binoculars might help you to locate them, although on a clear night you should be able to see them without aid, (see sketch below). Winding its way around this part of the sky is the head and long tail of Draco, the dragon. The stars again are dim, but visible. Ursa Minor is about a clenched fist across.



Project 3. An evening in winter.

Winter often offers the clearest nights but they are also the coldest. Few but the bravest astronomers venture out for more than an hour at a time in winter. However some of the finest sights await the keen winter observer. The key objects to look for are found by facing south, so find a location with a clear southerly view.

Orion.

The most spectacular winter constellation is Orion, the Hunter. You can see Orion from around November to March. The chart here shows the winter night sky in January when Orion is due south at about 10pm. Look for the three stars which form Orion's belt. The rest of the constellation will then follow. The full constellation is about two handspans from top to bottom.

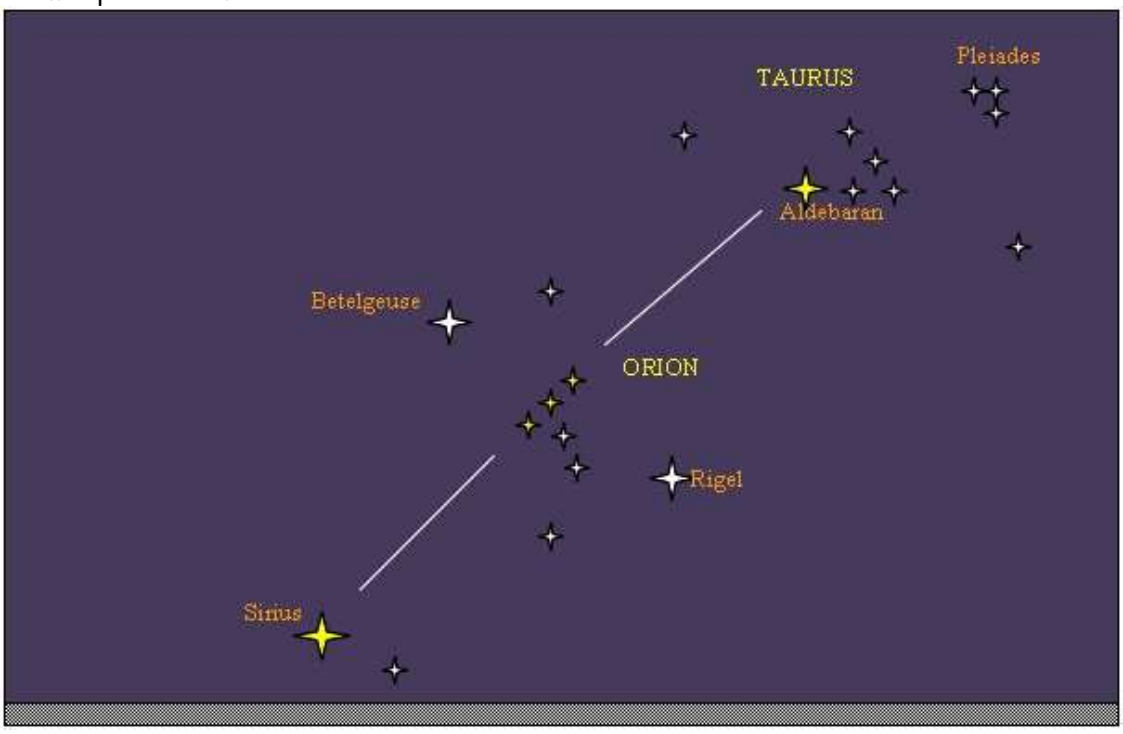
Hanging below Orion's belt is his sword, marked by a column of what appears to be three stars. Through binoculars these resolve to clusters of stars and a gaseous nebula.

Sirius.

Orion's belt will lead the eye towards two of the brightest stars in the sky. Below and to the left is Sirius, the brightest star as seen from Earth (apart from the Sun of course.) Sirius is a member of small constellation, Canis Major, the Great Dog.

Taurus.

Above and to the right lies Aldebaran in the constellation of Taurus, The Bull. Taurus is worth exploring as it contains two open clusters of stars. The first cluster, the Hyades, are widely scatted in the area next to Aldebaran. The second cluster, perhaps the best known of all clusters, is the Pleiades, or seven sisters. Use the star chart to find the Pleiades to the right of Aldebaran. This area is a rich part of the sky for binocular viewers. The stars which form the Pleiades really are close to each other and are some of the youngest stars in the night sky, being a mere fifty million years old or so. The Pleiades are just less than one thumb span across.



Project 4. An evening in spring.

The constellations to be seen in springtime include some which were visible late at night in winter and others which will remain until summer. Such is the nature of the night sky. There is an overlap between seasons.

Leo.

The constellation Leo is perhaps one of the few which vaguely resembles the animal after which it takes its name. The reverse question mark which forms the Lion's head is the best target for you. The lion's back and body lie to the left of the head. The main star, Regulus, forms the base of the question mark. Leo is more than a full handspan across.

Gemini.

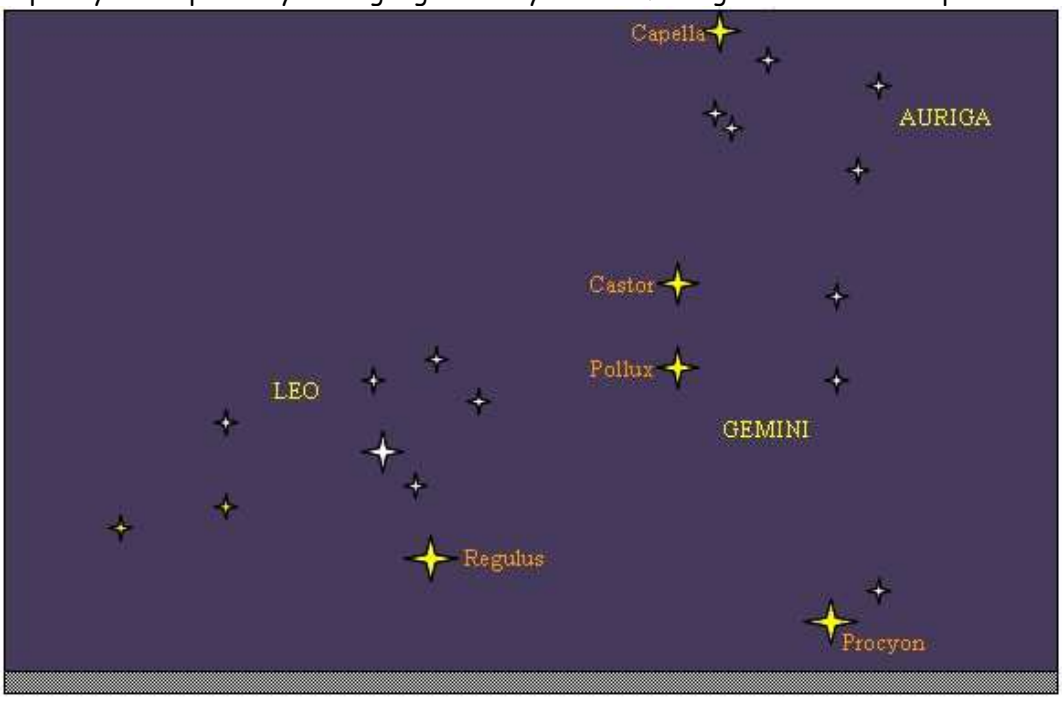
The twins in question are two stars of roughly equal brightness, Castor and Pollux. Find them and make a judgement as to which is brighter. Not too difficult. The stars in a constellation are labelled in order of brightest. Greek alphabet is used for this with alpha being the brightest, followed by beta etc. Pollux is therefore also known as 'alpha Gemini'. The twins are about one clenched fist across.

Canis Minor.

Whilst looking in this part of the sky you'll probably notice a bright and lonely star below Castor and Pollux. This star is Procyon, the brightest star in the constellation of Canis minor, the little Dog.

Auriga.

Above Castor and Pollux lies another constellation dominated by a bright star. The constellation is Auriga, the Charioteer. The bright star is Capella. If you are looking at Capella you are probably looking high above your head. Auriga is about a handspan across.



Project 5. An evening in summer.

In summer we enjoy long warm days. Star watchers will have to wait till late before the sky darkens. Even late at night you are likely to find that the residual light hampers good viewing. However there is still much to see. We'll concentrate on three stars which form what is known as the summer triangle. They are from three different constellations.

Cygnus.

The constellation of Cygnus, the Swan, is also known as the northern cross. In July the Swan will be seen flying headfirst towards the southern horizon. The tail star, Deneb, is bright but not especially so. However it is does have a status as one of the brightest stars in the sky in an 'absolute' sense. At a distance of about 2000 light years it represents one of most distant stars visible with the naked eye. To still appear reasonably bright at such a distance means that in a real sense it is a giant of a star. Cygnus is about a handspan across.

Lyra.

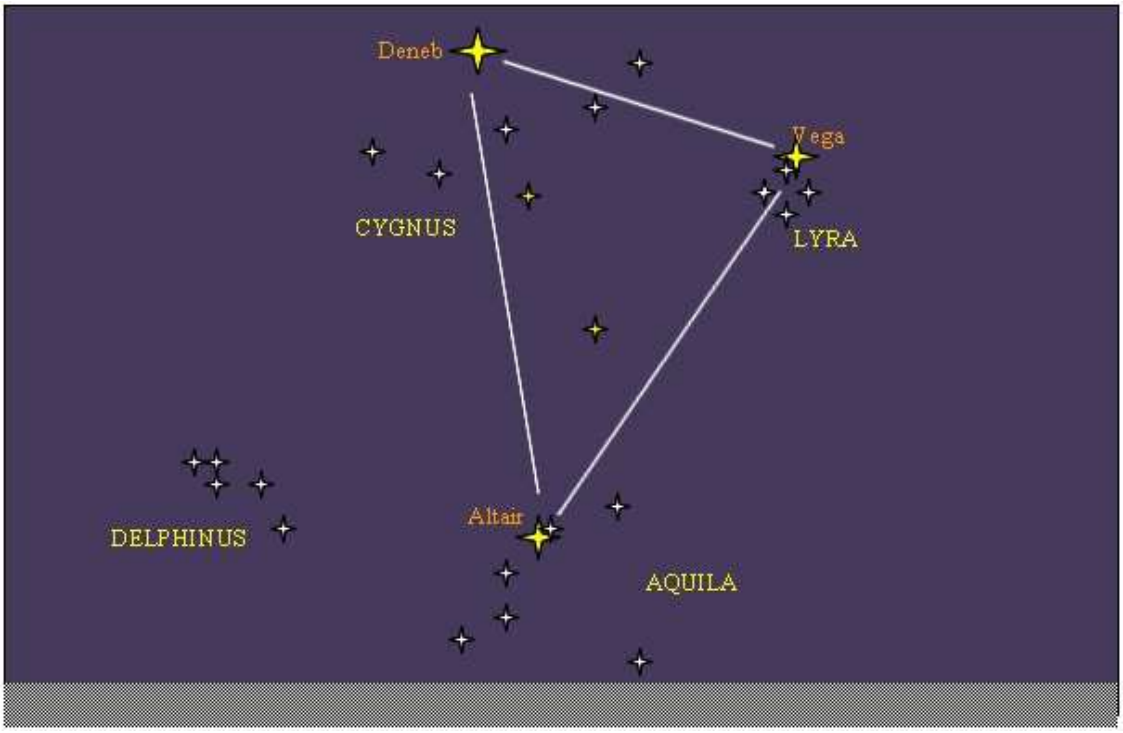
This small constellation, named after an ancient harp or lyre, contains the bright star, Vega. Lyra is less than a fist span across.

Aquila.

Aquila, the Eagle, lies low in the southern sky in summer. Its brightest star, Altair, forms the third star in the summer triangle.

Delphinus.

This tiny constellation is a gem to find. It lies to the left of Altair and has a neat dolphin-like shape. It is unremarkable in any stellar sense but it is just cute.

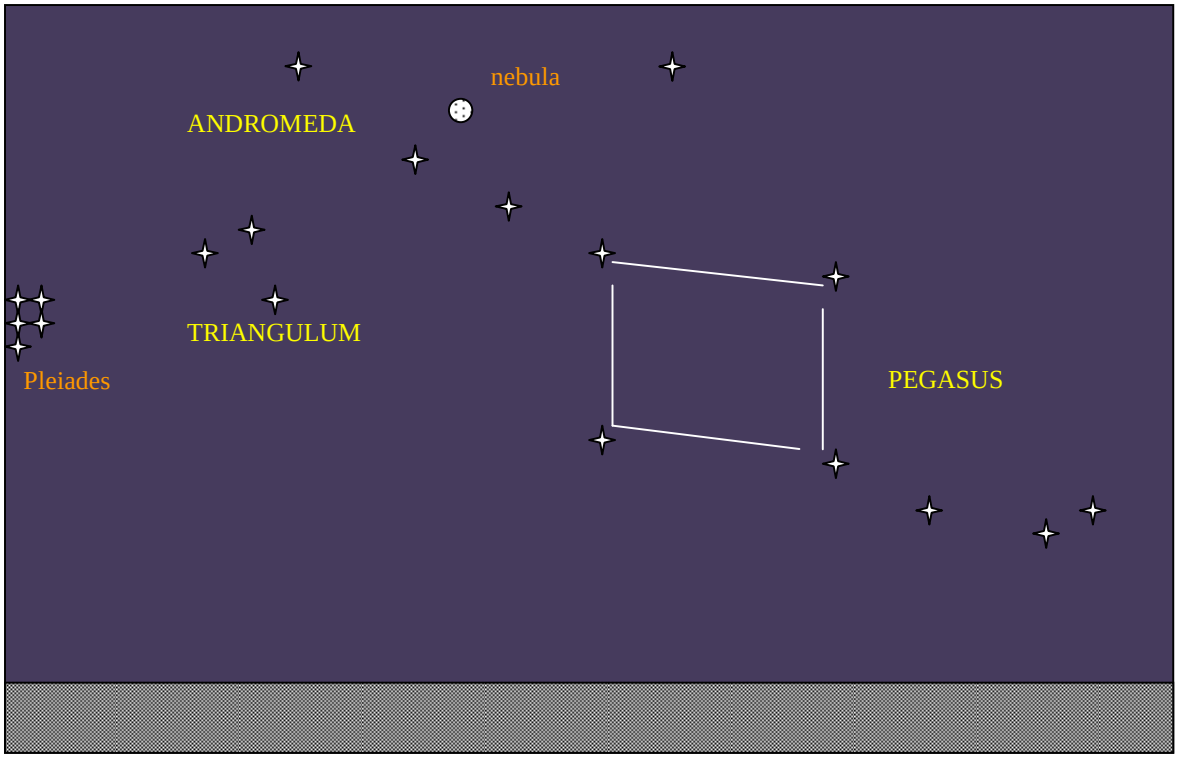


Project 6. An evening in autumn.

Pegasus.
The southern sky in Autumn is dominated by the constellation Pegasus, the flying horse. Cassiopeia is likely to be high above your head. Start here. Drop down below Cassiopeia to locate the four stars which form the great square of Pegasus. These stars are not particularly bright but there are no bright stars within the square and this makes the square easy to locate. It is about a handspan across.

Andromeda.
Leading off the top left corner of the square of Pegasus is the constellation of Andromeda. This is not a particularly impressive area of the sky as far as stars go. However within this constellation lies a special object, the Andromeda nebula. This appears as a faint fuzzy patch, only just visible by the naked eye and better seen through binoculars. However it is worth trying to locate it if your sky is particularly dark and clear. What you are looking at is one of our neighbouring galaxies. The Andromeda galaxy is a huge star island in space. It contains thousands of millions of stars, many of which will be rather like our Sun. With the naked eye, Andromeda is often best seen by finding it and then averting your vision slightly to allow you to see the fuzzy patch out of the corner of your eye.

Triangulum.
Far to the left of the Andromeda constellation you'll pick up the open cluster of the Pleiades, soon to be a target for your winter observations. Between The Pleiades and Andromeda lie the three faint stars which form the triangle which is Triangulum.



Project 7. **Planet spotting.**

Planets look very much like stars. It is often difficult to distinguish one from another. The main difference is that the planets appear to change their position in the night sky as the seasons progress. This is why the ancient people called them the 'wandering stars.' On any one evening, however, you will not see a planet wandering. Only repeated observations over several weeks will reveal the slow changes in position against the 'fixed' star pattern. How do you find a planet and which ones can you see?

There are five planets visible to the unaided eye. Mercury, Venus, Mars, Jupiter and Saturn. The brightest tends to be Venus, both because of its proximity to the Earth and the high reflectivity of its surface. Planets don't give off their own light. Just like the Moon, they depend on reflected sunlight to be seen.

Generally speaking you need to look southwards to find the planets. Star charts will tell you which planets are visible on any particular evening. Once spotted with the naked eye, planets deserve to be seen through a telescope. Venus will then most likely show a crescent phase, Jupiter will show up to four of its bright moons and Saturn will show its rings. Venus can be so bright that it can be seen in the late afternoon and early morning. You can photograph it with a simple camera at these times. (See project 18.)

Two photographs showing the Moon and Venus. The left hand shot was taken at 5pm in December. In the foreground is the big wheel in Edinburgh Princes Street. The right hand shot was taken at 7pm from London.

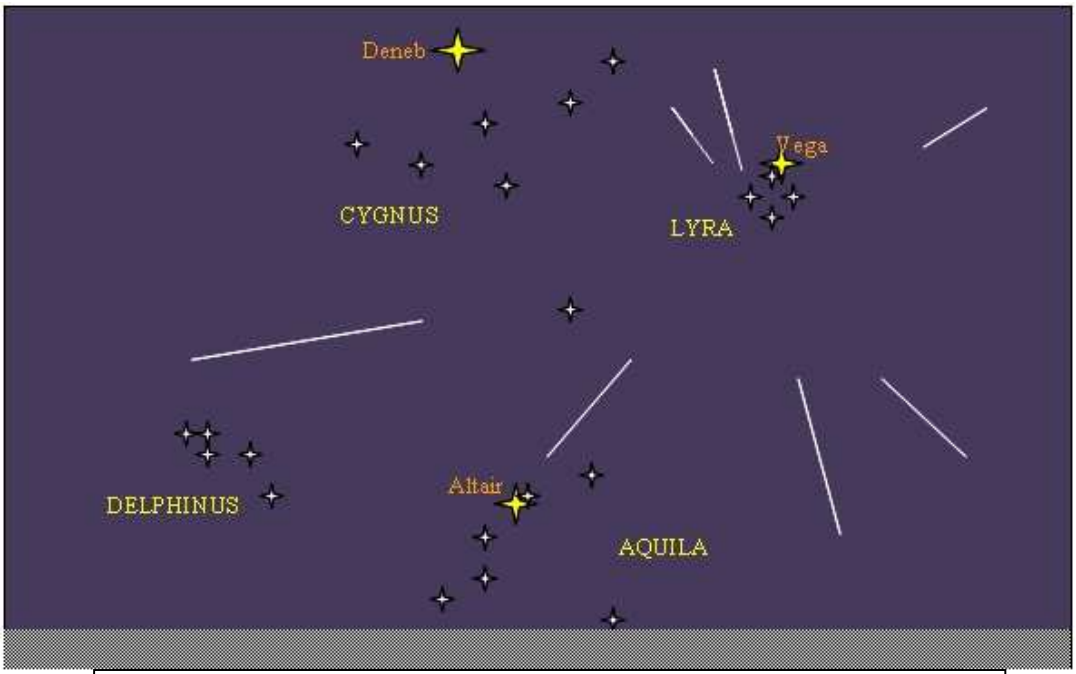
Project 8. Shooting stars.

A shooting star can be a most spectacular and unexpected event. Not everyone has had the good fortune to see one. After all, most people spend their lives looking horizontally. Looking upwards does improve your chances of seeing one. However you can further improve your chances by observing at, or near to a date when there is a particular 'shower' expected. Any astronomy book will give you the dates of the 'maximums' for the most obvious meteor showers. Some key ones are:

Quadrantids	January 3	Orionids	October 22
Lyrids	April 22	Taurids	November 5
Aquarids	May 6	Leonids	Nov 17
Perseids	August 12	Geminids	December 13

Shooting stars are not stars at all. They are pieces of dust and rock fragments which fall through the Earth's atmosphere. As they pass through the atmosphere they burn up and we see them glow as they disintegrate. This process happens all the time and it is quite possible for you to see the occasional meteor on any night. These are called 'sporadics'. However, at the dates shown above, and for a week or so either side of the maximum date, your chances of seeing a shooting star increase dramatically. This is because the Earth, as it orbits around the Sun, passes by places where comets have left a trail of debris. This extra debris is responsible for the increased frequency of shooting stars, the showers.

When looking for shooting stars, there is no need to look at a particular place. Simply get comfortable in a reclining garden seat and look skywards.



Shooting stars (Lyrid meteors) emerging from the constellation Lyra in late April.

Project 9. Some other objects and events.

Comets.
Comets are quite rare. There are thousands of them but they appear bright only when they approach the Sun. Comets appear as a fuzzy patch and so need to be seen through a telescope or binoculars. However there is the occasional bright comet visible to the naked eye. Comet Hale-Bopp, named after its two discoverers, was the surprise of the decade at the end of the 20th century. Bright comets will be signalled in the astronomy press.

Satellites.
There are dozens of satellites in orbit above the Earth. Those in low 'polar' orbits can be seen against a starry background. A typical satellite will appear about as bright as an average star. You will notice it moving slowly but steadily through the starry background. It might take several minutes to cross your sky. Occasionally a satellite will appear to pulsate or flash. This is most likely because it is turning slowly and you are seeing the result of light being reflected off the particularly smooth parts of the satellite.

Aurorae.
Particles from the Sun, the 'solar wind', crash through the upper atmosphere. As they do they energise the gas particles in the atmosphere. The result is a glow which we can see from Earth. Known as the Aurora Borealis in the northern hemisphere and Aurora Australis in the southern, you usually need to travel to extreme north or south latitudes to see it. However in recent years we have been lucky to see the northern lights from as far south as Peebles in the Borders.

Comet Hale Bopp in the twilight of a summer's evening.

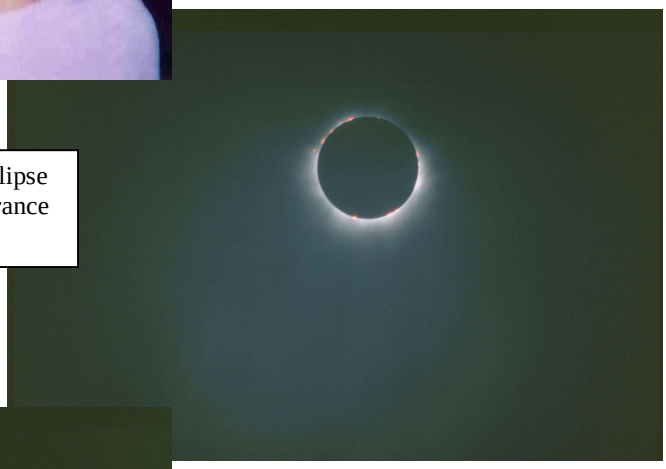
A pink aurora over the hills near Peebles, Scotland.

Eclipses

An eclipse of the Moon is relatively common. One or two will occur each year. You need no special equipment to see an eclipse of the Moon. The event will occur on a night or sometimes during early morning or twilight when the Moon is full. As the Moon passes into the shadow of the Earth you will notice the Earth's shadow slowly encroach on the full disc. Scattered light from the edge of the Earth will pass through the atmosphere and turn the Moon an orangish hue. The whole event will last about two hours.

An eclipse of the Sun is a much rarer event and all the more spectacular. Try to see just one such event in your lifetime. You might have to travel to locate yourself in the path of totality. If the weather is clear you will be treated to a spectacular and emotionally moving sight. See the astronomy press, or Astronomy Now, for details of the next eclipse.

Solar eclipse watchers require the right eye protection – always use CE approved equipment.



A total solar eclipse as seen from France 1999.

The Moon passing into the Earth's shadow, 1999.

Unit 3. Observing with binoculars.

Binoculars are often the preferred instrument for astronomers. They are relatively inexpensive, portable and offer a wide field of view. Binoculars are described by two numbers (8x40, 10x50 etc). High Street retailers (Dixons, Jessops etc) offer first time buyers excellent instruments for under £50. There is no need to pay more. My best buy (January 2004) was a pair of 8 x 40 from Jessops for £34.

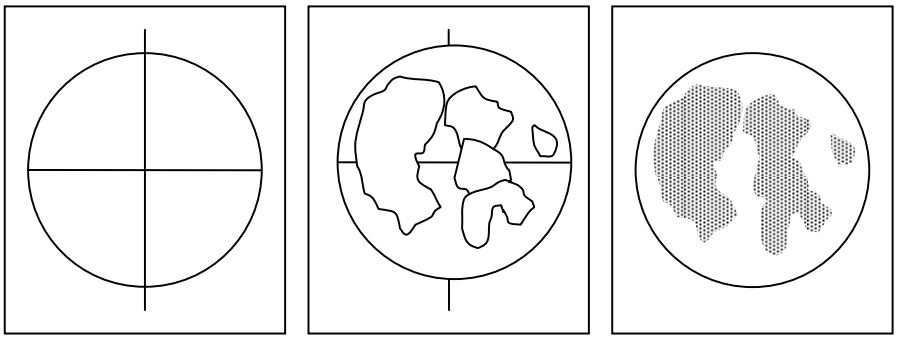
[The 8x40 means: a magnification of 8 times. The diameter of each objective lens is 40mm.]

Avoid the small aperture 'compact' models. They don't gather sufficient light for night time use. Also avoid the very high magnifications such as 15 times or higher. They will give shaky images when hand-held. A pair of 8x40 is compact, light and suitable for dark nights. Other models to look out for might be 7x50 or 10x50.
Take care when buying second hand. Binoculars which have been dropped are likely to be out of alignment and will result in you seeing double images.

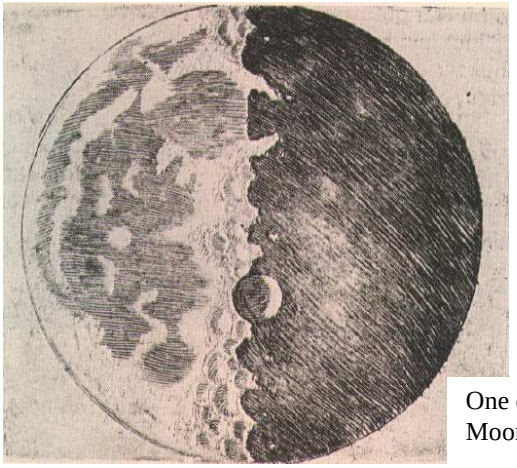
Project 10. Sketch the Moon.

Observing the Moon is an easy project. There are very few months in the year when the Moon is not visible for at least a few evenings. The Mare, or 'seas', are the most obvious features on the Moon's surface. They are huge plains of solidified lava which remain from the Moon's volcanic period. Mare appear as grey patches on the Full Moon's surface. They are responsible for the 'face' which people call the man in the Moon.

A good project for a beginner is to make a sketch of the Mare for yourself. Take a sheet of paper, perhaps about A4 or A5 in size and draw a large circle. Use a tea plate or a coffee mug. You might want to divide the circle into four quarters using a pencil. This will enable you to sketch a piece of the Moon at a time. Rest the paper on a book. You'll need binoculars and a pencil.



Make your observations from the top of the Moon and work downwards, sketching where the main mare appear to be. Use the edge of the pencil to shade in where the mare appear darker. You will produce a field sketch which looks a little like the original sketches made by observers such as Galileo. Galileo, using a primitive telescope, saw a view rather like you would through a pair of binoculars.

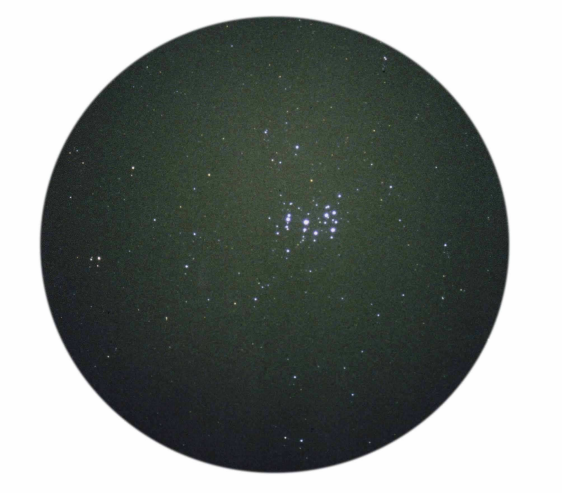


One of Galileo's early Moon sketches

Project 11. The Pleiades and Hyades

Star clusters are best viewed through binoculars. A telescope will usually not allow the full spread of stars to be seen. The field of view of binoculars, about 7 degrees, approximately a clenched fist across, can capture complete clusters.

The Pleiades and Hyades are best seen in late autumn or winter. Use the star chart for winter, see project 3.



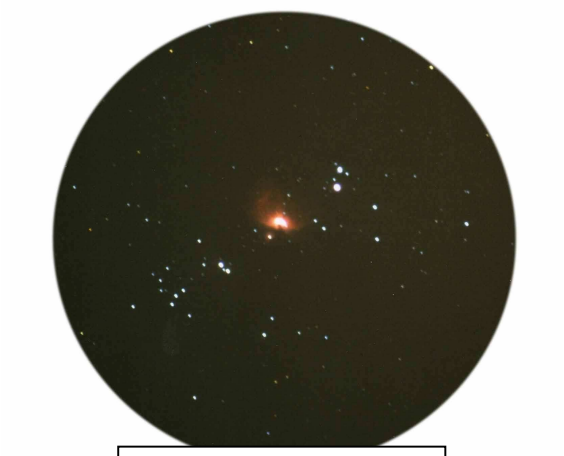
As a challenge, take a pencil and sketchbook and use your binoculars to make a sketch of the Pleiades. Take care to locate the bright stars first and then work in the positions of the fainter stars. The Pleiades are also called the 'seven sisters'. Can you see seven stars without binoculars? (Patrick Moore suggests this is a good homework task for children). Most people can locate five or six stars depending on the quality of the sky. How many stars can you see through binoculars?

Project 12. The Andromeda galaxy and the Orion nebula

Here are two targets which will not necessarily be visible at the same time. You might be lucky to catch them both in the early winter sky, Orion as it rises in the east and Andromeda as it sets to the west. Your star chart will help you to locate them. Project 3 and project 6 show these two areas of the night sky.

The Orion nebula.
Start your search at the three stars which form the belt of Orion. Just below the belt lies Orion's sword, a group of stars and nebulosity (fuzziness) which is particularly rich in interest through binoculars. Don't expect to see the beautiful pink and white chiffon-like wisps which you find in coffee table astronomy books. Such photographs are taken through telescopes with sensitive film and long exposures. However you can expect to catch a hint of the complexity of this region of the sky. Evidence of the central nebula ought to be visible to you.

This nebulous area is within our galaxy and is a region where new stars are being formed.



The Orion nebula through high powered binoculars

The Andromeda galaxy.
Although not quite as spectacular as the nebula in Orion, the value of searching for the Andromeda nebula is that, once located, you will be looking out to an object far beyond our own galaxy. The Andromeda nebula is in fact a spiral galaxy locates at about 2.5 million light years away. It is the only galaxy which is available for observation through binoculars and on a really clear dark night it is just visible to the naked eye. Don't expect to see any details. Your best hope is to locate a fuzzy patch – that's the Andromeda galaxy. Just remember, when you catch it, the light you are receiving left the galaxy about 2.5 million years ago.

Start your search at the great square of Pegasus. (see project 6)

Unit 4. Observing with a telescope.

Although most beginners aspire to own a telescope, the received wisdom is to make the intermediate step of buying binoculars first. Get to know the night sky before spending a small fortune on a telescope. It is most likely that your telescope will be used on no more than a handful of occasions during the first year. You'll be back to naked eye and binoculars on many occasions. You ought to appreciate that a star looks just the same through a telescope and with the naked eye. You'll be able to see fainter stars and groups of stars but there will be no more detail than without the telescope. Of course the Moon and planets will be far more spectacular. So if you feel you are ready, then the market is a rich source of instruments for all budgets. A guide to telescopes would require a book in itself. Indeed there are such books available. Here is a brief overview of beginner instruments to help steer you.

The first question people often ask when faced with a telescope is 'what magnification does it do?' The magnification depends on the type of eyepiece you add to your telescope. Many instruments will offer you at least a couple of eyepieces, perhaps offering ' x40 and x100.' Some beginner instruments claim magnifications of x250 or even x500. Don't be lured by such claims. For beginner instruments be satisfied by a magnification in the x20 to x 100 range. Any higher and the already blurred image will wobble so much as to be rendered useless.

The light-gathering power of a telescope is governed by its aperture. This is measured by the diameter of the main lens or mirror. Beginner instruments might have an aperture of diameter from 60mm to 120mm. Telescopes with mirrors tend to have larger apertures, perhaps 150mm. Good lenses are expensive and so tend to be smaller. Don't be overly influenced by aperture. You'll see very similar images in most beginner 'scopes.

The final feature to be aware of is the mount on which the instrument sits. For a beginner, go for as sturdy a mount as possible. Mechanical parts tend to slacken with use. Some of the best instruments use a simple camera-style tripod and mount. Used at low magnifications these mounts can provide excellent views for beginners. A starter scope such as the 'Infinity' scope can be cradled in your arms. The better beginning mounts are 'equatorial' and make tracking the moving sky easier. A common mount is the Chinese EQ3 mount which is quite adequate for a beginner and will last.

A wide range of instruments can be ordered from suppliers found within the pages of **Astronomy Now** magazine. It is impossible to make any recommendation. They will all offer images of the Moon's features, show that Saturn has a ring system and that Jupiter has four bright moons. They will not resolve Saturn's rings into distinct bands and they will not show detailed features on the surface of Jupiter.

How much should I pay?
You can get good results from 'scopes in the less-than-£150 bracket, as outlined above. These will usually come with a couple of eyepieces and some basic bits and pieces. If you want to spend more, up-to-£500 will net you an 'advanced beginner' instrument, which may have a sturdier mount for example, or facilities to control the 'scope via a computer link. As with anything, there will be a range in durability and portability to consider – that bargain £40 'scope will quickly lose it's appeal if bits keep dropping off, and while a big scope may get you some impressive views, if it won't fit in your car, it could be a problem!

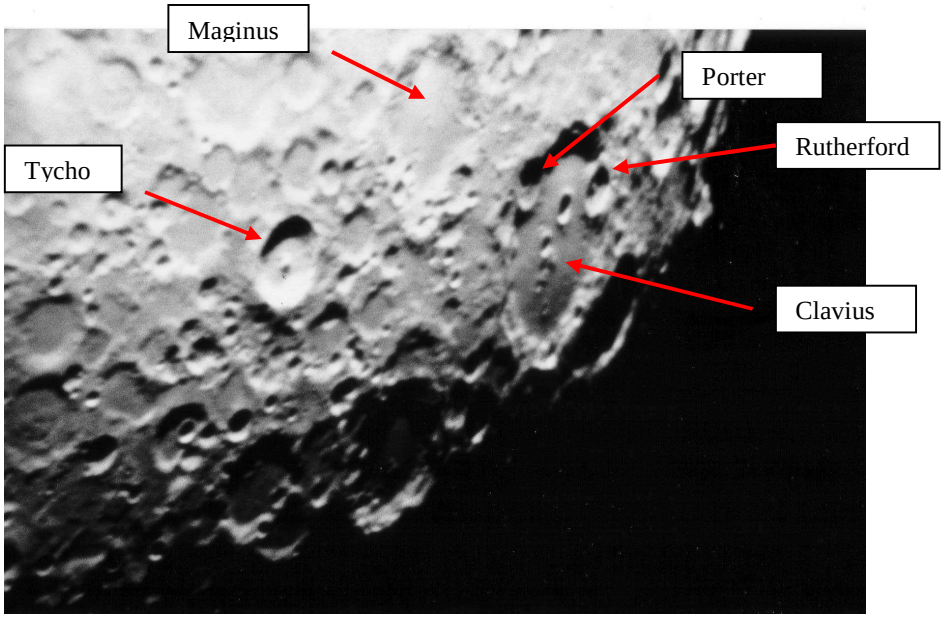
There is a thriving second hand market for telescopes. See the ads pages in Astronomy Now for example to start your search. One type of telescope worth mentioning are Dobsonians. Dobsonian telescopes are reflectors which sit in a simple cradle mount. They are simple but effective and you tend to get more aperture for your money with this design.

There is almost no limit to the number of objects you can look out for with a small telescope. It is difficult to offer ideas for projects as there are so many. However, to get you started here are three.

Project 13 (Moon craters)

The Moon is not visible every night. It orbits the Earth once every 28 days and so spends part of its journey on the 'Sun side' of the Earth. When it becomes visible however it is likely to be showing a phase, with only part of the illuminated side being visible to us. Such a time is just right for amateur observers with binoculars or telescopes. The most interesting details can be seen towards the Moon's terminator – the imaginary line which separates the bright from dark on the surface of the Moon. Near the terminator the Sun's light catches the features at a shallow angle and therefore casts long shadows. These shadows help to bring out the detail in the surface features.

In contrast, a full Moon, illuminated head-on by the Sun, offers a bright surface but with many of the subtleties of the Moon's features being less than apparent. A Moon map, available as a poster or in a good observer's handbook, will help you to identify particular features.



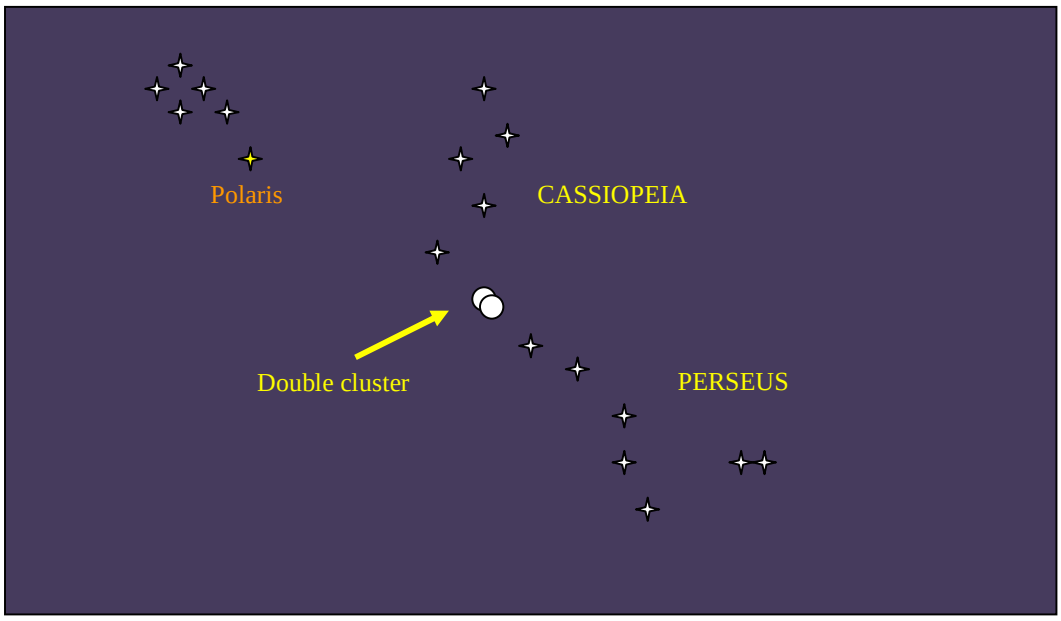
Details on the Moon's surface are more visible near the terminator – the light-dark interface. The crater Tycho shows an interesting central peak. The large crater Clavius has been the subject of more recent impacts producing several other smaller craters, notably Rutherford and Porter.

Project 14 (The Perseus double cluster)

Stars which appear to be close together in the night sky might in fact be linked by gravity and indeed be companions. However many apparent partnerships are in fact an optical illusion brought about by a 'line-of-sight' effect, one star being much further than the other.

Clusters of stars are groups which are indeed in the same location. Stars in a cluster such as the Pleiades would have formed together and have remained linked by their mutual gravity. Some open clusters form spectacular sights through small telescopes.

The constellation Perseus lies close to Cassiopeia. Use Cassiopeia to help you search for the Perseus double cluster. The clusters lie mid-way between Cassiopeia and Perseus.



Project 15 (Double stars)

Although it is true to say that a star seen through a telescope looks very much the same as a star seen without a telescope, some stars do appear different, notably those stars which appear to be one but in fact can be resolved as **more** than a single point of light. Amateur astronomers enjoy the challenge of resolving apparently single objects into two or more separate stars. There are some well known stars which you can use as targets for your own search.

Alcor and Mizar.

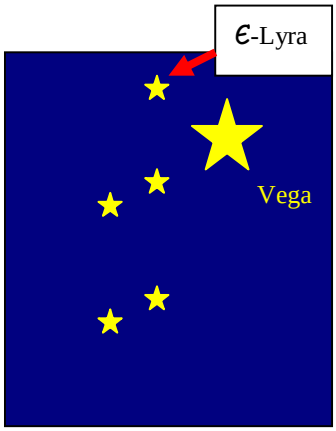
Start by locating the Plough, see project 1. The star in the middle of the handle of the Plough is Mizar. However, looking closely, even with the naked eye will reveal that Mizar has a fainter companion, called Alcor. This Alcor and Mizar pair can be more easily seen through binoculars. A small telescope has no trouble in seeing both stars. Look closely however and you'll notice that Mizar itself resolves into two stars. Look closely and a fourth star will be seen between Alcor and Mizar. This is Sidus Ludovicianum.

Albireo.

Start by locating the constellation Cygnus the Swan, see project 5. Move to the head of the Swan. The bright star which locates the Swan's head is Albireo. This is a yellow star in binoculars but through a telescope it becomes evident that Albireo has a fainter companion of a sapphire blue colour, making the pair a beautiful and easy double to search for. It is believed that these two stars are indeed linked by mutual gravity and are travelling through space together.

Є – Lyra

The constellation Lyra, see project 8, is already compact such that more than one of its stars will appear in a binocular view. However it is worth finding the star close to the bright star Vega, Є – Lyra. This is a widely separated double, visible through binoculars as well as through a telescope.

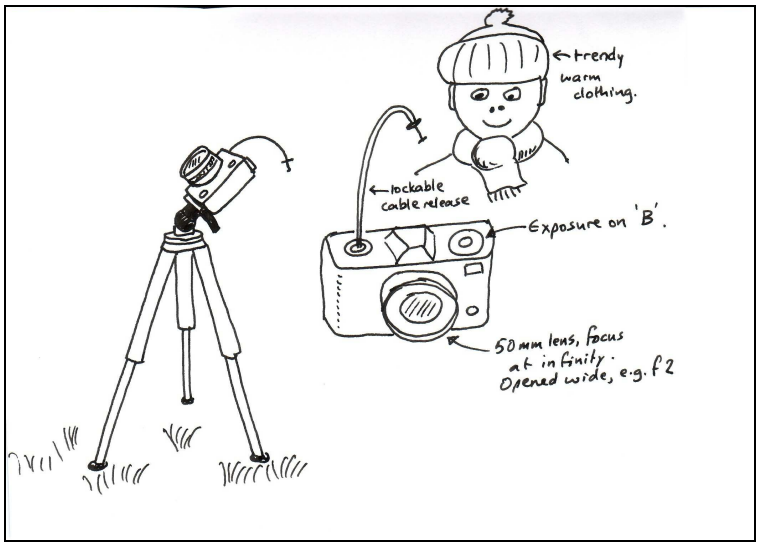


Unit 5. Photographing the sky.

It is easy to capture images of the sky with a camera. However, modern digital auto focus, auto everything cameras require specialist skills. For the beginner, astrophotography can start with a compact 'point and press' film camera. I recently (Feb 2004) bought one from a Dixon's on special offer for £15.

With such a camera you can capture sunsets with all their magnificent colours. The bright planet Venus is regularly seen either in the morning just before sunrise or in the evening just after sunset. A compact camera will record Venus against a twilight horizon. Find a shot with something in the foreground, perhaps trees or a rooftop, and you'll be surprised at the result.

For night-time shots you'll need a camera capable of longer exposures. Some compacts and digital cameras will give you exposures of several seconds. Sat on a tripod these will offer the faintest of star images and will be unimpressive. Far better is to find a second hand manual SLR (single lens reflex) camera. You can still buy these new but the second hand market is vibrant. A decent basic second hand SLR should not set you back more than £50 with a little negotiation. You don't need any auto features, in fact try to avoid them. Aim for a bog standard 50mm lens and the ability to take long exposure shots. Look for 'B', for bulb, on the shutter speed dial. Check that this function works before you buy. Explain your needs to the shop assistant.



The other components you'll need will be a simple tripod (available for about £20) and a lockable cable release (about £10). High Street camera shops will stock these. You might find that all these items reside in a neighbour's cupboard, redundant following their move to digital cameras.

Most films will capture the night sky. Slide film is preferred by advanced amateurs but print film is cheaper and will give good results. Film speed is not critical. Faster film speed such as 400ASA is more sensitive but I have had good shots from 100 ASA film. Save money by buying 24 or even 12 exposure film. It is unlikely that you'll use up a 36 exposure roll. If you are not confident in loading your film ask a photographer to assist you. You don't want your first four nights of astrophotography to be wasted by a film which wasn't winding on.

Helpful hint: Take the first shot of a daytime scene. This will help the auto processing machine to recognise when the exposures start. Tell the processor that your shots are of night scenes. Auto processors often interpret star images as 'unexposed'.

With film loaded, camera tripod and cable release ready, turn the lens to focus on infinity, open up the aperture and point upwards. The projects below give more details.

Project 16 (the pole star)

The pole star is a good place to start. Find a location where the horizon, looking north, is unobstructed and not too bright. (Keep away from street lights etc). Point the camera towards the Pole star and focus on infinity. Check that the star images are as sharp as you can make them. Open the shutter, lock the cable release and leave the camera for about five minutes. Wind on and repeat, this time for ten minutes. Repeat once again but for a twenty minute exposure. In a town environment, this is about the limit of exposure time before background light pollution becomes too intrusive.

Your shots will show star trails. The stars appear to move in a circular path around the pole star. (Of course this is caused by the rotation of the Earth.) Look closely and see if you can detect stars of varying colours. Can you spot the pole star itself? It ought not to have moved by much at all.

Project 17 (star trails)

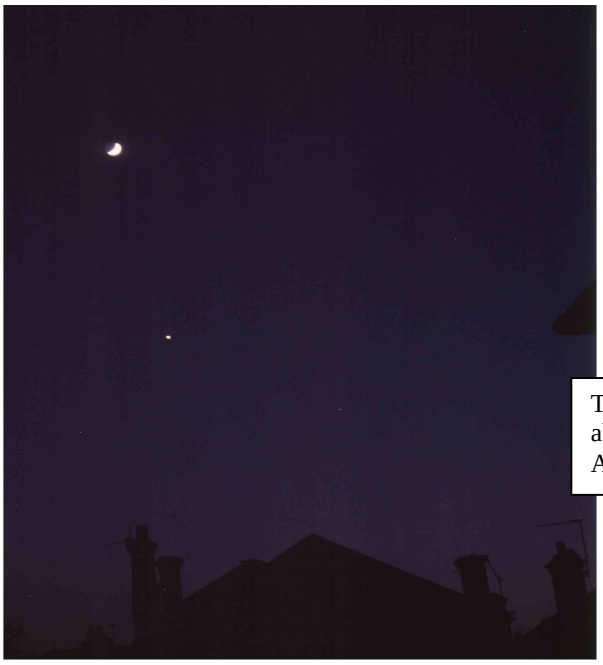
The procedure for project 16 can be repeated for any direction in the sky. The longer the exposures, the longer will be the star trails but the greater the chance of light pollution.

As the Earth takes 24 hours for one rotation, you can anticipate how far around in their journey the stars will go in the time allowed for the exposure.

The constellation Orion photographed, looking south, using an SLR. The exposure was about eight minutes. Note the different star colours evident in the photo but not always obvious to the naked eye.

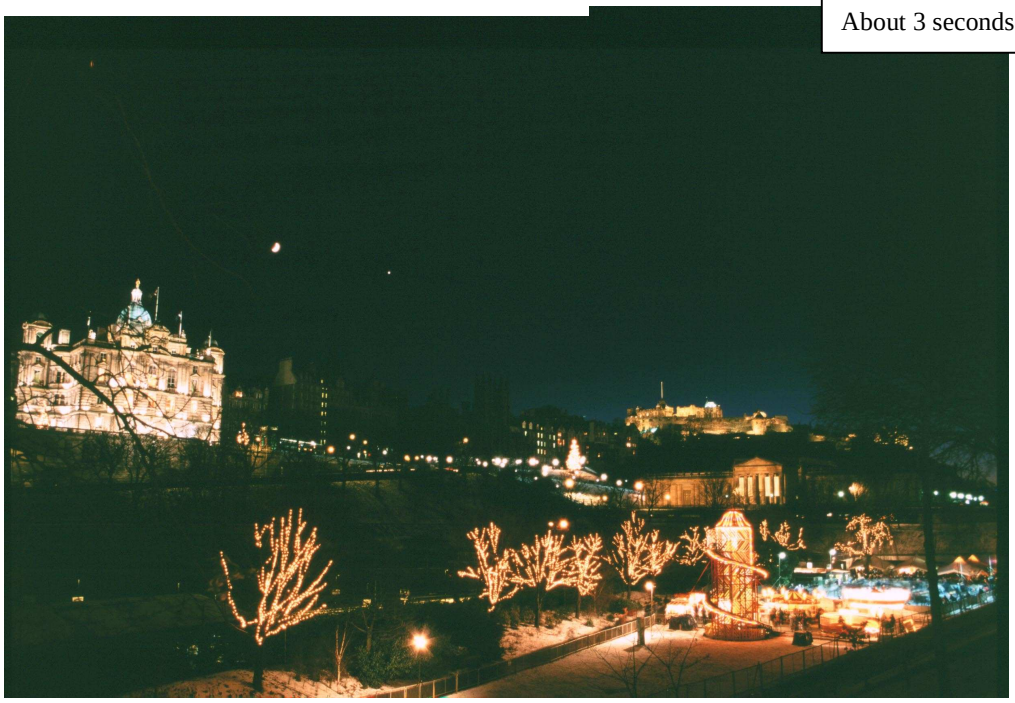
Project 18 (planets)

Capturing the planets on film is both rewarding and simple enough. With your photographic kit ready as before aim the camera at one of the bright planets. Of course you will need to do your research to check which planets are 'visible' on that particular evening. The first planet to start with is Venus. I prefer shots where something in the foreground helps to give the image a sense of depth. So try top catch a tree or the top of a building as well as the planet.



Planets look good without the trails which long exposures offer. To avoid a trail, use shutter speeds of up to 10 seconds. On a twilight evening, soon after the Sun has set, Venus can be captured with an exposure of little more than a second.

The Moon and Venus framed above a street scene.
About 5 seconds exposure.



The Moon and Venus set against a winter scene in Edinburgh.
About 3 seconds exposure.

Unit 6. Daytime observing.

Astronomy is often associated with evening and night time activities. However there are opportunities for the interested observer to enjoy their hobby in daylight. Contrary to popular belief, the Moon is visible during the daytime for several days each month. In the early morning and afternoon observations can be made of the crescent Moon, particularly impressive through binoculars or a small telescope.

The Stars are of course 'out there' during the daytime. It just happens that their light is so faint that the Sun's light outshines them all. Let's not forget that the Sun is a star. It just happens to be very close to us. By studying the Sun we are studying a star.

CAUTION. It is dangerous to look directly at the Sun. Do not do this. The Sun's radiation, both visible and invisible, can cause permanent damage to our eyes. The safest observing method is to project the Sun's image onto a piece of white card.

As I am writing this booklet, the world is preparing for the transit of Venus across the face of the Sun. This is a rare event and not something which is included in our two projects below. However it will be repeated in 2012. Solar eclipses are also rare but not impossible to experience if you are prepared to travel to the locations through which the totality line passes. It is worth noting that the observations of the planet Venus referred to in project can be made during twilight.

Project 19 (sundials)

There are those whose hobby it is to find sundials, record and photograph them. The British Sundial Society, BSS, maintains such records. With the Sun occupying the southern sky during the daytime, dials are most often located on south facing walls. Many churches have dials located somewhere on their south facing wall. This project, rather than encouraging you to make your own dial, is really designed to encourage your observation and record keeping.
Why not visit the BSS website: www.sundialsoc.org.uk

Project 20 (sunspots)

It is possible to observe the Sun though a special solar filter. However the most common, and safest, method is to project an image of the Sun onto a piece of card.
You can use binoculars to project the image or a telescope (see photograph)

Make sure that you stop down our telescope to reduce the amount of energy your instrument captures. (see photograph above). An aperture of about 10cm is ample to capture enough sunlight to form a clear image. Too much light, and heat, and the focussing effect of the telescope will concentrate the energy onto your optics and will damage the coatings and even crack the glass.

Sunspots will be visible at most times during the year. However the Sun does appear to go through an 11 year sunspot cycle. There are years when the activity is expected to be high and others when it is expected to fall.

By holding a card on which to capture the Sun's image you can sketch just where the sunspots are on a particular day and time. An observation a day or two later will show that the sunspots will have moved and most likely have also changed their shape. This was the first piece of evidence that the Sun was rotating. The Sun takes about 24 days to complete one revolution.

Project 21. Moon and tides.

This is a special project for anyone living near the sea or with an interest in tides. Most places on Earth experience two high tides each day, separated by approximately 12 hours. The gravitational attraction between sea water and the Moon is responsible for the tides giving the tides an astronomical link.

Tide tables for your locality, available from the internet , will show times of high and low tides but also will show a monthly cycle of extreme tides (called spring tides) and modest tides (called neap tides). Each month, near to when the Moon is either full or new, the tides reach their greatest highs and lows – these are the spring tides. [Note: the term spring doesn't refer to a season]. Check what the Moon is doing at these times either from your own observation or a Moon chart. You will find that the exact times of the spring tides differ slightly from the exact times of the full and new Moon – but not by much. Can your research ascertain just how big this difference is?

The times of new and full Moon are the times when the Moon, Earth and Sun are approximately in a line. The gravitational attraction of both Sun and Moon combine and, as a result, the added forces create greater tides.

You might also be interested in knowing that the same forces of attraction influence other fluids in the Earth, notably the molten magma beneath the Earth's crust. This is why, at times of full or new Moon, volcanic activity is most likely.

7. Organising your own star party.

You will no doubt want to share your newfound enthusiasm for the night sky with others, perhaps friends and family and children. A little forward planning will make their first experiences all the more positive. Here are some pointers:

- Select an evening when the Moon is not intrusive. A Moon chart or diary will show you when the moon is approaching full phase. Unless you want to look at the full moon (not the best idea) then avoid such times in the month. A crescent Moon is far more interesting and less intrusive.
- Select a dark, safe venue. A school playground might be fine. Make sure that you don't set off the automatic security floodlights!
- Warn people about clothing. Extra layers, sturdy footware and hats are advisable.
- Encourage as many pairs of binoculars as you can muster. Having to join a long queue at a single telescope is no fun for anyone.
- Know just what is 'up' on that evening. Do your homework. People will need directing. Being able to point out key objects is important. A friendly local astronomer will be of value. Contact your local astro society (details from local library)
- Don't keep people out too late. An hour or two is plenty.
- Have a bad weather contingency – either a telephone link to cancel the event or access to a video show on the planets etc.
- If you lay on any of the following features, your event will be enriched:

Warm fruit drinks, hot nibbles (mince pies or sausage rolls etc), a meteor shower, the crescent Moon, a bright planet.

Unit 8. Curriculum perspectives

Astronomy is a feature of the new Curriculum for Excellence, as it was in the 5-14 guidelines. In writing this pack, we are assuming that teachers will already have access to the most up to date material available in terms of what the curriculum contains, (http://www.ltscotland.org.uk/Images/science_planet_earthv3_tcm4-443205.pdf will give you some pointers dealing with Astronomy) however if you are not a teacher, but still wish to hit specific points during activities or projects, we suggest you contact a local teacher. They will be able to offer guidance on what to cover, and at what level, and that contact may even result in audiences for the activities themselves.

Below are some ideas which might form a starting point from which a teacher can launch some interesting learning activities.

- **Modelling**. By all means make some models of planets – papier mache around a party balloon will give a messy but fun planet for painting and suspending. What about a model of the Sun showing is interior or a model of the Moon showing key 'seas' and craters. Space exploration is a good context for models of rockets, space stations and martian research bases.
- **Design**. Keeping the concept of 'need' in mind, pupils might be invited to collaborate in designing, for example: a training programme for an astronaut, an advert and interview/selection programme for astronauts, an observing plan for an orbiting space camera, a holder' for a pair of astronomy binoculars, a chart for recording the phases of the Moon, a poster promoting an astronomical event or a start party, an insulated lunchbox for a lunar cosmonaut, a message box to be sent into deep space and picked up by extraterrestrials……
- **Literacy, affective and emotional learning**. Space is a lonely place and space explorers take risks: 'Ground control to major Tom, your circuit's dead, there's something wrong…'. How might it feel to be orbiting in space? What about feelings during the five minutes before lift-off or the night before the launch? Creative writing in such novel contexts offers children a chance to explore feelings, both their own and those projected via characters.
- **Cultural and historical**. The night sky is one feature of our modern world which we share with all civilisations preceding us. All ancient peoples saw the night sky, our night sky. They observed with the same wonder as we do and they recorded with the same precision as we do. What stories did they tell to each other and to their children? Of course we might expect the stories told by the North American Indian people to be different to those told by the Mediterranean people and different in turn to those of the Aborigines in the Australian outback. However there are some surprising similarities. Animals feature strongly in star stories as do gods, kings and queens. Children can make up their own star stories. They can also make up their own star patterns and add stories of their own. Such stories are closely linked to belief systems and in particular, offer perspectives on stories of creation and the relationship between humankind and deities. There are books which explore the cultures, myths and legends of the night sky.

Useful websites

The web is full of astronomy information. Here are some sites that are particularly useful for budding observers.

www.heavens-above.com

You can use this site to get your own star chart for any date and time in the future, find out when the International Space Station will be visible, and lots more.

www.popastro.com

This is the website of the Society for Popular Astronomy, the main UK organisation promoting public involvement in observing.

www.roe.ac.uk

This is the site of the Royal Observatory Edinburgh which has a monthly summary of what you can see in the night sky.

www.darkskyscotland.org.uk

DSS run astronomy activities including workshops, family and community activities, and observing sessions.

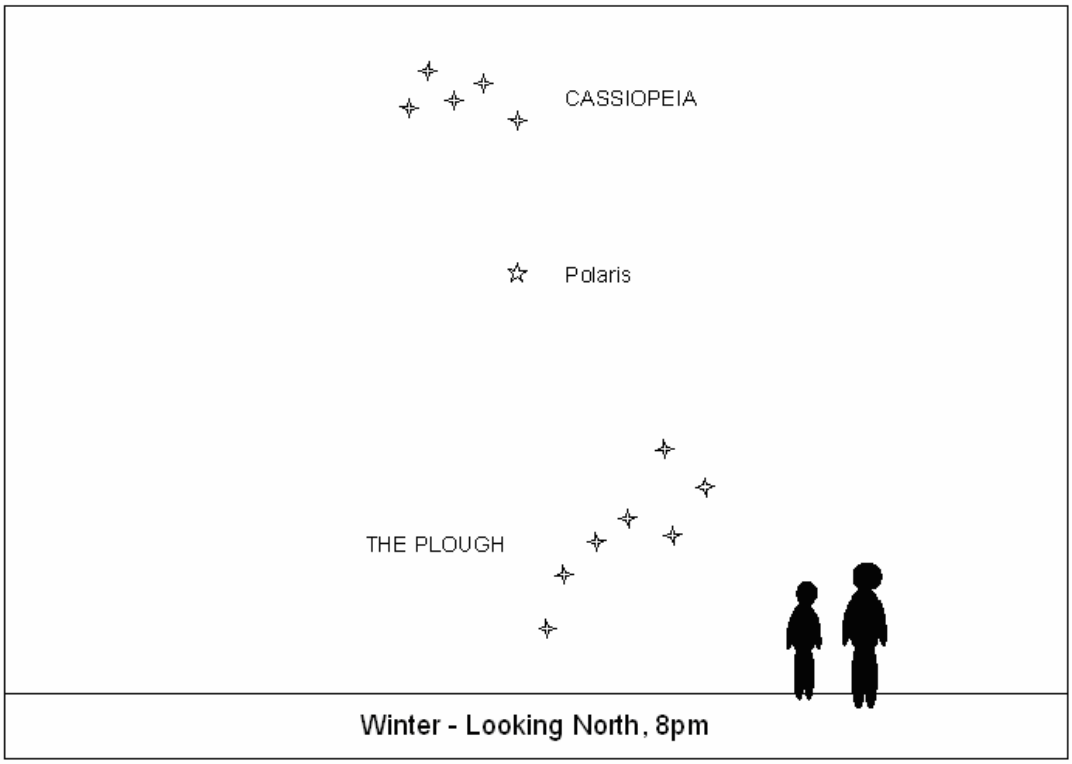
There are also many examples of free planetarium and space software, including…

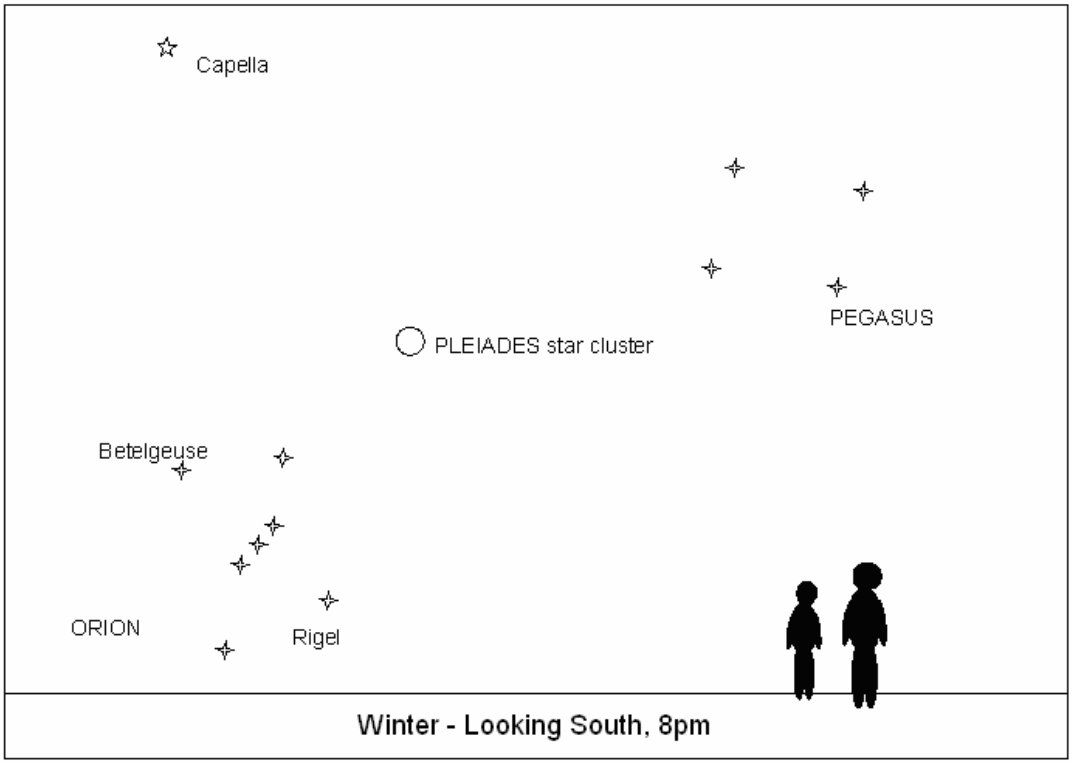
www.stellarium.org which is a fantastic planetarium program, really good for showing the night sky from anywhere on earth, or other planets and bodies in our solar system.

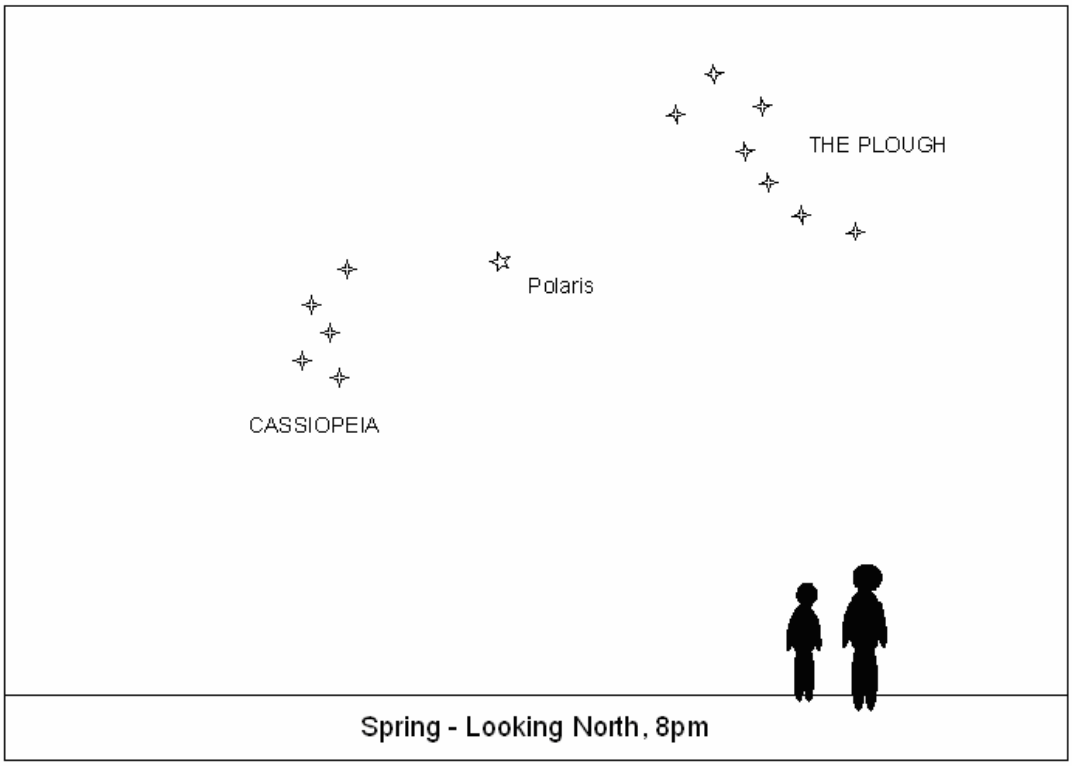
www.shatters.net/celestia which is better suited to fly-throughs round our solar system, but also other stars with known planets, major satellites and more.

http://earth.google.com as well as the fascinating Google Earth, Google Sky (bundled with later releases of Google Earth) allows you to turn the camera round, and look out into space.

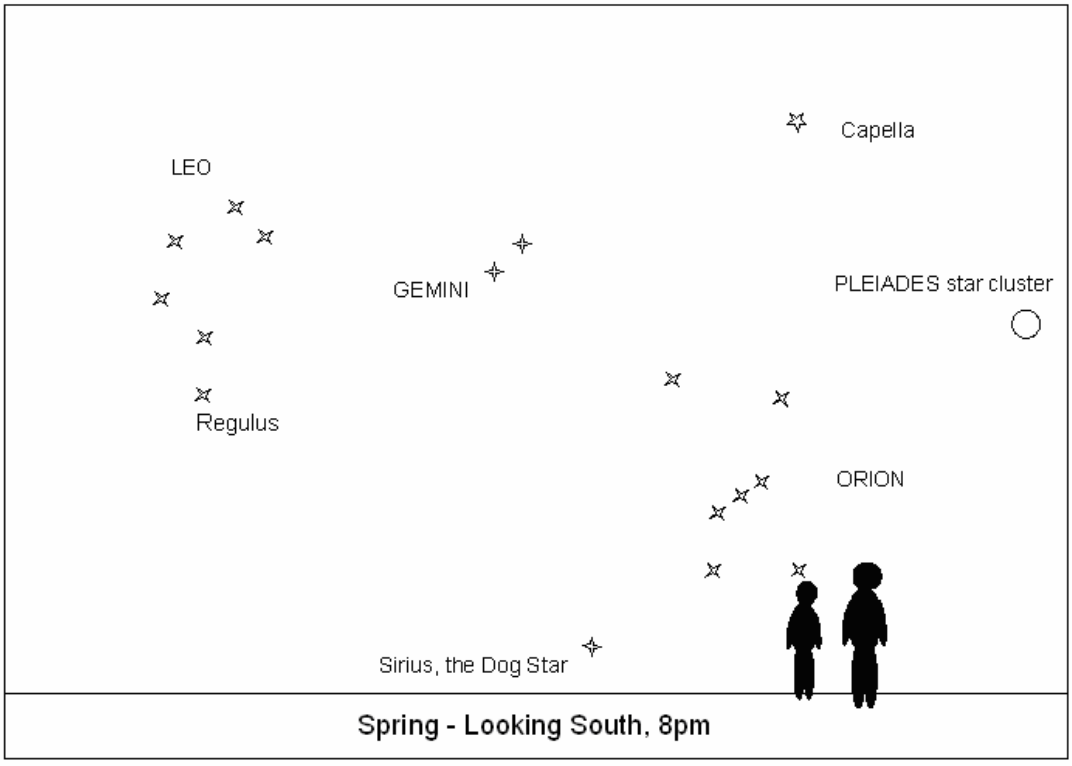
www.worldwidetelescope.org is similar to Google Sky, but looks better and smoother, at the expense of requiring a really good computer to run well.


CASSIOPEIA
Polaris
THE PLOUGH
Winter - Looking North, 8pm

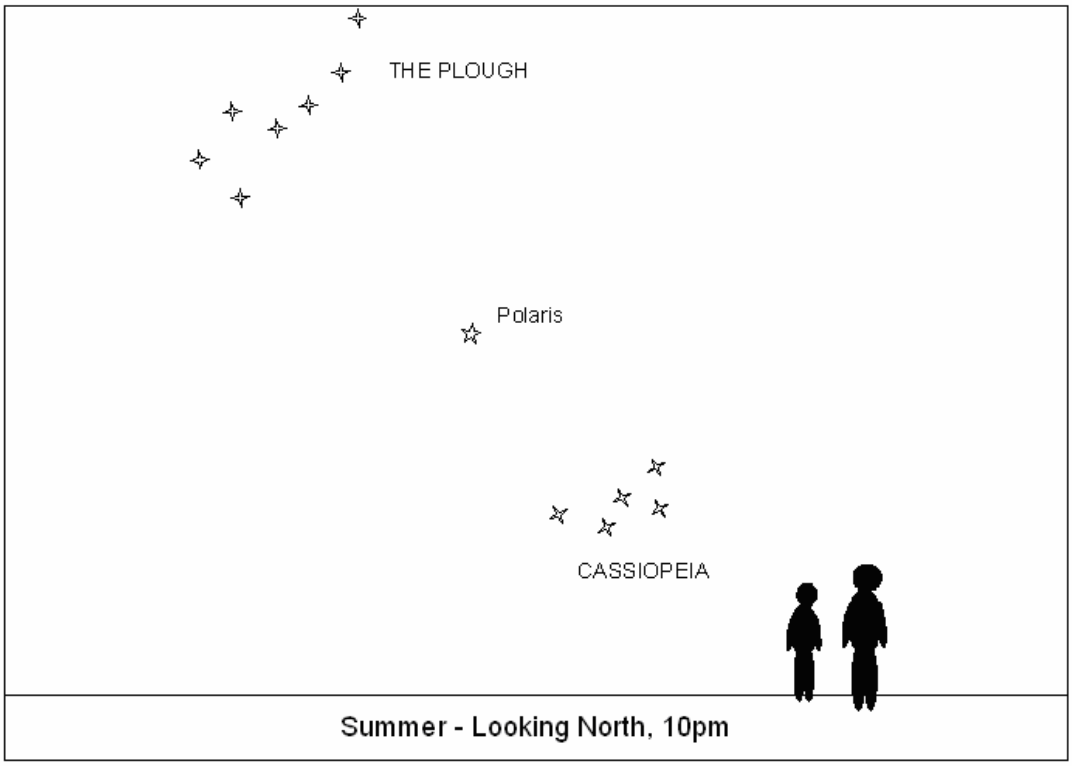

Capella
PEGASUS
PLEIADES star cluster
Betelgeuse
ORION
Rigel
Winter - Looking South, 8pm



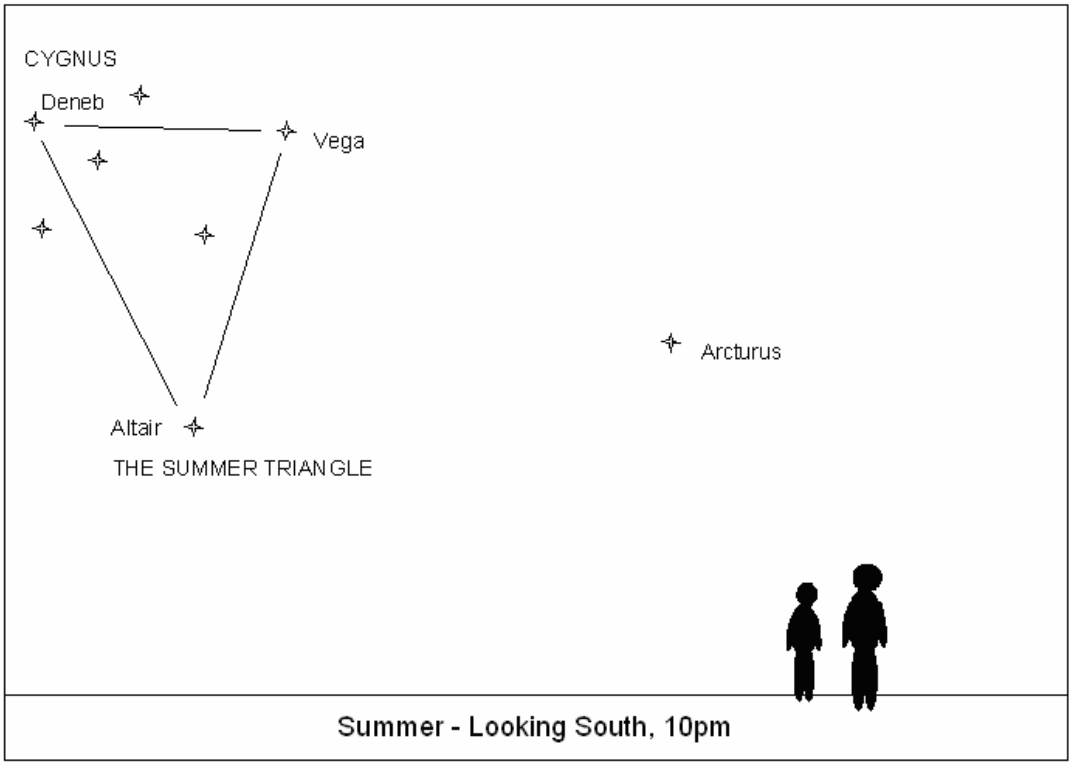
Spring - Looking North, 8pm



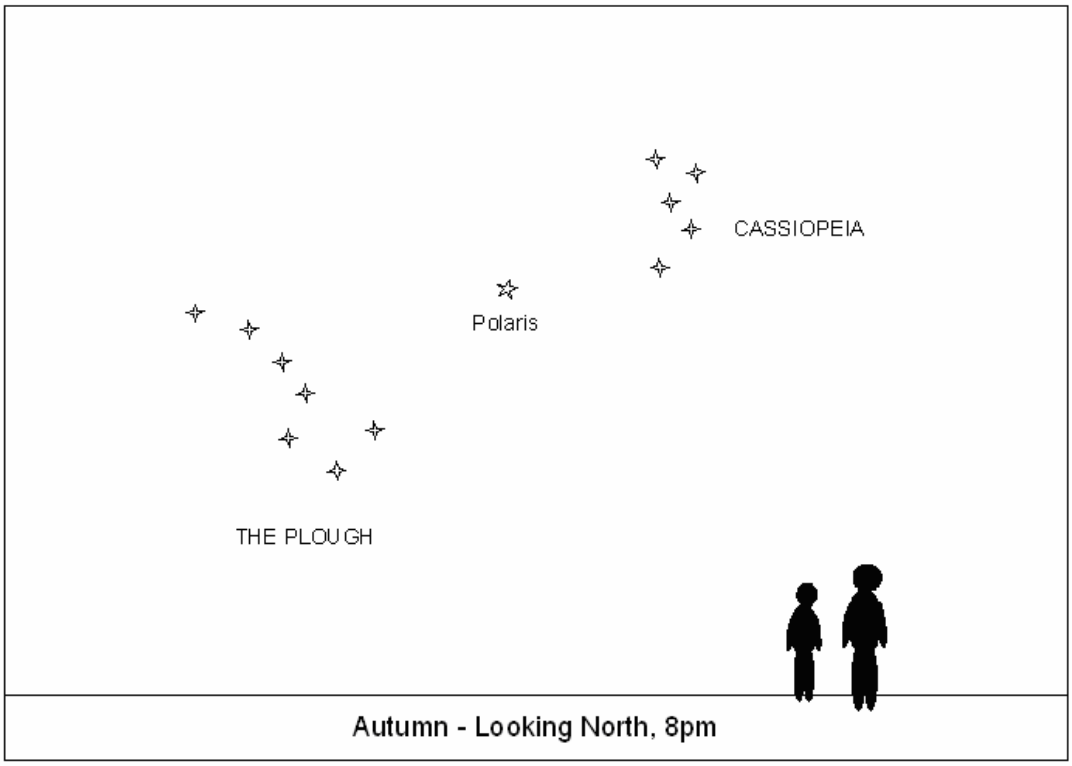
Spring - Looking South, 8pm



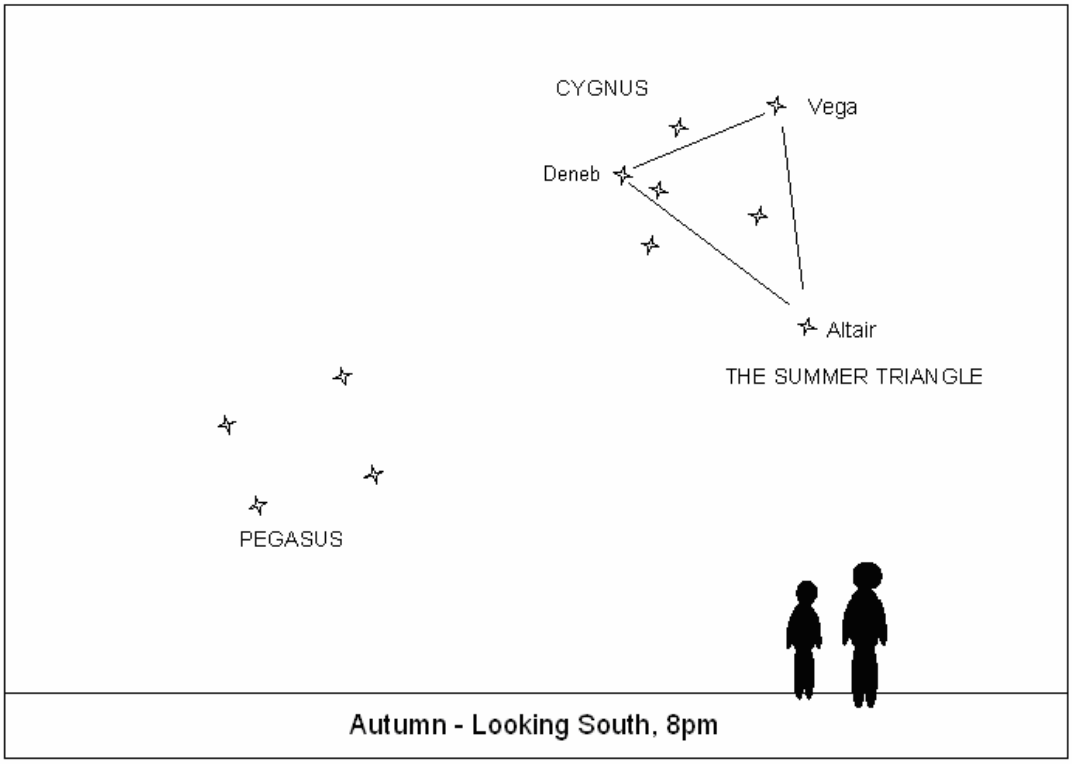
Summer - Looking North, 10pm



Summer - Looking South, 10pm



Autumn - Looking North, 8pm



Autumn - Looking South, 8pm