AN EYE IN THE SKY

13

One of the instruments at Delhi jantar-mantar.

You might have heard elders say that it is approaching dusk (or high noon) after looking at the shadow cast by a tree or some other object. Sometimes, they may also look at the sky at night and say that winter (or summer, or the rainy season) is near. How do they guess these things? In order to answer this question, we have to know about the motion of the sun and stars and we will have to learn to recognise some stars and constellations. Telling the time or date or making a calendar by looking at the sun, moon and stars is nothing new. People have been doing that since ancient times. In the 18th century, the king of Jaipur, Raja Jaysingh had instruments built especially for this purpose in Delhi, Jaipur, Ujjain, Mathura and Varanasi. These observatories are famous around the world even today as "*jantar-mantars* ".

One thing must be made clear at the outset. The movements of the sun, moon or stars that we will be discussing here, are as seen from the earth.

Before beginning the experiments, review the lesson on the mutual relationship of the sun and earth in your Geography book.

Now answer the following questions -

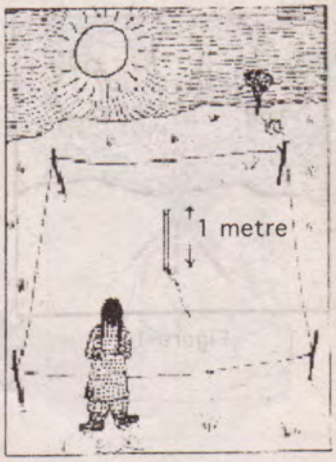
What causes day and night? (1)
Why does weather change during the year? (2)
Where exactly is the sun at noon? (3)
Where in the sky is the sun in the morning? And where in the evening? (4)
Between morning and evening, how does the shadow of a tree change? (5)

Let us now do a few experiments that will enable us to understand these questions more thoroughly.

Experiment-1

A standing stick - does it tick?

You will have to do this experiment on a clear day, between nine in the morning and four in the afternoon.



Locate an open area which will remain sunny for the longest amount of time during the day. Get a stick a little more than a metre long and plant it vertically in the ground. Plant it so that exactly one metre remains above the ground. Choose a place where nobody disturbs it. To protect it, you can even make a fence around it by putting pegs or sticks in the four corners and tying a string around them. The ground you choose should be as flat as possible and should be in an open area where no shadow falls around the stick any time of the day.

Make a mark at the point where the shadow of the tip of the stick falls at nine in the morning. Stick a peg or long nail there. Measure the length of the shadow. Make this observation every half hour using a clock. Make a table of time and length of the shadow. Make a graph of this data. Before making the graph, discuss among yourselves what you would plot on the 'x' axis - time or shadow length? What would be the basis for your decision?

You will have to leave your pegs and stick undisturbed in this place for about two weeks.

Is your graph a straight line or some other shape? (6)
From your graph, find out at what time the length of the shadow was the smallest. (7)

Recall the methods you have learned for finding directions.

Which direction did the smallest shadow point in ? (8)
In your experiment, at what time was the shadow longest? (9)
Why does the length of the shadow change with time? Explain with a picture. (10)
If you had done this experiment for a full day that is from sunrise to sunset, then at which times do you think the length of the shadow would be longest? (11)

A helpful tip

The smallest shadow cast by any vertical object standing on the ground always points north-south. You can use this to locate directions.

A riddle

Looking at the marks of the shadow we made, can you tell how the position of the sun appears to change from sunrise to sunset? If yes, then solve the riddle given in figure-1. This picture shows, the position of the sun at three different times of the day. Positions of the shadow cast by the stick at these times is also shown in the figure.

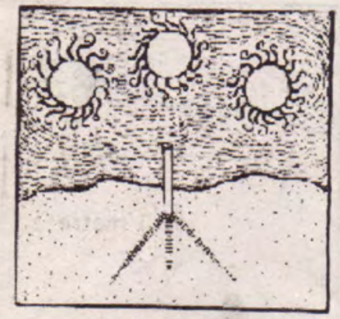


Figure-1

Copy this figure in your note book and try to guess the times of the day corresponding to the three positions of the sun. (12)

Let us proceed

The day after doing Experiment-1, see if the shadow of the stick falls on the same marks at the same times. (13)

Can you use the stick in the ground as a sun-dial? If yes, how? (14)

Two weeks later, check again to see if the shadow still falls on the same marks at the same times. (15)

If not, what could be the reason? Illustrate your answer with a drawing. (16)

A suggestion

In Experiment-1, you saw that the sun's position in the sky changes every hour. If you continued Experiment-1 for an entire year, you would find that the sun's position at any time changes from day to day also. This way, you could make a calendar by putting pegs in the ground at a certain time every week for a year. Next year with this calender, you would be able to figure out dates without the aid of another calendar.

Something to think about

Where in the sky is the sun when it feels hottest during the day? When the sun is rising or setting, does it feel more hot or less than at noon ? (17)

In experiment-1, you made another set of observations two weeks later.

Did the length of the shadows change during this time? If yes, were they longer or shorter? (18)

By looking at the changing shadow length, can you tell whether summer is coming, or winter? (19)

Do it yourself

Find a spot near your house from where you can see the sunrise. You may have to climb on a roof top or go out to an open field. Choose a tree, pole, or some other object as a point of reference and watch the spot where the sun rises for 10-15 days in a row. In your note book, make a sketch of the reference object you have chosen and the point where the sun rises every morning. It would be better if you could make these observations during September-October or March-April.

Does the spot where the sun rises change? If so, in which direction does it appear to move? (20)

When the sun is seen in the southern part of the sky, this is called the winter solstice (*Dakshinayana*) and when seen in the northern sky, it is called the summer solstice (*Uttarayana*).

During your observations, was the sun in the summer or winter solstice? (21)

Experiment-2

Make your own sun-dial

In order to make your sun-dial, first make a right angle triangle ABC out of cardboard. Angle 'C' should be equal to the latitude of your city and take 'A' equal to 90 degrees (Figure-2). A list of latitudes is given below.

Table-1

No.	District	Latitudes
1.	Betul, Chhindwara and Khandwa	22 degrees
2.	Hoshangabad, Narshinghpur, Dhar, Dewas, Ujjain, Indore, Jhabua, Rtlam and Shajapur	23 degrees
3.	Mandsaur	24 degrees

Fix this triangle vertically on a rectangular wooden board. As supports, glue some paper strips along the edge BC on both sides.

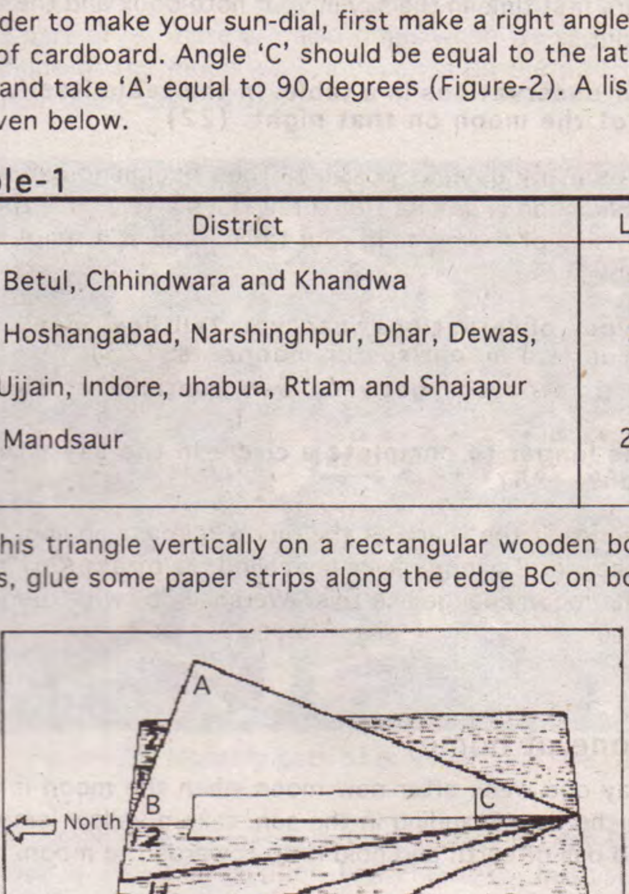


Figure-2

Now place the board on level ground at a place where it gets sunlight all day long. Place it so that the base of the triangle (BC) runs north-south, with point B pointing exactly north. Starting at 9 am by clock, look at the shadow of edge AC which falls on the board and draw a line on it. Do this every hour thereafter and note the time with each line. This is your sun-dial.

Looking at the shadow on the sun-dial, you can tell the time. Make sure that when you are using the sun-dial, the base of the triangle is exactly north-south.

Experiment-3

Motion of the moon

(Do at home)

After the new moon (*Amavasya*), write down the date on which the moon appears first time in the sky in your note book and the time it sets that night.

Record your observations in a table. In the table itself, draw the shape of the moon on that night. (22)

Do this for as many days as possible. Then beginning a few days before the full moon (*Purnima*) till a few days after, note the date and time of rising of the moon in your table. Draw it's shape also in the same table.

Based on your observations, can you tell how many hours pass between two moonrises or moonsets. (23)

How much time passes between two sunrises or sunsets? (24)

Which takes longer to complete a circle in the sky - the sun or the moon? (25)

You have seen that the shape of the moon keeps changing. These changes in the moon's appearance are called the **phases of moon.** Why does the moon change like this? We shall do two experiments to find this out.

Experiment-4

(To be done at home)

Choose a day one week after new moon when the moon is visible even during the day. Standing in the sun, take a yellow lemon or a whitewashed ball of earth and hold it up towards the moon.

Look at the shape of the illuminated part (on which the sunlight falls) of the ball or lemon.

Do you see any similarity between the shape of this part and shape of the moon? (26)

Experiment- 5

(Do around 4 pm)

Wrap a ball tightly with a white handkerchief or some other white cloth. Assume this is the moon. Hold the ball in front of you in the sun. Now turn around slowly. Observe how the shape of the illuminated part of the ball changes.

As you turn, does the sun's light always fall on half the ball? (27)

Despite this, does the shape of the illuminated portion appear different to you in different positions? (28)

Why does that happen? To understand this better, study Figure-3b carefully. In this figure, the big circle in the middle is the earth and the outer ring of smaller circles is the moon in different positions. Half of the moon's surface always remains sunlit. However, the entire illuminated portion is not visible all the time from the earth. Sometimes, we see the entire illuminated portion and sometimes only a part of it. There are also times when we see nothing at all. The shape of the moon we see depends on the part of the illuminated portion visible to us.

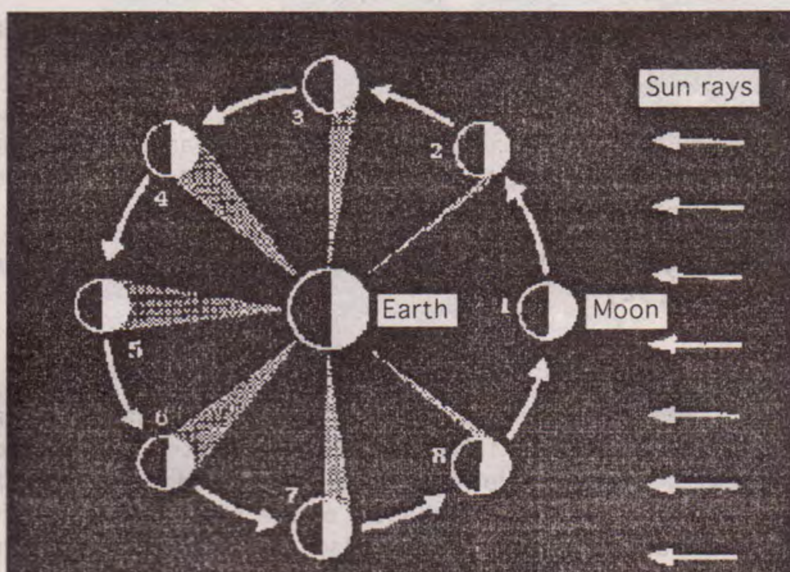


Figure-3b: Monthly path of moon around the earth.

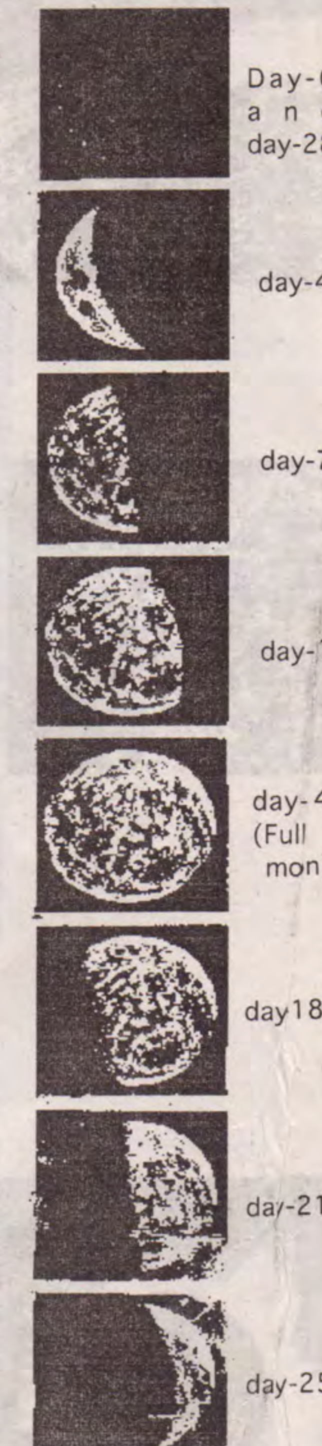


Figure-3a

The day of the new moon is called day-0 here. On day-0 (Figure-3a), the moon is shown in position-1 in Figure-3b. In this position the illuminated portion of the moon is not visible from earth. Therefore anyone looking at it from earth will not be able to see it. Four days later the moon is in position-2. Now a small part of the illuminated portion of the moon is visible from earth. Seven days later the moon comes into position-3. Growing larger and larger, it is in position-5 fourteen days later. In this state, the entire illuminated half of the moon is visible from earth. This is called full moon. After this, the moon grows smaller and smaller each day and passes through positions 6, 7, and 8. When 28 days have gone by, it will again look like position 1.

For instance, though on a new moon day half the moon is illumi-

nated, we can not see it. With your ball, try to create this position. For this, hold the ball towards the sun.

In this position, which half of the ball is illuminated? (29)

On a full moon day, the situation is reversed. The illuminated half of the moon faces us and we see a full round moon.

Similarly, in the intervening phases, we see different shapes of the moon.

Hold the ball in different positions and draw pictures of the shapes of the illuminated portion. (30)

In Figure 3a the shapes of the moon in different phases are as seen from the earth.

Compare your own drawings with the shapes in Figure 3a. (31)

You must have understood by now that on a new moon day, the sun and moon must be in the same direction from the earth. In the same way, on a full moon day, the sun and moon must be in opposite directions from the earth.

Can you say in which direction the moon will rise on a full moon day? (32)

Why do eclipses occur?

In class 7, in the chapter, "Light", you read about solar and lunar eclipses. Why do eclipses take place? In our country, the myth of *"rahu-ketu"* is popular. However, as we know today that a solar eclipse takes place when the shadow of the moon falls upon the earth, and that a lunar eclipse takes place when the shadow of the earth falls on the moon. In the same chapter you did some experiments on formation of shadows.

Describe the situation at the time of a lunar eclipse on the basis of Figure 3. (33)

Why does the lunar eclipse occur only on a full moon day? (34)

On the basis of Figure 3, figure out the situation in which the shadow of the moon will fall on the earth. (35)

Can this situation come about only on a particular day? (36)

Can you now tell why a solar eclipse occurs only on a new moon day? (37)

But why does a solar eclipse not occur on every new moon day and a lunar eclipse not occur on every full moon day?

Let us try to figure this out

On the afternoon of February 16, 1980 a solar eclipse occurred.

During the eclipse, it became quite dark during the day because the sun was covered. Figure 4 is a multiple exposure photograph of the eclipse.

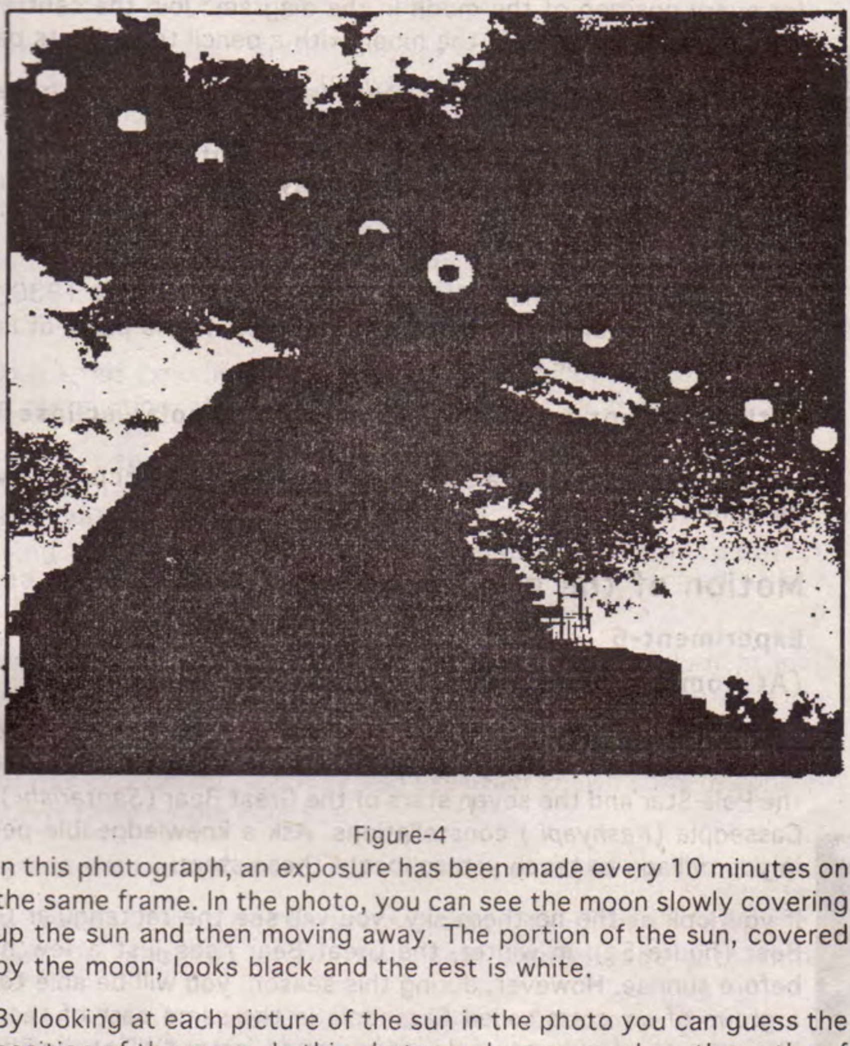


Figure-4

In this photograph, an exposure has been made every 10 minutes on the same frame. In the photo, you can see the moon slowly covering up the sun and then moving away. The portion of the sun, covered by the moon, looks black and the rest is white.

By looking at each picture of the sun in the photo you can guess the position of the moon. In this photograph, can you show the paths of the sun and the moon with different lines?

To make the job easier, a larger diagram based on Figure 4, is given in your kit copy. In one corner of this figure, two round discs are drawn. One black and one white. Their centres are also marked in the figure. The white disc will be the sun and the black disc will be the moon. Cut these two discs from the paper neatly with a blade. In the figure, too, we will assume the white portions to be the sun and the black portions to be the moon. Now we have to find the centres of the sun and the moon in the figure. To do this, start with the white disc. Place it exactly on top of the white portion of any one of the positions in your kit copy diagram. Now pierce a pin at its cen-

Earth

tre. Take away the disc. The pin must have left a mark at the centre of the sun's outline. Make a pencil mark over this. In the same way mark the centre of the sun in every position of the diagram. Join these points with a line. This is the path of the sun. In order to find the moon's path, use the black disc and repeat the same procedure for every position of the moon in the diagram. Join the centres of the different positions of the moon with a pencil to make its path.

Do the sun and moon follow parallel paths or do their paths cross one another? (38)

What would be the difference in the positioning of the sun and the moon on the new moon days when a solar eclipse takes place and when there is no eclipse anywhere. Think about it on the basis of the diagram. (39)

Did you notice one thing in the photo? On 16 February 1980, the sun and moon, each on its own path, arrived at the point of intersection at the same time.

If this had not happened, would a total solar eclipse still have occurred? (40)

Now can you say why a solar eclipse does not occur on every new moon. (41)

Motion of the constellations

Experiment-6

(At home, at night)

When you look at the sky at night do the stars also seem to be moving? In order to study the paths of the stars in the sky, observe the Pole Star and the seven stars of the Great Bear (*Saptarishi*) and Casseopia (*Kashyapi*) constellations. Ask a knowledgeable person in your village to teach you to locate these stars.

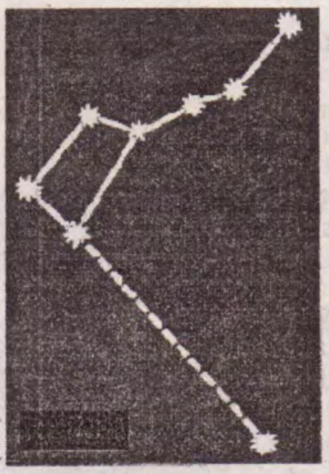


Figure-5(a)

If you look at the northern sky, you will see the rectangular Great Bear (figure-5a). In winter, the Great Bear rises just a few hours before sunrise. However, during this season, you will be able to see a group of six stars called Casseopia in the same part of the sky. These six stars are arranged in the form of letter "W" of the English alphabet (Figure-5b).

With the help of these two constellations as shown in Figures 5a and 5b, you will easily be able to find the Pole Star. If you are only able to see the Great Bear, look at the two stars making up its rectangular end. Extend an imaginary straight line from these two stars. The Pole Star will be found on this line (Figure 5a).

If only Casseopia is visible, the Pole Star can be found on a line passing from the middle of the constellation (Figure-5b).

After locating the Pole Star and Great Bear or Casseopia in the night sky, do the following experiment.

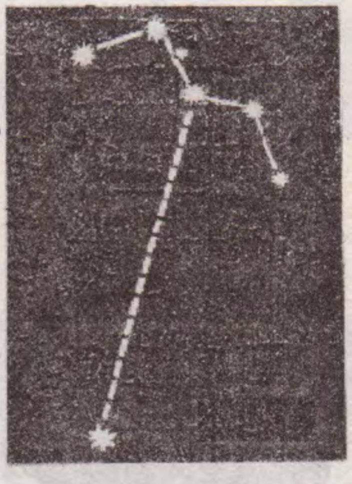


Figure-5(b)

Get a piece of paper about 20 cms long and 20 cms wide. In the middle of it, make a hole one cm in diameter. On one side of the paper, draw a cross (X) mark (Figure-6).

Now hold the paper so that the X is on the bottom. Holding it this way, look at the Pole Star through the hole. As soon as you see the Pole Star, hold the paper in that position and see in which direction is the Great Bear or Casseopia.

Draw an arrow on the paper in the direction in which you find either of the constellations. (42)

From wherever you are standing, choose some nearby tree or house as a reference object. On the paper, draw a picture of the tree or house, indicating its location. (43)

Repeat this experiment every hour thereafter. Every time you make an observation, stand at the same place to look at the stars.

On the paper, draw arrows pointing to the position of the Casseopia or the Great Bear and also note the time of observation. (44)

Using the tree or house you had chosen as reference object, find out if the position of the Pole Star has changed or not. If it changes, note the changed position. (45)

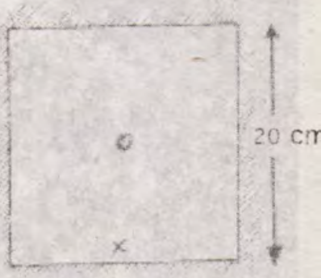


Figure-6

Repeat this activity as many times as possible, but do it at least four times for sure. Each time you must hold the paper such that the X mark is at the bottom.

For this experiment, you may also use other known stars or constellations close to the Pole Star.

Look at the picture you have made and answer the questions below:

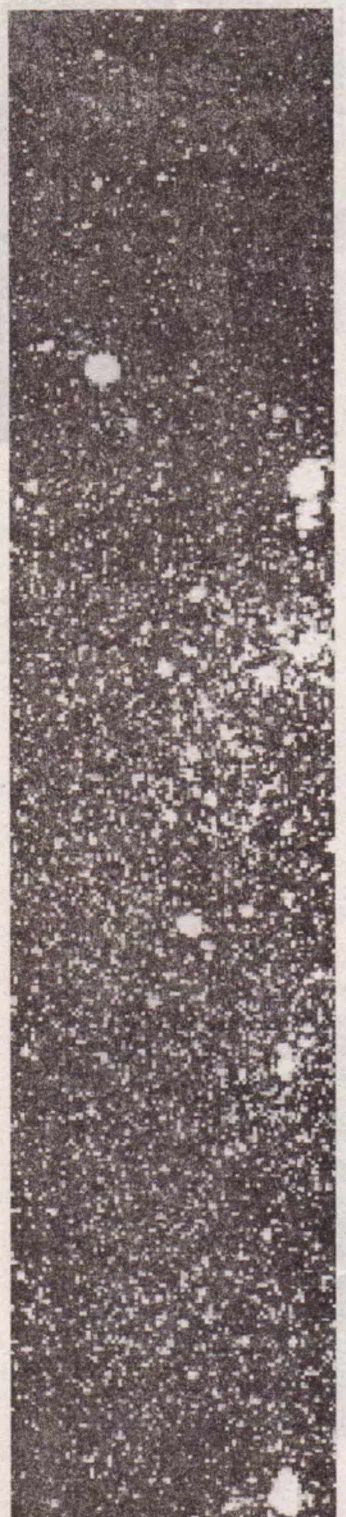
Do the positions of the stars change over time? (46)

Does the position of the Pole Star also change with time? (47)

Do the shapes of the Great Bear or the Casseopia also change with time? Or only the position of the whole constellation changes? (48)

What sort of path do they follow in the sky? (49)

By now you must have realised that the stars too do not remain in one spot but revolve round the Pole Star. The Pole Star remains fixed in its place. It takes 24 hours for the stars to complete one revolution. However, we can see only half of this revolution during the night.



NEW WORDS:

constellation

summer solstice

phases

winter solstice

latitude

reference object