# ASTRONOMY

## FOR BEGINNERS

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FELLOWES.

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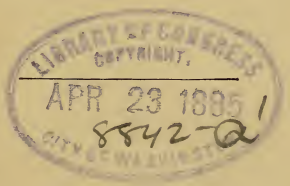
## FOR BEGINNERS,

*IN THIRTY-TWO LESSONS, WITH ILLUSTRATIONS.*

By FRANCIS FELLOWES, M. A.



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# PREFACE.

THIS book is designed for beginners.—Instead, therefore, of beginning in the middle, or at the end, it begins at the beginning; and seeking to avoid an indiscriminate blending of all things, treats of such things, and such only, as are suitable to be set before beginners.

It does not offer to the young learner, as his first lesson in Astronomy, any such positions as these: The Universe is infinite—the Sun is a vast globe 880,000 miles in diameter, placed in the centre of the Solar System, and dispensing light and heat to all the planets, which revolve round him in elliptical orbits—their radii vectores describing equal areas in equal times. Nor does it discourse upon the Laws of Kepler, nor descant upon the Centrifugal and Centripetal Forces, nor discuss the Properties of the Ellipse. If, in pre-

paring a treatise for beginners, such things had entered into the plan of the author, he would have written in Arabic.

The first thing to be done, in studying Astronomy, is to observe the Heavens, and to become familiar with the appearances which present themselves there; for without doing this it is impossible to arrive at any proper understanding of the science. First of all, therefore, I have directed the attention of the pupil to the general form of the Heavens; then to the situation, most remarkable appearances, motions, etc., of the sun—moon—planets—fixed stars, and comets—and, finally, I have given a brief view of the Solar System. Such I believe to be the natural order;—it is the order which was followed in establishing the science—and necessary to be followed by those who would acquire any proper knowledge of it.

But the attention of the learner has not been confined to appearances merely. As opportunity offered, remarks have been made and hints thrown out, calculated to show him the *illusive* nature of the scenery of the Heavens, and to lead

him to just notions of the *real* magnitudes, motions, distances, and nature of the heavenly bodies.

The work is not a compilation. The author's design was to place the science of Astronomy—fitted as it is to enlarge the understanding and elevate the moral feelings—within reach of beginners. For this end, no compilation would suffice. It was necessary to employ an arrangement—a style—and a manner entirely new. The designs for the engravings are many of them original, being expressly adapted to illustrate the *simple*, *elementary* ideas which it is the object of this book to inculcate.

When the pupil has acquired these ideas, he will be prepared to advance to the study of larger and more difficult works.

FRANCIS FELLOWES.

HARTFORD, CONN.,
*February*, 1885.

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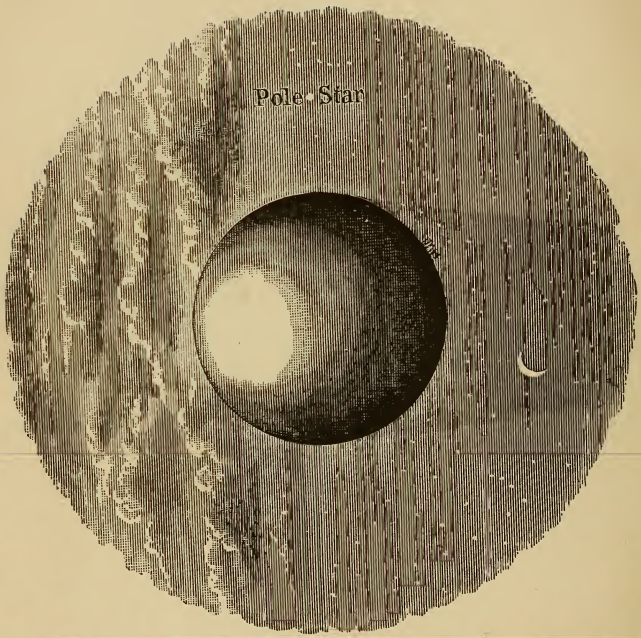
Pole Star

# ASTRONOMY.

## LESSON FIRST.

### THE HEAVENS.

1. You have all read, that in the beginning God created the Heavens and the Earth. I suppose you have studied Geography. Geography treats of the Earth. If you now wish to learn something about the Heavens, you must study Astronomy. Astronomy treats of the Heavens.

2. *The Heavens* consist of the sky, and of the sun, moon, and stars, which seem to be placed within it. The earth, as you have learned, is round like a ball. The Heavens surround the Earth. We know this because the people, on all sides of it, can look up and behold them. If you should go to Europe, or to Asia, or to any other part of the earth, you could always see sky; and in a clear night it would be a beautiful blue sky with stars.

3. On the opposite page is a picture of the

Earth surrounded by the Heavens. Travellers tell us that when it is day on one side of the earth, it is night on the other side. On the light side of the picture, it is day; on the other side, it is night. You see no stars represented on the light side. There are stars there as well as on the dark side, but on account of the sun's light, which spreads all over the sky, they cannot be seen. There are stars overhead in the day-time as well as in the night. We know this because the sun has been eclipsed, or darkened, in the day-time, and then the stars have appeared. On the dark side of the picture, where it is night, the stars are seen, shining through the darkness.—In the day-time, you cannot perceive the light of a candle, placed at some distance from you; but in the night you can see the lights through the windows of very distant dwellings. So it is with the stars.

4. You have all looked up to the sky on a clear evening. It looks like a beautiful blue vault, with thousands of stars set in it, all sparkling like diamonds.—The highest point in the sky appears to be that which is right overhead. This point is called the *Zenith.* All around you, at the most distant limit to which the eye can reach, the sky seems to touch the ground, making as it

were a circle. This circle is called the *Horizon.* Horizon means *boundary;* it is the boundary of the sight,—you cannot look beyond it.

5. We call certain points in the horizon, *East*, *West*, *North*, and *South*. *East* is near where the sun rises. *West* is near where he sets. If you stand with your back towards the sun at noon, your face will be towards the *North;* your back, towards the *South;* your right hand, towards the *East;* and your left hand, towards the *West.*

6. The sun, moon, and stars, all appear to move in the sky. The moon appears very differently at different times; and the stars, although at first glance they may seem to be alike, have different degrees of brightness. Numerous as they are, men have given names to them all. They began to give names to them thousands of years ago. In one of the oldest books which we have, the *Book of Job*, we find the names *Arcturus*, *Pleiades*, *Orion.*

7. The most important things to be learned, in beginning to study Astronomy, are the *names*, *appearance*, *positions*, and *motions*, of the sun, moon, and stars. In some respects, Astronomy is like Geography. In studying Geography, you learn the appearance, names, and situation of places on the Earth; in studying Astronomy,

you learn the appearance, names, and situation of objects in the Heavens.

8. It will be of little use to you to study books on Astronomy, unless you go out and look at the Heavens for yourselves. Men first began to study Astronomy by observing the Heavens. They observed them a long time before any books on Astronomy could be written. The shepherds, on the plains of Babylon, were the first Astronomers. As they lay upon the ground, under the open sky, watching their flocks, they observed the stars, and thus learned Astronomy. —David, king of Israel, was once a shepherd; and, as I think, while taking care of his flocks, used to observe the Heavens. Filled with admiration of their glory, he thinks how glorious He must be who made them. He says, "the Heavens declare the glory of God." Like David, observe the Heavens, and learn to adore their Maker.

QUESTIONS.

1. Who created the Heavens, and the Earth?
   What science treats of the Earth?
   What science treats of the Heavens?
2. What are the Heavens?
   What is the shape of the Earth?
   How do we know that the Heavens surround the Earth?
3. What does the picture opposite to page first represent?
   How do we know that, when it is day on one side of the Earth, it is night on the other side?
   On which side of the picture is it day?
   On which side is it night?

Are there any stars in the sky, in the day-time?
How do you know this?
Why cannot the stars be seen in the day-time?

4. How does the sky look in a clear evening?
Which seems to be the highest point in the sky?
What is this point called?
What is the circle called which the sky seems to make, where it appears to touch the ground?
What does Horizon mean?

5. What are East, West, North, and South?
Where is East?
Where is West?
Where is North?
Where is South?

6. Do the sun, moon, and stars appear to move?
Which of these bodies appears very differently at different times?
Do the stars all appear just alike?
In what respect are they unlike?
Who have given names to the stars?
What names of stars are found in the Book of Job?

7. What are the most important things to be learned in beginning to study Astronomy?
Tell me some things in which Geography and Astronomy are alike?

8. How did men first begin to study Astronomy?
Who were the first Astronomers?
What king of Israel was once a shepherd and Astronomer?

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# LESSON SECOND.

## THE SUN—DAILY MOTION.

1. The Sun seems to be the largest, brightest, and most powerful object which ever appears in the heavens. His light wakes men, and animals, and birds from their sleep, and renders the face of the earth visible; while his warmth seems to impart life and activity to all things. He is so

powerful, it is no wonder that he should be called the king of day. The Bible says that God made the sun to *rule over* the day.

2. The sun *appears* to have *two* motions; a *daily* motion, and an *annual* motion. The *daily* motion is that which he seems to perform through the heavens every day. Although you have observed it many times, I will describe it, and then, perhaps, you will observe it more attentively.

3. A short time before sunrise, you may see a few rose-colored streaks of light reaching up into the eastern sky, and separating from each other very much like your fingers, when you hold them up and open them wide. The Greeks used to imagine them to be the fingers of a goddess, whom they called rosy-fingered *Aurora*. These rays become thicker and thicker, until the whole eastern sky is of a rosy red. The light which appears before the sun rises, is called the *Morning Twilight*.

4. Soon the sun himself is seen, just where the eastern sky seems to touch the ground. He is now said to be in the *horizon*. He looks large, round, and of a reddish color. The rising sun is a glorious object to behold. He is compared, in the Bible, to a bridegroom coming out of his

chamber. You will understand this, when you are informed that in eastern countries, the bridegroom came out of his chamber in the night, in a dress adorned with gold and precious stones, reflecting the light of many torches, borne by his friends, and went forth to meet the bride. Just so the sun comes up, arrayed in his glory.

5. The sun seems to ascend into the sky always a little south of you, until he has come to the highest point to which he can reach. He is then said to be on the *meridian*, and is *exactly* south of you. He has now finished just one half of his daily journey, and it is said to be *mid-day*, or *noon*.

6. As soon as the sun reaches the meridian, he begins to descend. This he continues to do, until you see him in the western horizon, just opposite to where he was when he rose. He has now finished the other half of his daily journey, and soon disappears.

7. After the sun disappears below the horizon, his rays continue for a while to come up into our sky. The light which appears in the evening, after the sun sets, is called the *Evening Twilight*.

8. I have now described to you the daily motion of the sun. You think, perhaps, that the sun *really* moves. He *appears* to move, but you

must not, from this, conclude that he *does* move. When you ride in a coach, or sail down a river in a boat, if you fix your eyes upon the trees and other objects on the earth, they *seem* to move, but you do not conclude from this, that they *do* move. It is the coach, or the boat, in which you are, that moves, and this makes the objects, on which you fix your eyes, *appear* to move. If we suppose that the sun remains perfectly still, and that the earth, suspended in the heavens, turns round, presenting its sides one after another, to the sun, the sun will *appear* to move just as he now does.

9. Day and Night.—The sun's daily motion, whether real or apparent, makes *day* and *night*. It is very plain that if the sun were always in the sky above us, we should always have day; and that if he were always in the sky on the other side of the earth, we should always have night. We know that when the sun disappears from our sky, he appears in the sky on the other side of the earth; and that when *we* see him, he cannot be seen there, because people who have been there tell us so.

Look at the picture opposite to page first, and you will see day represented on one side of the earth, and night on the other.

QUESTIONS.

1. Which seems to be the largest, brighest, and most powerful of all the heavenly bodies?
2. How many motions does the sun appear to have?
   What are they called?
   What is the sun's daily motion?
3. What is the color of the light which first appears in the morning?
   How do the streaks of light reach up into the sky?
   What did the Greeks use to imagine them to be?
   What is the morning twilight?
4. When the sun first appears in the morning, where is he said to be?
   How does the rising sun look?
   To what is he compared in the Bible?
   Explain this.
5. Which way from you is the sun as he ascends into the sky?
   When the sun is highest, where is he said to be?
   Which way from you is he at that time?
   How much of his daily journey has he then finished?
6. When the sun has reached the meridian, which way does he begin to go?
   How much of his daily journey has he finished when he appears in the western horizon?
7. What is the evening twilight?
8. Is it certain that the sun really moves?
   Tell me some instances in which things *appear* to move, that do not.
   What may make the sun appear to move, although perfectly still?
9. What makes day and night?
   Where does the sun go, when he disappears from our sky?
   When we see the sun, can he be seen on the other side of the earth?
   How do we know this?

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# LESSON THIRD.

## THE SUN—ANNUAL MOTION.

1. The sun does not always rise and set in the same points of the horizon.

In summer, he rises and sets farther north, and in winter, farther south. Have you not ob-

served, that he seems to be farther south of us, in winter, than in summer? In winter, his rays come to us, from the south, in a slanting direction; but in summer, he appears to pass through our sky more directly overhead, and his rays come more directly down upon us.

2. The sun rises and sets farthest north on the 21st day of June. This is the longest day in the year. On this day, the sun has the longest distance to go through our sky. Hence he is the longest time above our horizon.

The sun rises and sets farthest south on the 21st day of December. This is the shortest day in the year. On this day, the sun has the shortest distance to go through our sky. Hence he is the shortest time above our horizon.

After the 21st day of December, he rises and sets farther and farther north, until the 21st day of June, when he begins to rise and set farther and farther south again.

Two days in the year, the sun rises exactly in the east and sets exactly in the west. These days are the 21st day of March and the 21st day of September. The day and night are then equal. We know all this from long observation.

3. Thus the sun seems to be moving, the whole year, from north to south, and from south

to north again. This motion is called his *annual*, or *yearly motion*. It is not so perceptible as his daily motion, but you may easily discover it. If you notice a tree, a building, or some other object in the direction of the rising or setting sun, you will see, after several days, that he appears to have moved.

4. I told you, in the last lesson, you must not conclude that the sun, because he *seems* to move across the heavens every day, *really does* move. Neither must you conclude that he *really moves* north and south every year, because he *seems* to do so. The motion of the earth would make him appear to move.

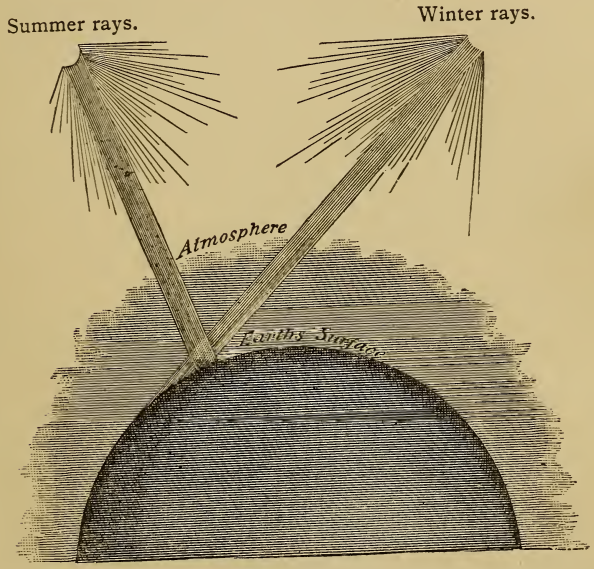
5. The annual motion of the sun makes the days and nights of unequal length. You know that the days are much shorter in winter than they are in summer; and the nights, much longer. The reason of this is very plain. Look up at the sky, and you will see that it does not appear to be so far across it, south of you, as it does right overhead. Now, it is the sun passing through our sky, that makes the day. In winter he passes through it quite south of us, and has less distance to go. It therefore takes a less number of hours. In other words, the sun is in our sky a shorter time; the days are shorter, and the nights longer.

6. WINTER AND SUMMER.—The annual motion of the sun also makes Winter and Summer. It does this in several ways. Since in winter the days are shorter, the sun's heat comes to us a *shorter* time than in summer, and in the long nights, the earth has a longer time to cool. This is one thing which makes the difference between winter and summer. I will now tell you another.

7. When the sun is far south of us, as he is in winter, his rays fall upon the earth *slantingly*, and for this reason, are more scattered than they are in summer, when the sun is overhead, and his rays fall straight down upon us. On page 13, is a picture representing the sun's rays as they fall upon us in winter, and in summer. Look at the picture, and you will see that in winter they are more scattered than in summer. For this reason, they do not feel so hot to you.

If you should put some coals of fire into a little pan and hold your hand over them, they would feel much hotter than the same coals would if scattered about in a larger pan. So it is with the sun's rays. Have you ever seen a sun-glass? When a sun-glass is held up to the sun, his rays, in passing through it, are brought closer together, and on this account, feel very hot to the hand, and will even set paper on fire.

8. There is still another reason why we have less heat in winter than in summer. The earth, you know, is surrounded by the air or atmosphere, through which the rays of the sun have to




travel before they can reach us. It has been found that some of the sun's rays which enter the atmosphere get lost on the way. I suppose the atmosphere swallows them up.

Now look on the picture, and you will see that the winter rays have to travel a greater distance through the atmosphere than the summer rays. The atmosphere through which they travel is also nearer the earth, and on this account, thicker. For these reasons, more of them are swallowed up, and never come to the earth. Of *ten thousand* rays which enter the atmosphere when the sun is in the horizon, it has been computed, that only *five* reach the earth.

I have now explained to you the principal causes of Winter and Summer.

## QUESTIONS.

1. Does the sun always rise and set in the same points of the horizon?
   When does he rise and set farther north?
   When farther south?
   In what direction do the winter rays come to us?
   In what direction, the summer rays?
2. On what day of the year does the sun rise and set farthest north?
   On what day farthest south?
   After the 21st of December, which way does the sun seem to move?
   Which way after the 21st of June?
   How many days in the year does he rise exactly in the east, and set exactly in the west?
   What days are these?
   When are the days and nights of equal length?
3. What is the motion of the sun, north and south, called?
   Is it as perceptible as his daily motion?
   How may you easily discover it?
4. Do you certainly know that the sun moves north and south?
   What might make him *appear* to move in this direction?
5. What makes the days and nights of unequal length?

In what season are the days shortest, and the nights longest?
Explain the reason of this?

6 What makes winter and summer?
When has the earth a shorter time to become hot by day, and a longer time to cool by night?

7. How do the winter rays strike the earth?
Are they more or less scattered than the summer rays?
Which feel the hottest, scattered rays, or the same number of rays close together?

8. What must the sun's rays travel through, before they can reach us?
Do all the rays which enter the atmosphere, reach the earth?
What becomes of some of them?
Why do less rays reach the earth in winter than in summer?
Of ten thousand rays which enter the atmosphere when the sun is in the horizon, how many reach the earth?

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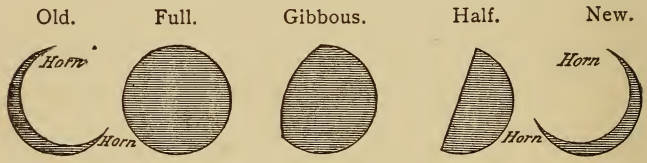
## LESSON FOURTH.

### THE MOON—APPEARANCE AND MOTION.

1. The Moon is the most beautiful object which we ever behold in the sky. Every one admires the moon. Even young children think her so beautiful that sometimes they cry, because they cannot reach their little hands up into the sky, and pull her down to them. How dark the nights would be, if there were no moon to spread her soft and silvery light over the face of the earth.

2. The sun, all-powerful and splendid as he is, is sometimes called a king. The moon, less powerful and splendid, but more lovely and beau-

tiful, is sometimes called a queen. The Bible says that God created the moon to *rule over* the night. This means that she seems to be the largest of all the bodies seen in the sky by night, and has power to chase away the darkness. Here is a picture of the moon's *phases*.




3. *Phases* means *appearances*. The phases of the moon are her different appearances. They are a most wonderful thing. The sun and the stars always preserve very nearly the same appearance, but the moon is almost continually changing. Sometimes, she looks like a bow of light hung up in the sky. Then, after a few days, she resembles the half of a new cheese, which seems to increase every night, on the straight side, growing rounder and rounder, until she seems perfectly round. The most remarkable phases of the moon are *five* in number. You see them represented on the picture. Their names are *new*, *half*, *gibbous*, *full*, and *old*.

4. The moon has some other remarkable appearances. She does not seem of a silvery whiteness all over; some spots appear dark. Once, astronomers supposed that the moon's surface, like the earth's, consists of land and water. The bright parts, they thought were land, and the dark spots, water. Recent observations seem to prove that, while there are many mountains and volcanoes on the moon, there is no water.

5. The moon, like the sun, appears to have *motion.* Two of her motions are very perceptible. One of them is from east to west. This motion you can see every night, when she is visible. If you observe her at any time, and then an hour or two afterwards observe her again, you will see very clearly that she seems to have moved towards the west. If you observe her long enough, you will see her set, like the sun, below the western horizon. The earth turning round like a great ball, from west to east, would make the moon appear to move from east to west. But you will ask me, Where does the moon go, when she sets? She is in the sky on the other side of the earth.

6. The other motion of the moon is from west to east. You cannot perceive this motion by looking at her only one night. If you wish to

perceive it, you must observe her several nights in succession. You will then see that every night she appears farther and farther towards the east, when she first becomes visible. I think that the moon *really moves* through the sky around the earth, from west to east. I have reasons for believing that it is not the motion of the earth which, in this case, makes her appear to move. But I cannot explain them to you now.

## QUESTIONS.

1. What is the most beautiful object which we ever behold in the sky?
   How do we know that even young children admire her beauty?
2. What does the Bible say that the moon was created to rule over?
   What is meant by the moon ruling over the night?
3. What does the word *phases* mean?
   What are the moon's phases?
   What different appearances has the moon?
   How many in number are her most remarkable phases?
   What are they called?
4. What other remarkable appearances has the moon?
   What did astronomers once think the bright parts to be?
   What did they think the dark spots were?
   What do recent observations seem to prove?
5. How many motions of the moon are very easily perceived?
   Which way does the moon appear to move every night?
   Where does she go when she sets?
6. Which way is the other motion of the moon?
   Can you see this motion on any one night?
   What must you do if you wish to perceive it?

# LESSON FIFTH.

## THE NEW MOON AND HALF MOON.

1. Here is a picture of the New Moon.

NEW MOON.

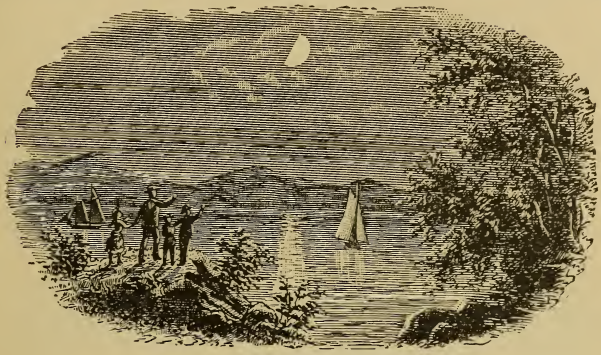
The New Moon appears in the west, when the sun is setting. It is a little way above the sun. You can see the new moon but a very short time. It seems to be going down lower and lower, and soon disappears below the western horizon.

2. There was once in Judea a beautiful custom of announcing the appearance of the new moon. Some persons used to keep watch for it, and, as soon as they saw it, they came to Jerusalem to tell the rulers. The rulers sent a man with a bundle of straw or brush to the top of the Mount of Olives, which was near Jerusalem. There the man set his bundle on fire, and kept waving it backward and forward. As soon as the people saw it, they made similar fires on the surrounding hills, which other people imitated, until the whole country blazed with the joyful signal. All this was done to tell the people when the holidays would come. The holidays happened a certain number of days after new moon. Some nations used to observe the time of new moon as an occasion of feasting and rejoicing. Every one is pleased to behold the moon when she returns to gladden the earth with her light.

3. The moon continues to increase, appearing farther and farther east every night, at sunset, and in about a week she appears on the meridian, a *Half Moon.* On the next page is a picture of the Half Moon.

You see the sun setting in the west, and the Half Moon on the meridian. If you observe it, in the sky, a little while, you will see that it

seems to be moving towards the west. Can you tell me at what time it will go down? It takes



HALF MOON.

the sun half a day to go the same distance. It will, then, take the moon half the night. It will set at midnight.

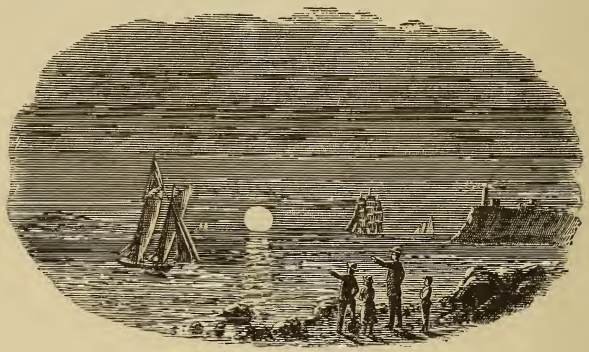
QUESTIONS.

1. Where and when does the new moon appear?
   How far does it seem above the sun?
   How long can you see the new moon?
   Which way does it seem to be going?
   Where does it disappear?
2. What beautiful custom of announcing the appearance of the new moon once existed in Judea?
   What was this done for?
3. How long a time is it from new moon to half moon?
   Which way does the moon seem to be moving during this time?
   Where does the half moon appear at sunset?
   Which way does it seem to be moving?
   At what hour will it set?

## LESSON SIXTH.

### THE FULL MOON, AND OLD MOON.

1. The moon still continues to increase, appearing farther and farther toward the east every



FULL MOON.

night at sunset. When her eastern side begins to look roundish, she is said to appear *gibbous*.

2. In about two weeks from new moon, you see the *Full Moon*, rising in the east, while the sun is setting in the west. Here is a picture of the Full Moon.

You have often seen the full moon coming above the horizon, round and large, like the sun. The full moon rises when the sun sets, and sets when the sun rises. It shines all night.

3. The moon, after her full, rises after sunset, and later and later every night. She now seems to decrease, on her western side, until she appears first a gibbous, then a half moon, and in

OLD MOON.

about a week from the time of her full, again looks like a bow of light suspended in the sky. She seems almost worn out, and is for this reason called *Old Moon.* Here is a picture of the Old Moon. You see it in the east, just above the rising sun.

4. The old moon and the new moon look just alike. But the new moon, you remember, appears in the *evening*, just above the *setting* sun, and its horns are turned towards the *east*. The old moon appears in the *morning*, just above the *rising* sun, and its horns are turned towards the *west*. Will you remember that the round side of the moon is always towards the sun?

5. The old moon is in the sky over our heads in the day-time. I have seen her in the sky about the middle of the afternoon. A few days before I wrote this lesson, I saw her at this time. A little boy about six years old first observed her, and showed her to me. The air was a little hazy, and the sun's light somewhat darkened.—But where is the moon when we cannot see her in the evening sky? Like the sun when he is gone down, she is in the sky on the other side of the earth. The people there can see her. God takes care of them as well as of us. He gives them the moon, a part of the time, and us, a part.

6. I have now told you about all the different phases, or appearances, which the moon has. Are they not a very wonderful thing? Have you never wondered what it can be that makes them?

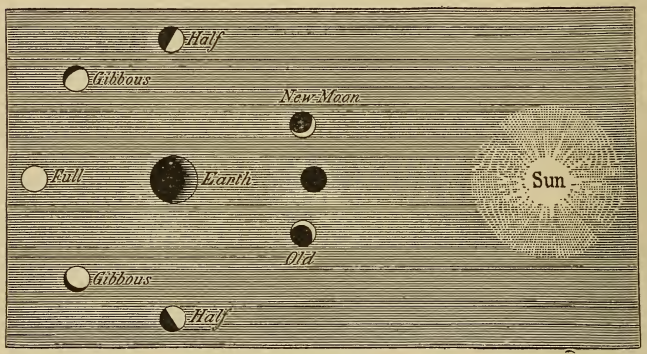
7. I will now tell you. The moon is a great dark ball. She has no light of her own ; it is all borrowed from the sun. The sun's light falls upon her surface, and bounds off until it strikes the earth. Sometimes it comes to us through the dark sky of night, and makes the moon visible.

8. The moon goes round the earth from west to east once a month, always presenting one side to the sun. You remember that we saw her moving from west to east, day after day, as we watched her progress from new moon to full moon. The side towards the sun is light, and the other side, dark.

9. Now look on the picture on the next page, and I will show you what makes the moon's phases.

You see the moon represented here, just as she appears in different parts of her course around the earth. In one place she is right between the earth and the sun. Here her dark side is towards us, and we cannot see her at all. As she moves up, her light side begins to be towards us, and we see that little bow of light which we call new moon. As she moves forward, her light side turns towards us more and more, until she has completed half her journey round the earth. Now the whole of her light side is towards us,

and she appears full. Look on the picture, and you will perceive that from new moon to full moon is half way round the earth.




MOON GOING ROUND THE EARTH.

10. Now the light side begins to turn *from* us, and we see the moon decreasing, during the other half of her course, just as she before increased. At length she becomes a slender bow of light again. She seems almost worn out, and we call her *old* moon. Finally, coming to the spot from which she started, between the earth and the sun, her whole enlightened side is again turned from us, and she disappears. Thus the moon travels

round the earth every month, showing to the inhabitants, on its different sides, her wonderful phases, cheering them with her light, and like Him who made her and placed her in the sky, seems never weary in well-doing.

## QUESTIONS.

1. As the moon increases, which way does she seem to have moved every night?
   When is she said to appear gibbous?
2. How many weeks from new moon to full moon?
   Where does the full moon first appear?
   When does the full moon set?
   How much of the night does it shine?
3. Does the moon rise earlier, or later, every night after her full?
   Which side now begins to decrease?
   How long before the moon again looks like a bow?
   What is she now called?
4. At what time of day, and where, does the new moon appear?
   Which way are its horns turned?
   At what time of day, and where, does the old moon appear?
   Which way are its horns turned?
   Which way is the round side of the moon always turned?
5. Where is the old moon in the day-time?
   Where is the moon gone, when we cannot see her, in the night?
6. Have you never wondered what makes the moon's phases?
7. What is the shape and color of the moon?
   Where does she get her light?
   What becomes of the sun's light when it falls on her surface?
   What makes the moon visible to us?
8. How often does the moon go round the earth?
   Which way does she move?
   As she thus goes round the earth, which side is light, and which side dark?
9. Now look on the picture, page 26. How is the moon represented there?
   Point to her when right between the sun and the earth.
   Why do we not see her when she is there?
   Point to the new moon.
   What makes the new moon?
   Point to the half moon.

How much of the light side is now towards the earth?
How much of her journey has the moon now completed?
Point to the gibbous moon.
Point to the full moon.
What makes the full moon?
How much of her journey has the moon now completed?
10. Which way does the moon's light side now begin to turn?
What phase does the moon have next after full moon?
Point to the gibbous moon again.
What phase does she have next?
What phase next?
Why do we call this phase old moon?
Show me, on the picture, where the moon disappears.

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## LESSON SEVENTH.

### ECLIPSES OF THE SUN.

1. Eclipses are the most remarkable appearances ever seen in the heavens.

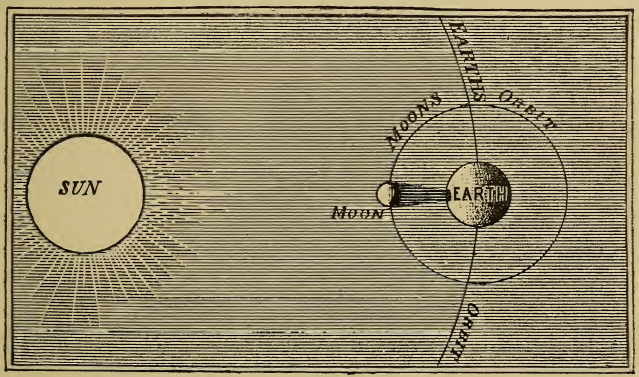
To see the unclouded sun suddenly grow dark strikes people who do not understand the cause, with fear and amazement. All nature seems suddenly shivering with a chill. The moon and stars appear, the birds and animals seek their resting-places. In broad daylight, Night suddenly resumes her reign, covers the heavens with her dark mantle, bespangled with stars, and marked with the strange and wonderful appearances of the eclipse.

2. This darkening of the sun is called a Solar

Eclipse. Eclipse means *failure*, or *extinction*, of light. Thus, blind Milton says:

"Light, the prime work of God, to me is *extinct*,
Irrecoverably dark, total *eclipse*."

3. A heavenly body is eclipsed when it is darkened by a dark body coming between it and the




ECLIPSE OF THE SUN.

observer. Thus the sun is eclipsed when the moon comes between him and the earth.

4. To understand this, you must imagine the sun to be fixed as a centre, while the earth revolves around him, in a great path, or orbit, and the moon revolves around the earth in a small orbit. Look at the above figure, and you will

see that the moon, in her revolution around the earth, will sometimes come between the earth and the sun.

When this happens, the moon, being a dark body, will prevent so much of the sun's light, as strikes her, from coming to the earth. In other words, the moon will cast a shadow towards the sun, covering more or less of his disk.

5. *Disk*, in astronomy, you must remember, means the *face*, or flat surface, of a heavenly body, as it appears to us. The sun, moon, and planets, you know, are shaped like a globe or ball, but owing to their distance from us, we cannot see their shape. We see only so much of their surface as is towards us, and this surface, on account of the distance, appears flat. This flat surface is what astronomers call the *disk*. Thus they say, the disk of the sun, the disk of the moon, the disk of Jupiter, and so on of other planets.

6. A solar eclipse never occurs except when the moon is new, because the moon is never between the sun and the earth except when she is new. Look at the figure on page 19, and you will see the new moon just above the horizon, between the earth and the setting sun.

But eclipses of the sun do not occur at every new moon, because the moon is not always in the

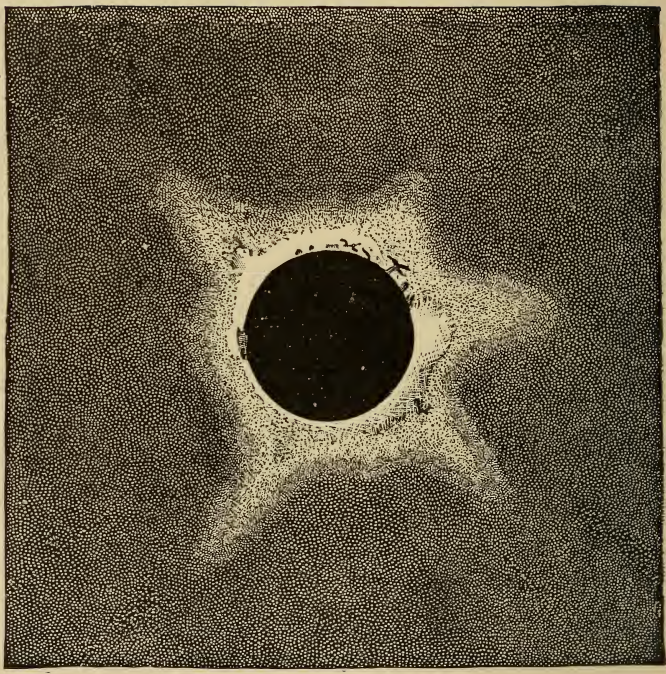
right position to obscure the sun every time she is new.

7. An eclipse of the sun always begins on the western, and passes off on the eastern, side of his disk. You will observe this whenever you look at a solar eclipse. This is because the moon, in her revolution around the earth, comes between the western side of the sun and the earth first.

8. There cannot be more than five, nor less than two, solar eclipses in any one year. This is because the moon never comes between the earth and the sun, in the right points of her orbit, to darken the sun more than five times in a year, and always comes into such points at least twice in a year. Astronomers have ascertained this by calculation and observation.

9. Solar eclipses are either total, annular, or partial. When the eclipse is total, the sun's whole disk is obscured. When it is annular, there is left a rim or border of light quite around the outer edge of his disk, shaped like a ring. Hence the eclipse is called annular, which word means *ring-shaped.* When the eclipse is partial, only a part of the disk is obscured. In a total solar eclipse, total darkness never lasts more than seven or eight minutes.

10. For the purpose of measuring the extent



TOTAL ECLIPSE OF THE SUN.

of partial eclipses, astronomers divide the disk into twelve equal parts, called *digits*.

You read in the almanacs, the sun will be eclipsed, or the moon will be eclipsed, so many *digits*. By keeping in mind that a *digit* is one twelfth part of the whole disk, you will know the extent of the eclipse, that is, how much of the disk is obscured. Thus, if the sun be eclipsed six *digits*, one half his disk is obscured.

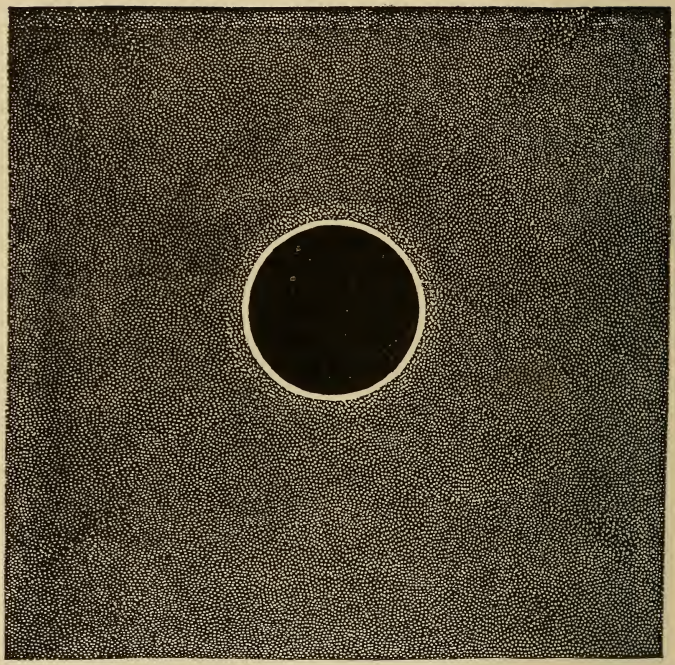
11. The figure on page 32 represents a total solar eclipse.

When you observe such an eclipse in the heavens, you will see a white silvery rim quite around the darkened disk of the sun, from which there shoot forth rose-colored protuberances of different heights.

12. This appearance is caused by matter surrounding the body of the sun. When he is shining, you cannot see it. But when he is totally eclipsed, so as to appear a mere black spot, then it becomes visible.

The following figure represents an annular eclipse of the sun. You will observe a rim or border of light quite around the sun's disk, but no protuberances.

Observe that the ring in an annular eclipse, is on the outer edge of the sun's disk, and is a part



Annular Eclipse of the Sun.

of the disk, while the rim, in a total eclipse, is outside of the disk, and is no part of it.

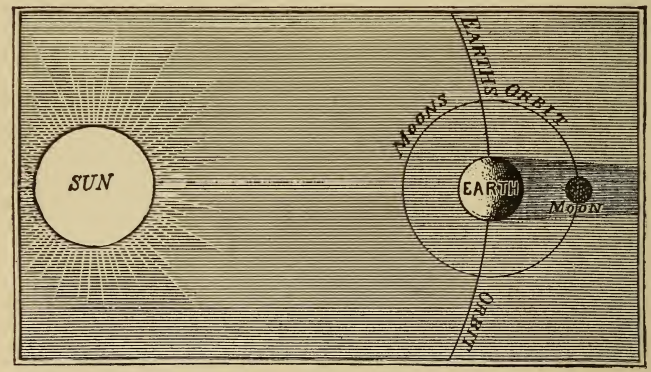
## QUESTIONS.

1. What remarkable appearances accompany an eclipse of the sun?
2. What does the word *eclipse* mean?
   What is a solar eclipse?
3. When is a heavenly body eclipsed?
   What dark body comes between the sun and the earth when the sun is eclipsed?
4. Look at the figure on page 29, and explain how the moon eclipses the sun.
5. What is the meaning of the word *disk*?
   Why is it that we can see only the face, or disk, of the sun, moon, and planets?
6. At what phase of the moon do solar eclipses always occur?
   Why cannot a solar eclipse occur at any other time?
   Look at the picture on page 19, and point out the position of the moon when new.
   Do eclipses of the sun occur at every new moon?
   Why not?
7. On which side of the sun's disk do eclipses of the sun begin?
   Why?
8. How many solar eclipses may there be in a year?
   How many must there be?
   Why is this?
   How have astronomers ascertained this to be true?
9. Name the three classes of solar eclipses.
   When is a solar eclipse total?
   When is it annular?
   When is it partial?
   What does the word *annular* mean?
   Why is an annular eclipse so called?
   When the eclipse is neither total nor annular, what is it?
   In a total solar eclipse, how long may the total darkness last?
10. How do astronomers divide the disk for the purpose of measuring eclipses?
    If the sun is eclipsed six digits, how much of his disk is obscured?
11. Describe the appearance of a total solar eclipse, as represented in the figure on page 32.
12. What is the cause of this appearance?
    Describe the appearance of an annular eclipse, as represented by the figure on page 34.
    What is the difference between the position of the rim of light, in an annular eclipse, and the rim, in a total eclipse?

## LESSON EIGHTH.

### ECLIPSES OF THE MOON, AND OCCULTATION OF STARS.

1. Eclipses of the moon are caused by the earth, in its revolution in its orbit around the sun, coming between the moon and the sun, as in the following figure.




ECLIPSE OF THE MOON.

2. An eclipse of the moon can never be annular, since the earth is larger than the moon, and

is capable of obscuring the moon's entire disk. An eclipse of the moon must therefore be either total or partial, according as the earth, in its exact position between the moon and the sun, darkens the whole, or more or less, of the moon's disk.

3. An eclipse of the moon can never take place except when the moon is full, since at no other time is the earth between her and the sun. Look at the picture of the full moon, page 22, and you will see her in the east, while the sun is in the west, and the earth between them.

4. If you will observe eclipses of the moon, you will see that they always begin on the eastern part, and end on the western part, of her disk. This is because the moon moves from west to east. You will also see that her disk is not wholly obscured, but seems to be of a reddish color. This is because some of the sun's rays, instead of being intercepted by the earth, are bent out of their course by the atmosphere, and fall on the moon's disk.

5. You will wonder when you learn that astronomers can tell, hundreds of years beforehand, when eclipses will happen. They can tell with certainty, and within a minute of the exact time. They can also tell whether the eclipse will be total, annular, or partial, and if partial, just

how much of the disk will be eclipsed. They can also go back and calculate eclipses that have happened, and tell the exact time when they happened.

You will scarcely be able to understand, now, how astronomers can do this, but as you advance in the study of Astronomy, you will be able not only to understand it, but to do it.

6. OCCULTATION.—Stars and planets which lie in that part of the heavens in which the moon moves may be concealed by the moon coming between them and the earth. This concealment is called an *Occultation.* Occultation means *concealment.*

When an occultation occurs, you will see the star or planet near the edge of the moon. Suddenly the moon will pass over it and conceal it from your sight until, in a short time, it emerges from beneath the moon's disk, and shines again with its usual splendor.

7. Also, one star or planet may occult another star or planet.

QUESTIONS.

1. What causes eclipses of the moon?
   Look at the figure on page 36, and explain how the earth causes eclipses of the moon.
2. Can an eclipse of the moon ever be annular?
   Why not?
   If the earth comes between the moon and the sun, so as to

darken the moon's whole disk, what will the eclipse be?

If the earth comes between the moon and the sun, so as to darken only a part of the moon's disk, what will the eclipse be?

3. At what phase of the moon can an eclipse of the moon take place?

Why cannot an eclipse of the moon occur at any time except when the moon is full?

Look at the figure on page 22, and point out the position of the earth, as it respects the sun, when the moon is full.

4. On which side of the disk do eclipses of the moon begin?

On which side do they end?

Why is this?

In a lunar eclipse, is the disk wholly obscured?

Of what color does the disk appear to be?

Why is this?

5. What can astronomers calculate and predict in regard to eclipses?

6. What is the meaning of the word *occultation?*

What heavenly bodies may be *occulted* or concealed by others.

What heavenly body *occults* stars and planets?

In what part of the heavens must stars or planets be in order to be occulted by the moon?

7. Are there any other heavenly bodies, besides the moon, which occult others?

What are they?

What heavenly bodies do they occult?

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# LESSON NINTH.

## THE PLANETS—VENUS AND MERCURY.

1. I have told you about the sun and moon. I shall now tell you about the stars. There are two kinds of stars.

2. Most of the stars move across the heavens like a great army of soldiers marching. They seem to keep time, being always at the same

distance, and in the same place, with regard to each other. Such stars are called *Fixed Stars.*

3. There are a few stars which seem to *wander* to and fro in the sky like a sentinel on guard. These are called *Planets.* The word *planet* means *wanderer.*

4. The brightest and most beautiful of all the stars is the planet *Venus.* You have all seen her in the western sky, just after sunset. She is the first star which appears.

"The vestal light of eve came on,
And silvered tree, and tower, and spire,
And in the warm blue sky there shone
A gem of pure and living fire.

"The boy one wondering moment eyed
The bright thing shining clear and far,
Then caught his father's hand, and cried,
'Look! father, God has made a *star.*'"

5. This star was Venus. She appeared so beautiful, the first thought of the little boy was that God made her. She shines with a steady, silvery light, like the moon. She does not twinkle like the fixed stars. She is the only star which has been seen, with the naked eye, in the day-time.

6. The motions of Venus are very wonderful. There is only *one* star, among the thousands which

spangle the sky, whose motions are like hers. Observe this picture attentively, while I describe them.


VENUS.

7. For about ten months Venus is seen in the evening sky, just after sunset. She is then called the *Evening Star*. The poets sometimes call her Hesperus. Thus Milton says:

"Hesperus, that led
The starry host, rode brightest."

When she first becomes evening star, she appears where you see her on the picture, a little way above the western horizon, and near where the new moon appears. Like the new moon,

she seems to be moving west, and soon goes down. This motion may be perceived every evening when she is visible. You must not conclude that it is a *real* motion. The motion of the earth from west to east is sufficient to make Venus, like the sun, appear to move in the opposite direction.

8. But Venus has another motion much more curious. You must watch her evening after evening, if you wish to perceive it. Observe some star near her, and after a while you will see that Venus appears to have moved away from it towards the east. See her in the second highest place on the picture.

9. If you continue to observe Venus, you will see that she appears farther and farther east, and higher and higher up, until she gets about half way up to the highest point of the sky. See her represented here on the picture. Now she seems *stationary* or *still*, for a time.

10. Soon she begins to move again, but it is towards the west. She appears to be going back. She continues to do so week after week, until, setting at the same time with the sun, she bids farewell to the evening sky. You may look out to see her adorning it with her beauty; you will look in vain. But she is not lost.

11. In a few days she will appear in the eastern sky, just before sunrise. She is now called the *Morning Star*. The poets sometimes call her Lucifer, which means *Light-bearer*, because she *brings in* the dawn. Thus the prophet Isaiah, who was also a poet, addressing the King of Babylon, whom he likens to the Morning Star, says:

"How art thou fallen from heaven, O Lucifer, Son of the Morning!"

She will be morning star just as long as she was evening star; moving in the eastern sky as she then did in the western.

12. Thus this wonderful planet seems to move back and forth, like the pendulum of a clock; and changing from one side of the heavens to the other, she divides her time equally between the morning and the evening. But to the midnight sky she is a stranger. She is never seen at midnight.*

The only star whose motions are like hers is the planet *Mercury*. This planet can be seen only a few days, twice in the year.

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* Venus is never above the horizon more than three hours after sunset, nor does she ever rise more than three hours before sunrise.

13. The reasons why the motions of Venus and Mercury appear, to us on the earth, so different from the motions of the other planets, is because their orbits around the sun are nearer to him than the orbits of the earth and of the other planets.—*See the picture of the Solar System*, page 131.

14. Hence, Mercury and Venus are called *Inferior Planets*, and the other planets are called *Superior Planets*. *Inferior*, you know, means *below*, and *superior* means *above*.

Imagine yourselves to be standing on the earth, as represented in the picture of the solar system, page 131, and you will see the orbits of Mercury and Venus *below* you, and the orbits of all the other planets *above* you. Observe each orbit attentively, and you will never forget the distinction between inferior and superior planets.

15. As the orbits of the inferior planets, Mercury and Venus, lie between the orbit of the earth and the sun, these planets, in their revolution around the sun, sometimes come between him and the earth. As they are dark bodies,—when they do so, they will prevent the light between them and the sun from coming to us, and will appear as a round dark spot passing over the

face of the sun. This is called a *Transit.* The word *transit* means a *passing over.*

There have been many transits of Mercury and Venus, and there will be many more. The last transit of Venus occurred December 6, 1882, about two years ago. The next will occur in the year 2004, about one hundred and twenty years hence.

Mercury goes around the sun oftener than Venus, and comes between him and the earth oftener. Hence it will have more frequent transits. The next transits of Mercury will occur in May and November in the year 1891, about six years from now.

When the last transit of Venus occurred, the whole astronomical world came out to watch for it.

Many eminent astronomers, sent by their governments, at the expense of the nation, went to different parts of the four quarters of the earth, in order to observe this transit. A body of distinguished German astronomers came to the United States, and observed it, in Hartford, Connecticut.

## QUESTIONS.

1. How many kinds of stars are there?
2. How do most of the stars appear to move across the heavens?
   What are such stars called?
3. What stars are called planets?
   What does the word *planet* mean?
4. Which is the brightest and most most beautiful of all the stars?
   What star appears first after sunset?
5. Describe the light of Venus?
6. How many stars have motions like Venus?
7. When is Venus called the Evening Star?
   How many months is she evening star at a time?
   Where does she appear when she first becomes evening star?
   Which way does she seem to move *every* night?
   Do you know this to be a real motion?
8. Look at the picture on page 41, and describe the other motion of Venus.
9. Show me where she is, when she first appears as evening star.
   Show me which way she seems to move from week to week.
   Show me where she seems stationary.
10. When Venus begins to move again, which way does she go?
11. When Venus disappears from the evening sky, how long before she can be seen again?
    Where does she then appear?
    What is she now called?
    How long will she continue to be morning star?
    How does she now appear to move?
12. To what is this motion like?
    To what part of the sky is she a perfect stranger?
    What planet's motions are like those of Venus?
    How long a time, and how often, can Mercury be seen?
13. Why do the motions of Mercury and Venus appear to us so different from the motions of the other planets?
14. Why are Mercury and Venus called inferior planets?
    Why are the other planets called superior planets?
    Which alone of all the planets may come between the earth and the sun?
    Why is this?
    Which of the planets can never come between the earth and the sun?
    Why not?
15. When Mercury and Venus come between the earth and

the sun, how do they appear?
What is this appearance called?
What does the word *transit* mean?
Have there been many transits of Mercury and Venus?
Will there be many more?
When was the last transit of Venus?
When will the next occur?
What planet has more frequent transits than Venus?
Why has Mercury more transits than Venus?
When will the next transits of Mercury occur?
Can astronomers foretell when transits will happen?
Can Jupiter and the other superior planets ever have transits?
Why not?

## LESSON TENTH.

### THE PLANETS—JUPITER, AND THE OTHER SUPERIOR PLANETS.

1. Jupiter appears almost as large and bright as Venus, but of a different color. Venus, you remember, has a silvery whiteness like the moon. Jupiter, more like the sun, is of a golden hue.

2. You will wish to know where to look, to see Jupiter. You must not look to the north or to the south. He is always somewhere in that part of the sky through which the sun and moon appear to move. The paths of all the planets lie near together, and near the path of the sun and moon.

3. Jupiter, like Venus, has two motions. One

of them may be perceived every evening. This is called his daily motion, and is always from east to west. The other motion is back and forth from east to west, and from west to east.

4. We never see Venus anywhere but in the eastern or western sky. She seems to move back and forth there between two limits. It is not so with Jupiter. Like Venus he appears to move back and forth in the sky, but not always in the same places. We see him not only in the east and west, but also overhead.

5. There are *four* planets whose motions are like Jupiter's. Their names are *Mars*, *Saturn*, *Herschel* or *Uranus*, and *Neptune*. Only two of them can be often seen without a telescope. These two are *Mars* and *Saturn*. Mars appears of a fiery red color. Saturn is a large yellow star.

The Asteroids, also lying between Mars and Jupiter, are *Superior Planets*, and have the same apparent motion as Jupiter and the others.

6. Saturn is distinguished from all the other planets by a ring of light reflected from the sun, like the light of our moon. This ring encircles him midway between his North pole and his South pole, as represented in the picture, page 53. Eight moons are not enough; so there is added the light of this glorious ring.

7. No naked eye of man has ever seen it. It was discovered by the use of the telescope, and can be seen only through the telescope.

8. It appears to be divided into two rings, by a dark, narrow strip, as seen in the picture.

Recent observations disclose the existence of a third ring, of a dusky hue, lying within the other two, and nearer to the body of the planet.

9. Although astronomers speak of *three* rings, there seems to be, in fact, but *one*, since they all revolve around the planet in exactly the same period, as *one* substance.

10. The matter of the ring is independent of the matter of the planet, and separate from it, since the planet revolves upon its axis in about ten and a quarter hours, while the ring requires a little longer time for its revolution, that is, about ten and a half hours.

## QUESTIONS

1. How large and bright does Jupiter appear?
   What is his color?
2. Where must you look to see Jupiter?
   Where are the paths of all the planets?
3. How many motions has Jupiter?
   What is the motion, which can be perceived every evening, called?
   Which way is this motion?
   Which way is the other motion of Jupiter?
4. Where is Venus always seen?
   Where may Jupiter be seen?
5. How many planets are there whose motions are like Jupiter's?

What are their names?
How many of them can be seen without a telescope?
What are their names?
What is their appearance?
What other superior planets lie between Mars and Jupiter?

6. What distinguishes Saturn from all the other planets?
How does this ring encircle him?

7. Is this ring visible to the naked eye?
How was it discovered?
How can it be seen?

8. How does it appear to be divided?
What is the position and color of the third ring recently discovered?

9. How many rings are there in fact?
How does it appear that the three rings are, in fact, one?

10. Is the matter of the ring separate from the matter of the planet and independent of it, or is it a part of the same matter?
What proves it to be separate and independent?

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## LESSON ELEVENTH.

### THE ASTEROIDS.

1. Between the orbits of Mars and Jupiter, there are two hundred and forty, or more, very small planets, called *Asteroids.* Asteroid means a small star.

2. They are all invisible to the naked eye, except *Vesta*, which, though rarely, may be sometimes seen without a telescope, and have been discovered by the use of the telescope. No one of them had been discovered before the year

1801. Between that year and 1807, four of them had been discovered.

3. The names of these four are *Juno, Vesta, Ceres, Pallas.* The others have been discovered since, from time to time, by different astronomers, and named.

4. The distance between the orbits of Mars and Jupiter was so great, that astronomers thought there must be planets between these two orbits. Hence they worked diligently, and discovered them.

Look at the picture of the Solar System, page 131, and imagine two hundred and forty orbits, lying between the orbit of Mars and the orbit of Jupiter, and two hundred and forty asteroids, revolving, each in its own orbit, about the sun.

5. The Asteroids are extremely small. The largest of them is only three hundred miles in diameter. Compare this with the diameter of the earth, which is eight thousand miles, and you will see how small it is. The others are much smaller. Indeed, they are so small that some astronomers think they are parts of a large planet, now broken in pieces. Sir William Herschel calls this idea a harmless dream.

QUESTIONS.

1. What are asteroids?
   How many asteroids have been discovered?
   Where are they situated?
2. Are they visible to the naked eye?
   How were they discovered?
   How many of them were discovered between the years 1801 and 1807?
   When were the others discovered?
3. What are the names of these four?
   Have the asteroids all been named?
   By whom?
4. Why did astronomers think there must be planets between Mars and Jupiter?
5. What is the magnitude of these planets?
   What idea, as to their origin, do some astronomers derive from their smallness?
   What does Sir William Herschel call this idea?

## LESSON TWELFTH.

### THE PLANETS ARE WORLDS.

1. I think the planets are great worlds, with skies and sun, and moons, and stars, like the Earth on which we live. I will tell you why I think so.

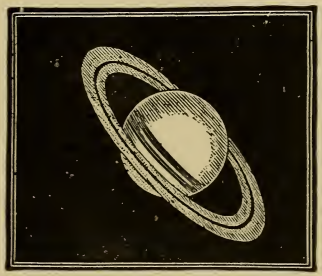
2. *First; they are dark bodies like the Earth.* —They look bright to us for the same reason that the moon looks bright.* The light from

* The teacher should here recur to the explanation given on page 26, and see that the pupil understands it.

some luminous body falls on them, and is reflected to us. Some of them have *phases* like our moon. The phases are not visible to the naked eye, but with a telescope they may be distinctly seen. Venus, for example, appears new, half, gibbous, and full, just like the moon.

If Venus shone with her own light, this would not be possible. She would always appear to us a round, full orb, like the sun.

3. *Second; I think the planets are like the Earth, because some of them have moons.*—Mars has two moons, Jupiter four, Saturn eight, and Herschel or Uranus six, Neptune one. If we look at these planets with a telescope, we can see the moons. The planets must be worlds like our earth, or they would have no need of moons.



4. *Third; Some of the planets, when seen through a telescope, look round like a ball,* which you remember is the shape of the Earth. I saw Saturn a few days ago through a telescope. He looked like a ball of light about as big as a walnut. He seemed to be swimming in a blue sea, surrounded by a wide ring or border of light, with a narrow strip of dark near the middle. I never saw anything more beautiful.

5. *Fourth; The planets are like the Earth, because they turn round like a ball.*—We cannot see the motion. But with a telescope we can see dark spots on the planets. If we watch any one of these spots, we shall soon perceive that it has moved. By and by it goes out of sight, and after a while appears again where we first saw it.

Make the head of a pin black in the candle-smoke, stick it in the side of an apple, and then turn the apple round. The pin-head will move, go out of sight, and appear again, just like the spots on the planets. In this way we learn that the planets revolve in a certain number of hours, like the Earth. I believe they do so, to make their day and night. They must be worlds, or they would have no need of day and night.

6. If the planets are great worlds, like the Earth, you will wonder that they should look like little bright spots in the sky. It is because they

are very far off. When the people on the planets look up at their sky, they see the Earth appearing like a bright star, just as the planets appear to us. Astronomers call the Earth a *planet*, because it is a dark, round body, has a moon, and revolves, just like the planets which we see in the heavens.

7. The sky around some of the planets must be even more splendid and beautiful than our sky. Nothing can appear more magnificent than the evening sky of Saturn.

To a spectator on the planet, the ring looks like a broad arch of light, with a narrow strip of dark, extending quite across the heavens. Moons appear, shining together, in every variety of phase, —new, half, gibbous, full, and old; some rising, some on the meridian, some setting, and, it may be, some in eclipse. Imagine the scene!

With what adoring wonder at the power and wisdom of the Creator must the inhabitants of Saturn, if such there be, standing under their open sky, gaze upon a sight so glorious!

QUESTIONS.

1. What are the planets?
2. Are the planets light bodies, or dark bodies? Why do they look bright to us? What have they, like our moon? How can we see the phases?
3. What planets have moons, like the earth?

How many moons has Neptune?
How many has Jupiter?
How many has Saturn?
How many has Herschel?
How many has Mars?
How does the planets having moons show that they are worlds?

4. What is the shape of the earth?
What is the shape of the planets?
How does Saturn look when seen through a telescope?

5. How does the earth turn round?
Do the planets turn round in the same manner?
Can you see their motion?
How, then, do you know that they turn round?
Why do the planets turn round?

6. If the planets are great worlds, why do they look like little bright spots in the sky?
How does the earth appear to the people on the planets?
Why do astronomers call the earth a planet?

7. Describe Saturn's evening sky, as it appears to a spectator on the planet?

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## LESSON THIRTEENTH.

### THE FIXED STARS.

1. NUMBER.—As night begins to approach, a single star appears. Then others become visible; and when it becomes quite dark, the whole sky seems to twinkle.

2. The stars appear very numerous. We think we see a great many thousands. But we are deceived. To the naked eye, only about two thousand stars are visible, at any one place, at any one time.

3. The stars have been counted. There are about *seven thousand* stars visible to the naked eye. But they are not all visible to us at the same time. Some of them are in the sky on the other side of the earth, and we cannot see them until they appear in our sky. Some of them are in the sky around the South pole, and we never see them, where we are.

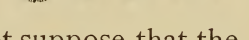
The telescope reveals to us that the stars are a great many millions in number, perhaps so many that God alone can count them.

Look at the picture opposite to page 1. The children, represented there as standing on the earth, can see the stars above them, and those around the North pole, but they cannot see those on the other side of the earth, nor those around the South pole, because the earth is between them and those stars.*

4. MAGNITUDE.—The stars seem to be of different magnitudes. Those which appear largest are called stars of the *first magnitude;* the next largest, stars of the *second magnitude*, and so on to the smallest stars visible to the naked eye, which are of the *sixth magnitude.* Thus there

* The teacher should take particular care to see that the pupil understands this illustration.

are six classes of stars, according to their apparent size, as represented in this picture.



You must not suppose that the *apparent* magnitudes of the fixed stars represent their *real* magnitudes. For example, *Sirius*, the brightest of them, *may* be smaller than the faintest of the *Pleiades*. It may be, that he appears so large and bright because he is nearer to us, and it may be partly because he is really larger, and *partly* because he is really nearer.

5. DISTANCE.—Astronomers have been able to determine the distance of the sun, moon, and planets, from the earth, and from each other, but not the distance of the fixed stars.

We know that, remote as they are, some of them are nearer to us than others. But their actual distance is so vast, that no human being has as yet been able even to compute it. As you have learned on page 30, the sun, moon, and planets have disks, or faces, which can be measured. But the fixed stars have no disk capable of measurement. They are so distant that they appear only as brilliant *points*.

6. MOTION.—The stars have two *apparent* mo-

tions, a *daily* motion, and an *annual* or *yearly* motion. They appear to move every evening, in exact order, towards the west. Watch any stars which you see in the east, just after sunset, and about midnight, you will see them together overhead, and in the morning, going down together towards the western horizon. This is called their *diurnal* or *daily* motion. The revolution of the Earth, every day towards the east, would make the stars, like the sun, *appear* to move towards the west.

7. The *annual* motion of the stars is also towards the west. You cannot perceive this motion by watching them a single evening. But if you observe where any star is this evening, and after several evenings, look for it again, at the same hour, you will see it farther west. Stars which appear in the east to-night at dark, three months hence, at the same hour, will be overhead, and six months hence, in the west.

While the stars seem to move through the sky every night, it seems as though the sky itself was slowly turning from east to west the whole year, carrying the stars along with it.

The motion of the Earth in her orbit, around the sun, would give the stars this apparent motion.

## QUESTIONS.

1. Are the stars all visible at once when night begins to approach?
2. How many stars do there appear to be?
   How many can we really see at once?
3. How many stars are there in all, visible to the naked eye?
   How do you know this?
   Are they all visible to us at the same time?
   Where are those which are not visible?
   What stars can never be seen, where we are?
   Look at the picture opposite page 1, point to the group of children standing there on the earth, and show me what stars they can see, and what stars they cannot see.
4. How many classes of stars are there, according to their apparent magnitude?
   What are the stars which appear largest called?
   What are the next largest called?
   What are the smallest stars visible to the naked eye called?
   Do their apparent magnitudes represent their actual magnitudes?
   Why may the brightest star, *Sirius*, for example, be actually smaller than the faintest of the *Pleiades?*
5. Have astronomers been able to determine the distances of the fixed stars from the earth?
   Why not?
   Have they ascertained that some of them are nearer to us than others?
   Have the fixed stars any disk?
   Why not?
   How do they appear to us?
   Why is this?
   Why do they not appear like the sun, moon, and planets?
6. How many apparent motions have the stars?
   What are they called?
   How do the stars appear to move every evening?
   Where will stars, which appear in the east just after sunset, be seen at midnight?
   Where will they be seen in the morning?
   What is this motion called?
   What would make the stars appear to move in this way, although perfectly still?
7. Which way is the annual motion of the stars?
   Can it be perceived by watching them a single evening?
   How may you perceive it?
   Where will stars, which appear in the east, at dark to-night, be seen at the same hour, three months hence?
   Where will they be six months hence?
   What would give the stars this apparent annual motion, although perfectly still?

# LESSON FOURTEENTH.

## DIVISIONS OF THE HEAVENS.

1. You have learned from Geography that the Earth is considered as divided into *Northern* and *Southern*, *Eastern* and *Western Hemispheres.* So are the Heavens. The Northern Hemisphere of the Heavens is over the Northern Hemisphere of the Earth, the Southern over the Southern, and so on with the others.

2. THE MERIDIAN OF THE EARTH is a line, imagined to be drawn around it, north and south, dividing it into two hemispheres, called the Eastern and Western Hemispheres of the Earth. The MERIDIAN OF THE HEAVENS is a line, imagined to be drawn on them, directly over the Meridian of the Earth, dividing them into the Eastern and Western Hemispheres of the Heavens.

3. THE EQUATOR OF THE EARTH is a line, imagined to be drawn around it, east and west, dividing it into Northern and Southern Hemispheres. The EQUATOR OF THE HEAVENS is a line, imagined to be drawn in like manner around

the heavens, and exactly over the Equator of the Earth. It is also called the *Equinoctial.*

4. The ECLIPTIC is the path in which the sun appears to move, in passing across the heavens.

5. THE ZODIAC is a broad strip of the heavens, lying half on one side, and half on the other side, of the ecliptic or sun's path. The Moon, Jupiter, Venus, and almost all the planets always move through this part of the sky. Their paths are said to lie within the Zodiac.

6. THE MILKY WAY is another broad strip, extending like a great white band across the heavens, northeast and southwest. It is called the *Milky Way*, because it is white like milk. You can see it every night when the sky is clear.

7. CONSTELLATIONS.—At first sight the stars seem to be scattered all over the sky, without any arrangement. But when you observe them more attentively, you see that they are arranged in clusters or groups. These clusters or groups are called *Constellations.* The word *constellation* means several stars lying close together.

8. The constellations have all been counted and named. They are *ninety-one* in number. *Thirty-four* of them are in the Northern Hemisphere, north of the Zodiac, *twelve* of them are in the Zodiac, and *forty-five* of them in the South-

ern Hemisphere, south of the Zodiac. The stars in the Zodiac, north of the Equinoctial, are in the Northern Hemisphere. The stars in the Zodiac, south of the Equinoctial, are in the Southern Hemisphere.

9. Thus you perceive that Astronomy resembles Geography. The heavens are supposed to be divided into hemispheres, constellations, etc., that we may be able to describe the situation of stars in the heavens, just as we describe the situation of places on the earth. Thus we say, *Arcturus* is in the Northern Hemisphere, in the constellation *Bootes*, just as we say, *Quebec* is in the Northern Hemisphere, in the province of *Lower Canada.*

QUESTIONS.

1. Into what hemispheres are the heavens imagined to be divided?
   Where is the northern hemisphere of the heavens?
   Where is the southern?
   Where is the eastern?
   Where is the western?
2. What is the meridian of the earth?
   How does it divide the earth?
   What is the meridian of the heavens?
   How does it divide the heavens?
3. What is the equator of the earth?
   What is the equator of the heavens?
   By what other name is it sometimes called?
4. What is the ecliptic?
5. What is the zodiac?
   What heavenly bodies are always within the zodiac?
6. What is the milky way?
   Why is it called the milky way?
7. How do the stars at first sight appear to be scattered over the sky?
   How do they appear to be arranged when observed attentively?

What are the clusters or groups of stars called?
What does the word *constellation* mean?

8. How many constellations are there?
How many of these are in the zodiac?
How many in the northern hemisphere, north of the zodiac?
How many in the southern, south of it?

9. For what purpose are the heavens supposed to be divided into hemispheres, constellations, etc.?
Describe, for example, the situation of the star *Arcturus*.
Describe the situation of *Quebec*.

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## LESSON FIFTEENTH.

### STARS OF THE FIRST MAGNITUDE.

1. There are twenty-two stars of the First Magnitude. Eleven of them are in the Northern hemisphere, that is, north of the equinoctial. Eleven of them are in the Southern hemisphere, that is, south of the equinoctial. *For the meaning of the word equinoctial, see page* 62.

2. Some of these stars are a little smaller than the others, and, although called stars of the first magnitude, may be, in fact, between the first and second magnitudes.

3. The following are the names of all the stars of the first magnitude, in the order of their distances from the equinoctial, and the names of the constellations in which they are situated:

In the Northern Hemisphere: *Procyon*, in the Lesser Dog; *Betelgeux*, in Orion; *Altair*, in the Eagle; *Regulus*, in the Lion; *Aldebaran*, in the Bull; *Arcturus*, in Bootes; *Alpherat*, in Andromeda; *Vega*, in the Lyre; *Deneb*, in the Swan; *Cappella*, in Auriga; and *Dubhe*, in the Greater Bear.

Thus you will observe that *Procyon* is farthest south, and *Dubhe* farthest north, of all the stars, of the first magnitude, in the Northern Hemisphere.

4. In the Southern Hemisphere, nearest the equinoctial, are: first *Rigel*, in Orion; then *Spica Virginis*, in the Virgin; *Sirius*, in the Greater Dog; *Antares*, in the Scorpion; *Fomalhaut*, in the Southern Fish; *Canopus*, in the Ship Argo; *Achernar*, in Eridanus; *Agena* and *Bungula*, in the Centaur; *Alpha Crucis*, in the Southern Cross; and *Maia Placida*, in the Ship Argo.

Thus you will observe, that of all the stars, of the first magnitude, in the Southern Hemisphere, Rigel, in Orion, lies nearest the equinoctial, that is, farthest north, and *Maia Placida* farthest from the equinoctial, that is, farthest south.

5. In order to have a true idea of the places of the stars in the heavens, you must imagine to yourselves the place of the equinoctial,—midway

between the North Pole and the South Pole. If a star is in the Northern Hemisphere, but not far north, look for it near the equinoctial. If it be far north, look for it far north of the equinoctial.

If a star be in the Southern Hemisphere, but not far south, look for it on the southern side of the equinoctial, but not far from it. If it be far south, look farther south.

## QUESTIONS.

1. How many stars of the first magnitude are there?
   How many of them are in the northern hemisphere?
   How many of them are in the southern hemisphere?
2. Are these stars all exactly of the same apparent magnitude?
3. Name the stars of the first magnitude, in the northern hemisphere, in the order of their distances from the equinoctial, and the constellations in which they are situated.
   Which is the farthest north, and which the farthest south, of all the stars of the first magnitude, in the northern hemisphere?
4. Name the stars of the first magnitude in the southern hemisphere, in the order of their distances from the equinoctial, and the constellations in which they are situated.
   Which is the farthest north, and which the farthest south, of all the stars of the first magnitude in the southern hemisphere?
5. In what way can you form a true idea of the places of the stars in the heavens, and find them?

## LESSON SIXTEENTH.

### THE POLE STAR—THE GREAT DIPPER.

1. There is one star which appears to be always in the same place. It is almost exactly in the north, and is called the POLE STAR. Some ancient astronomers called it *Alrucaba.* While all the other stars seem to be in ceaseless motion, there it remains, from evening to evening, and from year to year, always visible, unless hidden by clouds.

2. You will wish to find this wonderful star. You must first find the GREAT DIPPER. There are *seven* stars, in the northern sky, which make a figure shaped like a great dipper. Their names are *Dubhe, Merak, Megres, Phad, Alioth, Mizar,* and *Benetnasch.* Look at the situation of each of them, as represented in the Great Bear, on page 72.

3. When you have found the Dipper, you can easily find the Pole Star. There are two stars in the Dipper, called *Pointers,* because they always point to a solitary bright star about half-way between the northern horizon and the zenith. This is the pole star. See the Pointers, on the picture,


THE DIPPER GOING ROUND THE POLE STAR.

always pointing to the pole star. Go out when it is a clear evening and find them in the sky; then look where they point, and you will see the pole star. The names of the Pointers are *Dubhe* and *Merak*. These stars are in the eastern corners of the Dipper. The uppermost star is *Dubhe;* the lower one, *Merak*.

4. But you will not always find the Dipper in the same place; it is continually moving. It has two motions—a *daily* motion and a *yearly* motion. It seems to revolve round the pole star once every twenty-four hours. If it appears in the northeast early in the evening, at midnight it will be right over the pole star, and in the morning will be seen in the northwest. It takes six hours to go one quarter of the way round, twelve hours to go one half, and so on. In this way it shows the time of night.

5. While the Dipper revolves every night, it also seems to be turning slowly round throughout the whole year. Thus, in the fall, it appears, at dark, in the north, below the pole star, in winter, in the northeast, in spring, above the pole, and in summer, in the northwest.—*See it in these four positions on the picture.**—In this way it shows

* The student must always remember that the motion of the constellations and of the stars is *apparent* only. The *real* motion is the motion of the *Earth*.

the time of year. Will you not wish to observe this great clock which God has made, and suspended in the sky?

6. The pole star has been observed more than any other star in the sky. It is not so bright and beautiful as many others, but it has been very *useful* to mankind. The sailor on the wide ocean, the Indian in the pathless forest, and the caravan on the sandy desert, all watch this star, and by it direct their course. There it always stands in the heavens, a sure and never-sleeping guide.

QUESTIONS.

1. How many stars appear to be always in the same place?
   Where is this star?
   What is it called?
2. What must you first find in order to find the pole star?
   How many stars make the Great Dipper?
   What are their names?
   In what part of the sky is it?
3. When you have found the Dipper, how can you find the pole star?
   What are the names of the Pointers?
4. Can you always find the Dipper in the same place?
   Why not?
   How many and what motions has it?
   What does it seem to revolve round?
   How often?
   If it appears in the northeast early in the evening, where will it be at midnight?
   Where in the morning?
   How long does it take to go one quarter of the way round?
   How long to go one half?
   What does it in this way show?
5. How does the Dipper appear to move during the whole year?
   Where is it seen, at dark, in the fall?
   Where in winter?
   Where in spring?
   Where in summer?
6. Why has the pole star been observed more than any other star in the sky?
   Who watch this star in order to direct their course?

# LESSON SEVENTEENTH.

## CONSTELLATIONS ALWAYS VISIBLE.

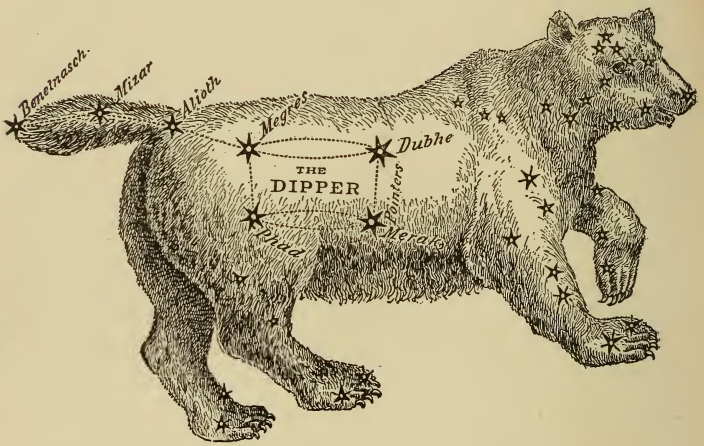
1. I shall now describe some of the most remarkable Constellations. I shall tell you where they are situated, how they look, and when they may be seen, that you may be able to find them in the sky, or when you see them, may know their names.

2. The constellations around the pole star are visible to us every night throughout the year, unless hidden by clouds. We never have the earth between us and them. The little group on the picture, opposite to page 1, stand on the earth, near where we are. Look at them, and you will perceive that they can see the sky all around the pole star.

3. THE GREAT BEAR.—On the following page, is a picture of a constellation, called the *Great Bear;* it is situated in the northern sky, and revolves around the pole star.

Find the Great Dipper, and then you can easily find the Great Bear. The Great Dipper is in this constellation, and contains its brightest stars.

It will seem strange to you that a cluster of stars should be called *Great Bear*. I cannot see that it looks like a bear, but it has been called the *Great Bear* thousands of years, and is everywhere known by this name. Almost all the constellations are called by the names of men,




women, animals, snakes, birds, or fishes. Some few of them look a little like the objects whose names they have.

4. ARCTURUS.—At some distance south of the stars in the tail of the Bear, or which is the same thing, in the handle of the Dipper, is a very large,

reddish star, called *Arcturus*. It is the largest and brightest star ever seen in the northern sky. On account of its superior size and brightness, the writer of the Book of Job seems to have fancied it the father or patriarch of the whole family of stars in this region. He speaks of Arcturus and his *sons*. It was once considered


as situated in the Bear's tail. The word *Arcturus* means, *In the Bear's tail.* But his tail must be very long to reach that star.

THE LITTLE BEAR.—Here is another bear; it is called the *Little Bear.*

The Little Bear is another of those constellations which revolve around the pole star. It is nearer the pole star than the Great Bear. The

pole star is in the end of its tail. It does not look like a bear, but there are seven stars in it which make a figure that really looks like a dipper. This figure is called the *Little Dipper*. The end of the handle is the pole star, around which the Dipper revolves once a day and once a year, just like the Great Dipper. It does not appear so plain as the Great Dipper, and you must not be disappointed, if you cannot find it, until some one has first shown it to you.

5. The polar regions of the earth are the country of bears; here they roam over the trackless snows and the fields of ice, without fear of man. Perhaps this is the reason why two constellations, in the polar regions of the Heavens, have been called bears.

6. CASSIOPEIA.—Find the Great Dipper, then look in the sky on the opposite side of the pole star, at about an equal distance from it, and you will see six beautiful though not very large stars, making a figure shaped like a chair turned over. Four of them make the bottom part, and two the back. These are the brightest stars of a constellation called *Cassiopeia*. Observe the picture on page 75. *Schedir* and *Caph* are in the bottom of the chair. *Ruchbah* is the middle star in the back of the chair.

7. Cassiopeia is the name of a queen who once lived in Ethiopia. She was very beautiful, and greatly admired. After she died her name was given to this constellation. Perhaps it was really believed that she had gone up to heaven, to live


CASSIOPEIA.

in these fair stars. Or perhaps it was that when men should look up in the sky and behold them, they might remember Cassiopeia and her beauty.

In this picture Cassiopeia is represented as a queen sitting in her chair, holding her robe in one

hand and a palm-leaf in the other. If you expect to see anything in the sky, looking like this picture, you will be disappointed. But you can see the chair-shaped figure.

8. Cassiopeia seems to revolve around the pole star, just like the Dippers and the Bears. All the stars in this part of the sky appear to revolve round it in the same manner.

9. In eastern countries, men, as they lay under the open sky, could observe this motion of the stars all night. They seem to have regarded it with the greatest admiration. It is mentioned in the Bible as one of the most remarkable examples of divine skill. God says to Job, "Canst thou guide Arcturus and his sons?" How very small indeed the wisdom and power of man compared with His who guides this patriarch of stars, with his sons, in their wonderful motion round the heavens!

QUESTIONS.

2. What constellations are always visible?
   Turn to the picture opposite page 1, and show me why we can always see these constellations.
3. Where is the constellation, called the Great Bear, situated?
   What does it revolve round?
   How can you easily find this constellation?
   Does this constellation look like a bear?
   How long has it been called so?
   Where is it known by this name?
   By what names are most of the constellations called?

Do any of them resemble the objects whose names they bear?

4. What is the name of the largest and brightest star in the northern sky?
   Where is it situated?
   Why was it fancied to be the patriarch of the stars in this region?
   Where was it once considered as situated?
   What does the word *Arcturus* mean?
5. What is the Little Bear?
   Which is nearest the pole star, the Great Bear, or the Little Bear?
   In what part of the Little Bear is the pole star?
   Does this constellation look like a bear?
   What figure is made by seven stars in this constellation?
   What star is the end of the handle?
   What does the Little Dipper revolve round?
6. How can you find the constellation *Cassiopeia?*
7. What was Cassiopeia the name of?
   Why was her name given to this constellation?
   Look at the picture and show me the chair-shaped figure in this constellation?
8. What does Cassiopeia revolve round?
   What stars appear to revolve in the same manner?
9. How was this motion of the stars regarded in eastern countries?
   Where is it mentioned as a remarkable example of divine skill?
   What does God say to Job about this motion?

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# LESSON EIGHTEENTH.

## SUMMER CONSTELLATIONS.

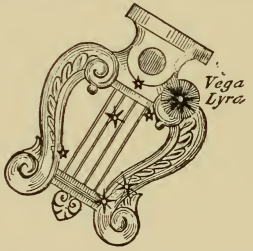
1. Some of the constellations appear in our evening sky only in summer. In our winter evenings they are in the sky on the other side of the earth. People in Europe, Asia, and Africa,

see them, but they do not come into our sky until daytime, when we cannot see them.

2. The summer constellations which contain the brightest stars are the *Lyre*, the *Eagle*, the *Swan*, and the *Scorpion*.

3. The Lyre.—This constellation may be known from its principal star, *Lyra*, also called *Vega*. It shines with a remarkably bright, silvery light.

4. About the first of June, *Lyra*, or *Vega*, rises




at sunset, in the northeast. You may see it every evening when it is clear, from this time until January. It appears higher and higher up at dark until October, when it is nearly overhead. Now it begins to descend farther and farther west, and at last in January it can be seen for a few days setting in the northwest, soon after the sun; and finally it disappears to be seen no more in our evening sky, until June comes again.

5. It is said that there lived, thousands of years ago, a musician, named *Orpheus.* He made such music with his lyre that the rivers stopped to hear him, the wild beasts stood still and listened, and even the trees on the mountains came dancing down to meet him. When he died, the gods placed his lyre in the sky, and it became the constellation *Lyra.*

6. ARIDED.—Somewhat northeast of *Lyra,* and at considerable distance from it, is another bright, white star, Its name is *Arided;* it is in the constellation called the *Swan.*

7. ALTAIR.—Southeast of Lyra, and farther from it than Arided, is another bright, white star, named *Altair;* it is in the constellation called *The Eagle.*

If lines could be drawn in the sky, joining the three stars, *Lyra*, *Arided,* and *Altair*, these lines would form a large triangle having a bright silvery star in each corner.

## QUESTIONS.

1. Some of the constellations appear in our evening sky only in summer; where are they in our winter evenings? In what countries can the people see them at that time?
2. What are the summer constellations which contain the brightest stars?
3. How may the *Lyre* be known? What is the name of this star? What is its appearance?
4. When does Lyra rise at sunset?

Where does it rise?
How long will it remain visible in our evening sky?
In what month is it nearly overhead at dark?
Which way does it begin to descend?
Where can it be seen a little after sunset, in the month of January?

5. Whose lyre is this constellation said to be?
Relate the story of Orpheus.

6. Which way from Lyra is the star *Arided* situated?
What is its appearance?
In what constellation is it?

7. What bright star south-east of Lyra?
Which is farthest from Lyra, *Arided* or *Altair?*
In what constellation is Altair?
If lines should be drawn in the sky joining *Lyra*, *Arided*, and *Altair*, what figure would they make?
What would the triangle have in each corner?

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## LESSON NINETEENTH.

### SUMMER CONSTELLATIONS—CONTINUED.

1. VIRGO.—There is a constellation called *Virgo*, or the *Virgin*, situated in the Zodiac, or sun's path. It contains one bright star, called *Spica Virginis*. *Spica* means an Ear of Grain. *Spica Virginis* means Virgin's Ear of Grain.

2. This star first appears in our evening sky in the month of April, and continues to do so until some time in October, when it sets with the sun. It is situated southwest of *Arcturus*, which, when *Spica* first appears in the east, may be seen in the northeast, and higher up in the sky. Find Arc-

turus, and then look some way southwest of it, and you will see *Spica*.

3. In eastern countries young ladies used to go out in the fields after the reapers, and glean or gather the grain which they had left. The Bible relates a beautiful story of Ruth, who did so. Now it is said that in eastern countries this constellation used to be overhead with the sun at the time of harvest, and that for this reason it was represented as a virgin with an ear of grain in her hand.

4. The Scorpion.—This is one of the twelve constellations of the Zodiac. It is situated some way east of Virgo. It appears in our evening sky about the first of June, and continues visible to us, but farther and farther west, until about the last of November. It really resembles a scorpion.

5. You may easily know it from its largest star, called *Antares*, which is of a fiery red. This star is imagined to be in the heart of the scorpion. There is a long crooked line of stars forming the body and the tail, with stars branching off each side, making the claws and the legs.


## QUESTIONS.

1. Where is the constellation Virgo?
   What is the name of its brightest star?
   What does *Spica* mean?
   What does *Spica Virginis* mean?
2. In what month does this star first appear in our evening sky?
   In what month does it disappear from it?
   Which way is it from Arcturus?
   When Spica first appears in the east, where may Arcturus be seen?
   Where may he be seen when it disappears in the west?
3. Why was this constellation called the Virgin?

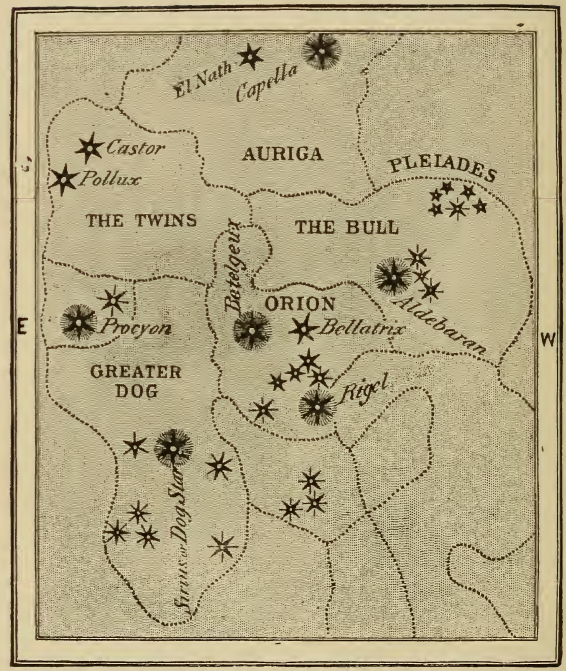
Why was this star called Spica?
4. Where is the constellation called the Scorpion?
In what month does it first appear in our evening sky?
Which way is it from Virgo?
How long does it continue visible to us?
Does it resemble a scorpion?
5. How may you easily know it?
In what part of the Scorpion is *Antares?*
What forms the body and tail of the Scorpion?
What form the claws and legs?

## LESSON TWENTIETH.

### WINTER CONSTELLATIONS.

1. The constellations which appear in our evening sky in winter are very splendid. Six stars of the first magnitude are seen all blazing at once, and in the same part of the heavens, and eight or nine stars of the second magnitude. When, besides all these, Jupiter, in his majesty, and Venus, in her beauty, appear at the same time, as they do if they happen then to be evening stars, the scene is brilliant indeed.

2. The winter constellations containing the brightest stars are seven in number. Their names are: *Orion, The Greater Dog, The Lesser Dog, The Bull, Auriga* or *The Wagoner, The Twins,* and *The Lion.* The six first, whether they be in the east, overhead, or in the west, appear together, as represented in the following map.




MAP OF WINTER CONSTELLATIONS.

### QUESTIONS ON THE MAP.

What are the names of the constellations represented on the map?
How many stars of the first magnitude in Orion?
What are their names?
Which of them is farthest north?
Which farthest east?
How many of the second magnitude?
What very bright, large star southeast of Orion?
In what constellation is Sirius?
Which way is Procyon from Sirius?
Which way from Orion?
Of what magnitude is it?
In what constellation is it?
What large star northwest of Orion?
In what constellation is Aldebaran?
What clusters of stars in this constellation?
How many stars form the Pleiades?
Which is farthest north—Aldebaran or the Pleiades?
Which farthest east?
What large star almost directly north of Orion?
Of what magnitude is Capella?
Which way are the twins from Orion?
What are their names?
Of what magnitude are they?
Which way are the Twins from the Pleiades?
Which way from Procyon?
Mention the names of the six largest stars on the map, and the constellations in which each is situated?

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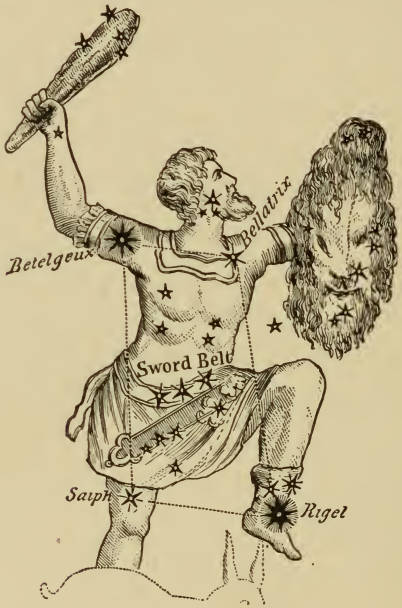
## LESSON TWENTY-FIRST.

### WINTER CONSTELLATIONS—CONTINUED.

1. ORION.—Orion is the name of a famous hunter, celebrated in Grecian fables. It is said that he was a giant. Standing in the very midst of the sea, the waters reached only to his shoulders. Being stung in the foot by a scorpion, he

died, and was placed in the heavens, where he is still imagined to have the appearance of a hunter.

2. Several small stars are imagined to form a




lion's head, which he is holding in one hand as a shield; others form a club, which he is holding in the other hand. Some small stars in a row form his sword, which is girded on by a belt com-

posed of three stars in a row You perceive that he is holding up one foot. This is the foot which was stung.

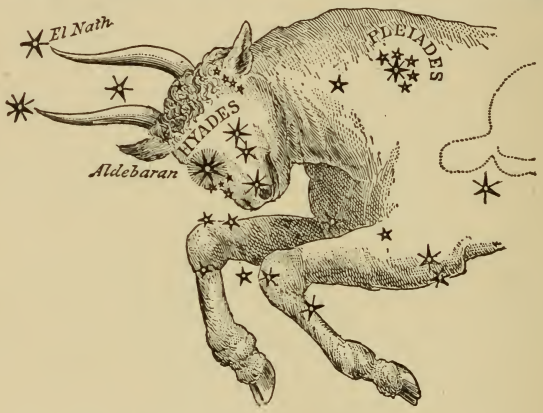
3. I need not tell you that you will see nothing in the Heavens resembling this picture. But you will see there a very remarkable constellation. Observe it once, and you will always know it. You will discover, as represented in the picture, four stars, two of them very bright, which you may easily imagine to make the corners of a long, square-like figure, with three bright stars, in a row, nearly in its midst. Look on the picture and learn the names of these four stars, so that you can point to them in the sky.

4. Orion rises nearly in the east, passes the meridian south of us, and sets nearly in the west. It appears in our evening sky soon after sunset, early in December, and continues visible to us until June, when it may be seen setting a little after the sun. Job seems to have admired this constellation as one of the most magnificent of the Creator's works. He says, "Who maketh Arcturus, Orion, Pleiades, and the Chambers of the South."

5. Northwest of Orion is a constellation of the Zodiac, called *Taurus*, or *The Bull.* You will know it from a fiery-red star, called *Aldebaran*,

which means *The Torch*, and from six * smaller stars in a cluster, called the *Pleiades*. Aldebaran and the Pleiades are in our evening sky from October to the last of May.

6. This constellation has been *imagined* to resemble a bull; a cluster of stars, including *Al-*




*debaran*, called the *Hyades*, form the face; the *Pleiades*, the shoulders; and other stars, other parts of the animal. The Bull is in the attitude of running furiously at Orion, who with one hand is striking at him with his club, and with the other is holding up to him his lion-headed shield.

* This cluster is commonly known by the name of *The Seven Stars;* but only six stars can now be seen by the naked eye, and one of *The Seven* is sometimes spoken of as the *lost Pleiad.*

7. The *Pleiades*, in Grecian fable, are said to have been daughters of king *Atlas*. Being pursued by Orion, Jupiter changed them into doves, and placed them in the sky. There they ever remain, from age to age, in one harmonious cluster. The meaning of the fable is, that though the fair daughters of love may be separated on earth, they shall meet again, and forever dwell together in the skies. Job alludes to the sisterly union of these stars when he says, "Canst thou bind the sweet influences of the Pleiades?"

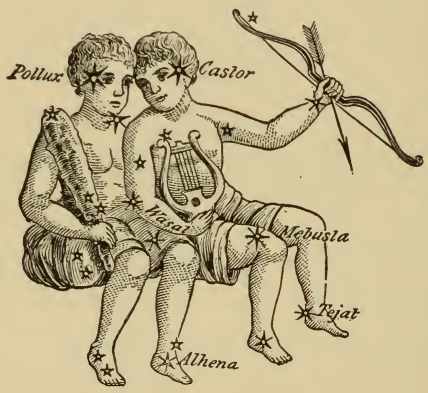
QUESTIONS.

1. Relate the story of Orion.
2. Describe Orion's appearance, as represented in the picture.
3. Is there anything, in the Heavens, which resembles the picture?
   Describe the constellation, as it appears in the sky.
   What four stars make the corners of the square-like figure?
   In which corner is Betelgeux?
   In which is Saiph?
   In which Bellatrix?
   In which Rigel?
4. Where does Orion rise?
   Where does it pass the meridian?
   Where does it set?
   In what months is it in our evening sky?
5. Where is the constellation Taurus situated?
   How may you know it?
   What does *Aldebaran* mean?
   When are Aldebaran and the Pleiades in our evening sky?
6. In imagining this constellation to resemble a bull, what stars form the face?
   What form the shoulder?
   In what attitude is the Bull imagined to be?
7. Who were the Pleiades, in Grecian fable?
   How came they to be placed in the sky?
   What may the meaning of the fable be?
   What does Job say of the Pleiades?
   To what does the expression, "bind the sweet influences of the Pleiades," allude?

## LESSON TWENTY-SECOND.

### WINTER CONSTELLATIONS—CONTINUED.

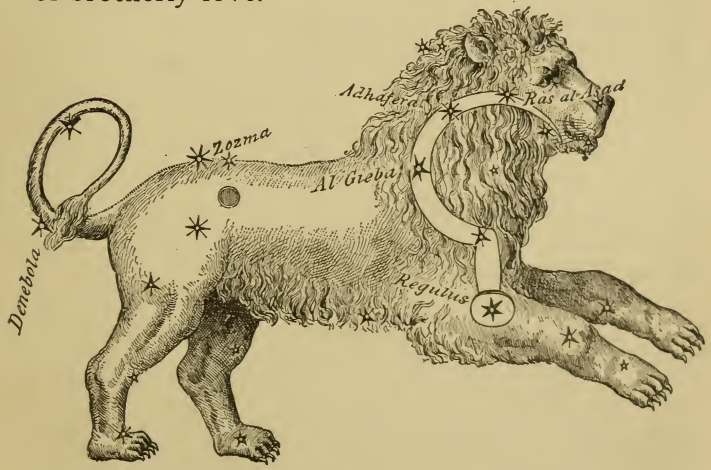
1. THE TWINS.—A good way east of Taurus, and northwest of Orion, appear two bright stars, a short distance apart, and resembling each other,




like twin brothers. Men in every age, looking up at the sky, behold them shining together, as though united by fraternal love. These twin stars are called *Castor* and *Pollux*, and the constellation, in which they are situated, is called the

*Twins.* Castor and Pollux may be seen in our evening sky from December to July.

2. Castor and Pollux are said to have been twin brothers, of whom Castor was mortal, and Pollux immortal. Castor having been slain, Pollux obtained leave of the gods to take the place of his brother among the dead, every other day. Thus they lived and died by turns. To reward such extraordinary affection, the gods at length placed them both together in the heavens. Go and learn from this beautiful fable a lesson of brotherly love.



3. Leo, The Lion.—Next east of the Twins is the constellation of the Zodiac, called the *Lion.* It is visible in our evening sky from January to July. It contains three pretty bright stars, *Regulus*, *Al Gieba*, and *Denebola.*

4. It is not easy to find any resemblance between this constellation and a lion. Perhaps, it was called by the name of this fierce animal, because it was in the sky with the sun at the season of raging heat.

5. Six or seven of the stars in Leo make a figure resembling a sickle. It may be easily traced out in the sky. The bright star *Regulus* is on the end of the handle.

6. The Greater Dog.—Southeast from Orion, and from us, blazes the most brilliant star ever seen in the heavens. It is *Sirius*, or the *Dog Star.* The constellation, in which it is situated, is called *Canis Major*, or the *Greater Dog.* Sirius may be seen glowing in our evening sky from December to July.

7. During a part of July and August, it is over our heads in the daytime, and close to the sun. It was once imagined that, thus united with the sun, it produced the raging heat sometimes experienced in these months. Hence this season is called the *Dog Days.* Now the dogs upon the

earth, sympathizing with the dog in the sky, go mad with burning rage.

8. On the picture you see the manner in which the stars of this constellation are imagined to form a dog. In fact, they might as well be im-


agined to form a wind-mill. Orion, that great hunter, having been placed in the sky, it was very natural to imagine his dogs and his game around him. Thus, in front stands the Bull, at his feet the Hare, and behind him his dogs; of

which this is one. Below is another, called *Canis Minor*, or the *Lesser Dog*.


9. The Lesser Dog.—Directly east of Betelgeux in Orion, and northeast of Sirius, is a very bright star called *Procyon*. It is in the constellation called the *Lesser Dog*. *Procyon* means *before the Dog*. This star is so called because it rises a short time before the Dog Star. It is the herald which announces his approach. A little northwest of Procyon is a smaller star called *Gomelza*. Procyon and Gomelza are situated, in regard to each other, very much like Castor and Pollux. They are visible in our evening sky from December till about the middle of July.

QUESTIONS.

1. Which way from Taurus and Orion are The Twins?
   What are their names?
   In what months may they be seen in our evening sky?
2. Relate the story of Castor and Pollux.
   What may be learned from this fable?
3. Which way from Virgo is the Lion?
   When is it visible in our evening sky?
   What three bright stars does it contain?
4. Why was this constellation called the Lion?

5. What figure do six or seven of its stars make?
   What large star on the end of the handle?
6. Which way from Orion, and from us, is Sirius?
   In what constellation is Sirius?
   In what months may it be seen in our evening sky?
7. When is Sirius overhead with the sun in the daytime?
   What influence was its union with the sun imagined to have?
   What is this season called?
8. Does this constellation really resemble a dog?
   Why was it imagined to resemble a dog?
   What stands in front of Orion?
   What at his feet?
   What behind him?
9. Which way from Orion and Sirius is Procyon?
   In what constellation is it?
   What does the word *Procyon* mean?
   Why was this star so called?
   What star a little northwest of Procyon?
   What stars do Procyon and Gomelza resemble in situation?
   In what months are Procyon and Gomelza in our evening sky?

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## LESSON TWENTY-THIRD.

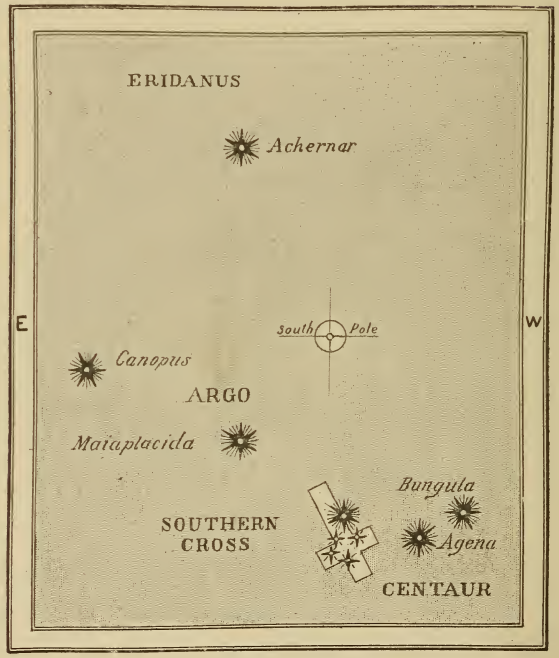
### CONSTELLATIONS NOT VISIBLE FROM THE UNITED STATES.

1. There are many stars, in the Southern Hemisphere, which we can never see, unless we go there.

2. The earth being a great globe, of which a great part lies between us and these stars, conceals them from our sight.

3. We can see *Rigel*, *Antares*, and *Spica Virginis*, although they are all in the Southern

Hemisphere, because they are but a short distance over the line of the equinoctial. They are all stars well worth seeing.




CONSTELLATIONS IN THE SOUTHERN HEMISPHERE NOT VISIBLE FROM THE UNITED STATES.

4. But the glories of the Southern Hemisphere shine too far south for our eyes. The Southern Hemisphere has no Pole Star, no *Alrucaba*; but you will envy the eyes of the young astronomers there, when you learn that six brilliant stars, of the first magnitude, glow in a radiant circle around the Southern polar sky. Their names are *Achernar*, *Canopus*, *Maia Placida*, *Alpha Crucis*, *Agena*, and *Bungula*. The map, page 96, represents their relative positions around the Southern Pole.

The voyager in the Southern Hemisphere always hails with delight the vision of the Southern Cross. As the sign of the Christian faith, it inspires the beholder with religious emotions.

"Then came night—th' intense
Dark blue—the burning stars! I saw *thee* shine
Once more in thy serene magnificence,
O Southern Cross!"

## QUESTIONS.

1. Where are the constellations not visible to us situated?
2. What conceals these constellations from our sight?
3. What brilliant stars of the first magnitude, in the Southern hemisphere, can we see?
   Why can we see these stars and not see other stars in the Southern hemisphere?
   How many brilliant stars of the first magnitude, in the Southern hemisphere, are invisible to us?
   What are their names?
   *Refer to the Map, page* 96, *and point out their positions around the Southern polar sky.*

## LESSON TWENTY-FOURTH.

### NEW, VARIABLE, AND DOUBLE STARS.

1. NEW STARS. — Sometimes stars suddenly flash forth where before there were no stars visible to the naked eye, and for a while continue to shine with great brightness, but finally disappear, and, so far as observed, never return. In two thousand years, only twenty-one such stars have been observed.

2. These stars are called *new* stars. Sometimes they are called *temporary* stars, since they appear only for a time. They have no names, neither are they counted in the number of the stars.

3. The most remarkable of all such stars was one observed in the constellation Cassiopeia, by that great astronomer, Tycho Brahe, a little over three hundred years ago. It was brighter than Jupiter or Sirius, or even Venus, and was visible in broad daylight. In a little less than a year and a half, it totally disappeared, and has not been seen since.

4. Another such star was observed by that

great astronomer, Kepler, about two hundred and eighty years ago, situated in the constellation called The Serpent-Bearer. It was brighter than Jupiter, but not quite so bright as Venus. At the end of about fifteen months, it could be no longer seen without a telescope. Another such star appeared in 1848, and another in 1866.

5. Astronomers do not think that these new stars, so called, are really new—that is, just created, when they appear. Neither do they think that when they disappear, they become extinct.

Astronomers think that certain changes in the matter of which they are composed, and perhaps also in the matter through which light passes from them to us, cause this sudden splendor and its cessation.

6. VARIABLE STARS.—There are many stars whose brightness varies; hence they are called *variable stars*. It is estimated that there are between one hundred and fifty and two hundred such stars. Perhaps there are many more, as observers are from time to time discovering new ones.

Instead of suddenly flashing forth with great brilliancy, like the new or temporary stars, they are observed to grow brighter and brighter

gradually, until a certain period, when they begin to grow gradually less and less bright, and finally become as they were at first, or entirely disappear. Some stars exhibit this appearance only for a few days, others for many years.

7. The variable star *Mira*, in the constellation called the Whale, is as bright as a star of the second magnitude for about two weeks. Then it decreases in brightness for about three months, when it becomes invisible to the naked eye. In about five months, it becomes again visible, and in about three months more, it is as bright as ever. It is a wonderful star. Hence its name *Mira*. *Mira* means *Wonderful*.

8. The star *Algol*, in the constellation Perseus, for about two days and a half, appears to be a star of the second magnitude. Then its brightness decreases until it appears as a star of the fourth magnitude. In about twenty minutes, it begins to grow bright again, and continues to do so for about four hours, when it appears, as at first, to be a star of the second magnitude; and so it continues to vary perpetually.

9. DOUBLE STARS.—Many stars which, when seen with the naked eye, appear to be only *one single* star, are discovered, when seen through the telescope, to be really *two* or more stars. They are so close together, that the naked eye, unable,

at their great distance from us, to distinguish between them, sees them as *one* object. These stars, when only two in number, are called *Double Stars.*

10. About eighty years ago only four such stars had been observed. Now the number observed, including stars visible only through the telescope, is about six thousand.

Generally, one of the two stars is larger than the other. Astronomers have discovered that some of the double stars revolve, one around the other, and have computed the time occupied by some of them in such revolution.

11. These double stars are frequently of different colors, of many delicate and beautiful shades, in harmonious contrast.

12. Sirius is the largest double star. Mr. Clark, with his great telescope, first discovered that he had a little companion star, not very far from him. The Pole Star, the stars Castor and Rigel, are other instances of double stars.

Imagine these double stars, always revolving one about the other, obedient to the command of their Great Creator, and shining for each other, in all their varied, rich, and contrasted colors. Wonderful companionship of the Heavenly Bodies! God has made even the stars for each other!

## QUESTIONS.

1. Do stars sometimes appear where before there were no stars visible to the naked eye?
   Describe the manner in which these stars appear and disappear.
   How many such stars have been observed in two thousand years?
2. What are these stars called?
   Have they any names?
3. Who observed the most remarkable of such stars?
   How long ago did Tycho Brahe observe this star?
   In what constellation was it?
   Describe its appearance.
   How long before it totally disappeared?
   Has it ever returned?
4. What great astronomer discovered another such star?
   In what constellation was it situated?
   How long since Kepler discovered this star?
   Describe its appearance.
   How long before it became invisible to the naked eye?
   How recently have such stars appeared?
5. Do astronomers think that such stars are *really* new, or that they become *extinct* when they disappear?
   What, do astronomers think, is the cause of their sudden splendor and of its cessation?
6. What are variable stars?
   How many variable stars are there?
   How do they differ from new or temporary stars?
   How long is the period of their variation?
7. Describe the variation of the star *Mira*, in the constellation called the Whale?
   Why is this star called Mira?
   What does the word Mira mean?
8. Describe the variation of *Algol*, in the constellation Perseus.
9. What stars are called double stars?
10. Eighty years ago, how many such stars had been observed?
    What is the number now?
    What is the magnitude of double stars, when compared with each other?
    What motion have such stars been observed to have?
    Has the time occupied in such revolution been computed?
11. Are double stars of the same, or of different colors?
12. Which is the largest of the double stars?
    Who discovered that *Sirius* has a companion star?
    How did Mr. Clark discover this?
    Name some other instances of double stars.

# LESSON TWENTY-FIFTH.

## COLORED STARS.

1. "In a transparent atmosphere," says Schellen, "especially in a southern clime, the stars do not all appear with the white brilliancy of the diamond: here and there the eye discovers richly-colored gems, sparkling on the sombre robe of night, in every shade of red, green, blue, and violet."

With the aid of the telescope, these colors can be seen more clearly.

2. The stars, viewed as single stars, are of different colors. Some are white, some red, some orange, some yellow, some green, with many varieties of delicate and exquisitely beautiful shades. For example: *Aldebaran*, *Antares*, and *Betelgeux* are red; *Vega* and *Sirius* are white; *Arcturus*, *Procyon*, and *Pollux* are yellow.

3. Some stars have changed their color. *Sirius* was once red, but is now white; *Capella* was once red, but is now blue.

4. The contrast between the colors of the double stars, or companion stars, is exceedingly beautiful. The following are examples: yellow

and purple, pale green and blue, orange and sea green, white and light purple, orange and emerald green, yellow and sapphire, blue, green, and bright blue.

It has been observed that the smaller star of the two companions has generally the more delicate color.

It must not be supposed that all double stars have different colors. Many such stars have the same color.

5. We do not know, that all the double stars are companion stars, or have any special relation to each other. Perhaps only the pairs which are of different colors are companion stars. I venture this suggestion, because these different colors seem to have been suited to each other.

6. Astronomers think that the different colors of the stars depend upon the nature of the matter of which they are composed, or by which they are surrounded, whence the light comes to us. As this matter changes, so also the color of the stars changes.

QUESTIONS.

1. Where and under what circumstances do the stars appear to be of different colors?
2. Enumerate some of these colors.

What is the color of Antares, Aldebaran, and Betelgeux?
What is the color of Vega and Sirius?

What is the color of Arcturus, Procyon, and Pollux?

3. Specify some stars which have changed their color.
4. Specify some of the contrasted colors of the double stars, or companion stars.
5. Have all double stars different colors?
6. Do we know that all double stars are companion stars?
7. What do astronomers think the different colors of the stars depend upon?

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## LESSON TWENTY-SIXTH.

### NEBULÆ.

1. *Nebula* is a Latin word, and means *mist.* In astronomy it means a whitish, misty spot on the sky. Look up in a clear night, when the moon is not shining, and you will see such spots in different parts of the Heavens.

2. Only a few *nebulæ* can be seen with the naked eye. With a telescope you can see many thousands. They are of many different shapes. Some are circular; some annular — that is, ring-shaped; some spiral—that is, shaped like a corkscrew; some crab-shaped, and many of very irregular form. The figures on pages 106 and 107 represent *nebulæ* of different forms.

3. The Milky Way—that white, luminous belt, which you see so clearly in a clear night, when the moon is absent, running across the Heavens,

ANNULAR NEBULA.

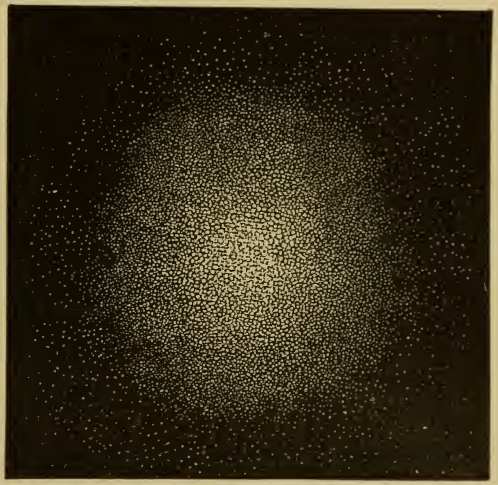
PLANETARY NEBULA.

SPIRAL NEBULA.

CRAB-SHAPED NEBULA.

northeast and southwest, from horizon to horizon, —is one great *nebula.*

4. Two white spots in the Southern Hemisphere, near the South Pole, visible to the naked



GLOBULAR NEBULA.

eye, but not visible in the United States, called the *Magellanic Clouds,* are great *nebulæ.*

5. To the naked eye, the *nebulæ* are merely white spots; but examine them with a telescope, and you will see that they are composed of innu-

merable small stars, lying so close together that their combined light spreads a soft, misty whiteness over the sky.

It is not necessary to suppose that these stars are in fact small. Their *apparent* smallness may be owing, in whole, or in part, to their great distance from us. Like all the fixed stars, they are regarded as suns to other systems.

6. There is a remarkable *nebula* in the constellation Orion, situated in that part called the Sword-Belt. Part of it is visible to the naked eye. You may look for it when it is clear and there is no moon. A part of it can be seen only through a telescope.

7. You must not suppose that all *nebulæ* are composed of clusters of stars.

Astronomers have not been able, with the telescope, to discern stars in all of them. This may be because the stars are so distant that even the telescope has not power to reach them. But astronomers have discovered, by means of an instrument called the *spectroscope*, that some *nebulæ* are composed of gas. This instrument shows the colors of the light coming from the *nebulæ* to be the same as the colors of *gases* well known to us. Hence it is concluded that the matter from which these colors come is gas.

## QUESTIONS.

1. What does the word *nebula* mean?
   What does it mean in astronomy?
   Under what circumstances can you see *nebulæ* in the sky?
2. Can you see many with the naked eye?
   How many can you see with the telescope?
   Are *nebulæ* all of one shape, or are they of many different shapes?
   Mention some of their different shapes.
3. What great *nebula* runs across our sky from horizon to horizon?
4. What great *nebulæ* are there in the Southern hemisphere near the South Pole?
   Are these *nebulæ* visible to the naked eye?
   Are they visible in the United States?
5. How do *nebulæ* appear to the naked eye?
   What are they found to be, when examined through a telescope?
   Are the stars in the *nebulæ* really small?
   To what may their *apparent* smallness be owing?
   What are these stars considered to be?
6. There is a remarkable *nebula* in Orion. In what part of the constellation is it situated?
   Is this *nebula* visible to the naked eye?
7. Are all *nebulæ* composed of clusters of stars?
   Have astronomers been able, with the telescope, to discover stars in all of them?
   To what may this failure to discover stars be owing?
   What does the *spectroscope* show that some *nebulæ* are composed of?
   How does the *spectroscope* show this?

## LESSON TWENTY-SEVENTH.

### THE FIXED STARS ARE SUNS.

1. Perhaps the fixed stars are suns in the skies of worlds like our Earth. Could you mount upon wings of lightning, and fly to some world near Sirius, you might behold him blazing in its sky, even larger and brighter than our Sun to us, while our Sun, should you be able to see it, would seem a faint glimmering star, among thousands of others.

2. I have two reasons for believing Sirius to be a sun. *First; it is is immensely large.* The Sun, which seems a round, bright spot upon the sky, no larger than your hat-crown, is in reality a vast globe, able to hold, were it hollow, hundreds of thousands of worlds like our Earth, with all their oceans, their continents, their islands, and their mountains. But astronomers have found that Sirius is four times as large as our Sun. A body so vast was never made just to twinkle, a little brilliant spot, upon our evening sky.

3. *Second: not only is Sirius immensely large,*

*but its light, like our Sun's, is not borrowed; it is its own.* I will show you how we know this. Sirius is very, very far from us—so far that the telescope which shows mountains and shadows on the moon, will not make it look any larger. So immensely distant is it, that light, which comes to us from the Sun in eight minutes, requires *three years* to come from Sirius. Feeble, borrowed light like the moon's could never perform a journey of three years; its strength would be spent long—long before it could reach the Earth. An immense globe of light, such as Sirius is—what can it be but a sun to other worlds?

4. If Sirius be a sun, the other fixed stars may be suns too. Arcturus, Aldebaran, Altair, Antares, Betelgeux, Rigel, Capella, Lyra, Procyon, Sirius, Fomalhaut, Achernar, Canopus, Maia Placida, Agena, Bungula, imagine each a vast globe of flame—a sun glowing in the sky of many a world. Behold the Dippers, and Cassiopeia, and the Twins, and the Bull, and the Lion, and the Southern Cross, each a constellation of suns, and each sun enlightening many a vast world. Observe the Pleiades—a cluster of suns; cast your eye all over the starry heavens, and behold in its thousands of stars thousands of

suns, enlightening tens of thousands of worlds. Turn then to the Milky Way and the nebulæ,—so thick-set with suns. Finally, raising your thoughts above the stars, think of Him who was able to make all these vast globes of flame, and the countless worlds around them.

QUESTIONS.

1. What may the fixed stars be?
   If you could fly to some world near Sirius, how might he there appear?
   How would our Sun appear?
2. How many reasons have you for believing the fixed stars to be suns?
   Mention the first.
   How many worlds like the Earth is the Sun large enough to hold?
   How much larger than the Sun is Sirius?
   Was a body so vast made for nothing but to twinkle in our sky?
3. Mention a second reason for thinking Sirius to be a sun.
   How do we know that Sirius' light is not borrowed light?
   What could such an immense globe of light have been made for?
4. If Sirius be a sun, what may we suppose the other fixed stars to be?

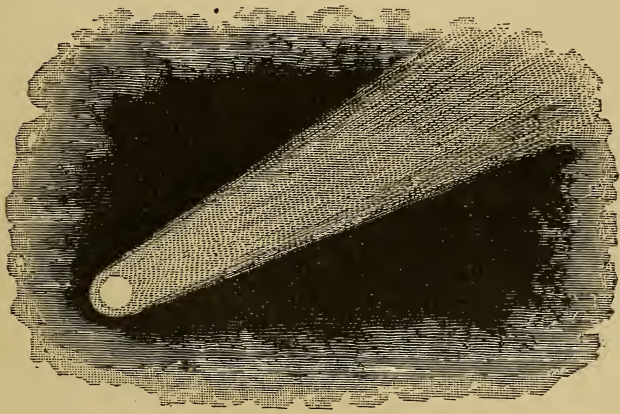
## LESSON TWENTY-EIGHTH.

### COMETS.

1. There sometimes suddenly appear in our sky bodies with a bright, star-like head, called the *nucleus*, from which streams forth a long, bushy tail of light, somewhat in the manner of

loose, floating hair. These are *Comets;* the word *Comet* means *long-haired.* They seem like *visitors;* for, after a few days, or at most months, they depart,—perhaps, never to return.

Some comets are not visible to the naked eye, and can be seen only through a telescope. Others



have been seen with the naked eye, in broad daylight.

2. No one can tell you *in what part* of the sky to look for comets. The paths of the planets, you remember, pass east and west, and always in that part of the sky through which the

Sun seems to move; but comets may appear anywhere—in the north or in the south, in the east or in the west. They seem to roam at will, being confined to no one region of the heavens.

3. Neither can any one tell *how large* a comet will appear. Some comets have been seen with a head no larger than a small star; others have looked as large as Venus, and it is said that there have been comets as large as the moon. Even the same comet does not always appear equally large. At first, it generally grows larger and brighter, and then smaller and fainter until it is gone.

4. Nor is it possible to tell *how long* a comet's tail will be. Of some, the tail is short—of others, pretty long—and of others, immensely long. About one hundred and fifty years ago, a comet appeared whose tail reached from the horizon to the very top of the sky; and about one hundred and thirty years after our Saviour, there was one whose tail was long enough to reach from one side of the heavens to the other, like the Milky Way. For many years, however, the comets have been short-tailed. The tail of the same comet does not always appear equally long. At first it generally grows longer and brighter, and then shorter and fainter, until it disappears.

5. Indeed, comets are the most capricious beings imaginable; it is not even possible to tell *how many* tails they will have, nor whether the tail will go before or follow after the head. Most comets have but one tail; but about a hundred and fifty years ago, there appeared a comet with *six* tails, spreading out like an immense fan; and one is mentioned as having been seen with both a tail behind and a tail before.

6. Comets are under no more control, in regard to their *apparent motions*, than in regard to the place of their appearance, their size, or the length and number of their tails. Some move from east to west, others from west to east; some from north to south, others from south to north; some go straight forward, others with a crooked, snake-like course; some move fast, others slow. Even the same comet moves faster at some times than at others. It is hard to tell where to look for a comet; and if you find it to-day, you do not know where it will be to-morrow.

7. Of some eight hundred and eighty comets which have appeared in our sky, been observed, recorded, and disappeared, only about twenty are known to have returned.

Of these, one disappears and returns in about three years, three in five, one in seven, one in thirteen, and one in seventy-five years.

8. Once it was thought, when a comet appeared, there would soon be war, or pestilence, or famine; and men have trembled at the sight of a comet, for fear the world would be destroyed, But of the eight hundred and eighty comets, which have been seen, not one is known to have excited men to fight, or to have made them sick, or to have killed their corn; and as for the world, it yet remains unharmed. Should the tail of a comet strike the earth, it is not certain that it would do any injury, for comets seem to be made of matter even lighter than the clouds, since stars have been seen shining through them.

QUESTIONS.

1. How do comets look?
   What does the word *comet* mean?
   Why do comets seem like visitors to our sky?
2. In what part of the sky must you look for comets?
3. How large do comets appear?
   Does the same comet appear always equally large?
4. How long are the tails of comets?
   Two comets are mentioned which had very long tails; *how long* were they?
   Are the comets now long-tailed or short-tailed?
   Does the tail of the same comet appear always equally long?
5. How many tails do comets have?
   Does the tail go before or after the head?
6. Which way and how do comets move?
7. How many comets have visited our sky?
   How many of them are known to have returned?
   Mention the periods of their return.
8. What was it once thought would soon happen, when a comet appeared?
   If the tail of a comet should strike the earth, would it do any hurt?

# LESSON TWENTY-NINTH.

## THE SOLAR SYSTEM.

1. The planets, as I have already told you, are great worlds, receiving light and heat from the Sun, while the fixed stars are themselves suns to other worlds, and so very far from our Sun that he cannot appear, at them, larger than a star.

2. The Sun, with the planets and their moons, composes, as it were, a regular family, or system. Astronomers call it the SYSTEM OF THE SUN, or the SOLAR SYSTEM. They do this to distinguish it from other systems of worlds, of which they suppose there are as many as there are fixed stars, or suns, to enlighten and warm them. Thus, there may be the system of Sirius, the system of Arcturus, and so on—as many systems as there are fixed stars, or suns.

3. The names of the planets, known to us, are Mercury, Venus, the Earth, Mars, Jupiter, Saturn, Herschel or Uranus, and Neptune. Besides these, are the Asteroids, Juno, Vesta, Ceres, Pallas, and the others, about two hundred and forty in number, all discovered within the

last one hundred years, and all named by their discoverers.

4. The Earth has *one* moon, Mars *two*, Jupiter *four*, Saturn *eight*, Herschel or Uranus *six*, Neptune *one*. Thus, we know that there are twenty-two moons in the Solar System. Others may yet be discovered. We also know that, including the eight planets and the twenty-two moons, there are thirty heavenly bodies in the Solar System, besides the Sun, the asteroids, and the comets.

5. These eight planets, as you know, all revolve in great orbits around the Sun, and these twenty-two moons revolve about the planets to which they belong, and accompany them in their revolution around the Sun. The asteroids also revolve around the Sun, in orbits lying near together.

6. You will observe that the planets, with reference to their moons, are called *primaries*, and that the moons, with reference to the planets around which they revolve, are called *secondaries*, or more generally *satellites*—that is, *attendants*, because they seem *to wait on* their primaries, *serving* them with their beautiful light.

7. Astronomers have discovered that the planets are arranged around the Sun, as represented

on the picture of the Solar System, page 131. Observe it. You see the Sun in the centre; nearest to him Mercury, next Venus, next the Earth; then come Mars, the Asteroids, then Jupiter, Saturn, Herschel or Uranus, and, most distant of all, Neptune.

Mercury, the planet nearest the Sun, is not, as it seems in the picture, very near to him. It is many millions of miles from him.

8. Astronomers have ascertained how large the Sun is. He is by far the largest of all the bodies of the Solar System. He is as much larger than the Earth as a ball, as large as a man can reach around with both arms, is larger than a pea. How very far from us he must be, to appear no larger than he does!

9. The Sun, as you have learned, seems to move through the sky every day, and also to be continually moving north and south the whole year. But there are many reasons for believing that it is the Earth and not the Sun which moves. How strange it would appear to see a ball, as large as a man can reach around, revolving about a pea!

But while the Sun remains in one place,* send-

* I mean that the Sun does not move, so far as regards the planets and other bodies which compose the Solar System. Astronomers

ing forth light and heat to all the planets, he revolves, like a wheel on its axis, once every twenty-five days. *

## QUESTIONS.

1. What are the planets?
   What are the fixed stars?
   How far from the Sun are the fixed stars?
2. What bodies compose the Solar System?
   Why do astronomers call it the Solar System?
   How many other systems of worlds do they suppose there are?
3. What are the names of the planets known to us?
   How many asteroids have been discovered?
   Have they been named?
   By whom?
4. How many moons has the Earth?
   How many has Mars?
   How many has Jupiter?
   How many has Saturn?
   How many has Herschel?
   How many has Neptune?
   How many moons in all, do we know, there are in the Solar System?
   May others yet be discovered?
   Including the eight planets and the twenty-two moons, how many heavenly bodies are there in the Solar System?
   What other bodies are included in the Solar System?
5. How do these eight planets and their twenty-two moons revolve?
   How do the asteroids revolve?
6. What are the planets, with reference to their moons, called?
   What are the moons called, with reference to their planets?
   What name is more generally used, when speaking of the moons, with reference to their planets?
   What does the word *satellite* mean?
   Why are the moons called *satellites* or *attendants?*

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have discovered that the Sun and the whole Solar System have an independent motion in space. So also have the fixed stars.

* Astronomers have learned this by observing black spots gradually move across the Sun, disappear, and in twenty-five days from the time when first observed, appear again in the very spot from which they started.

7. Which of the heavenly bodies is the centre of the Solar System?
Which of the planets is nearest to him?
Which next?
Which next?
What planet, after the Earth, is next nearest to the Sun?
Mention the three planets next nearest, in the order of their distances?
Which planet is farthest from him of all?

8. Which is the largest body in the Solar System?
How much larger than the Earth is the Sun?

9. Does the Sun really move through our sky?
What makes him *appear* to move?
Can you mention any reason for believing that the Sun does not move around the Earth?
How often does the Sun revolve on his axis?

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## LESSON THIRTIETH.

### THE SOLAR SYSTEM—CONTINUED.

1. THE EARTH.—Strange as it may seem to you, this great globe, the Earth, with its green continents and islands, and its blue ocean, appears at the other planets, as they do to us—a little bright star. It is a planet as much as Jupiter or Venus, or any other one; for it is round like them, lighted by the Sun like them, and revolves like them.

2. The Earth revolves on its axis from west to east once every twenty-four hours—presenting its different sides one after another to the Sun. In this way it makes the Sun, moon, and stars

appear to move from east to west over our heads; and in this way, too, the countries on its different sides have each their turn of day and night.

3. The Earth has another motion: while it is continually revolving like a wheel on its axis, it is at the same time travelling, from west to east, in a great circuit round the sun. This circuit, or *orbit*, as it is called by astronomers, you see represented on the picture of the Solar System. The time, which the Earth takes to go round the Sun, is called a year. It is this motion of the Earth in its orbit which makes the apparent annual motion of the Sun and of the stars which I have already described. Perhaps you wonder that you do not feel the Earth's motion. It is because the motion is so easy—there is nothing for the Earth to strike against and jolt you. The moon revolves from west to east round the Earth, and, at the same time, moves forward to keep company with the Earth, in its motion round the Sun.

4. All the other planets are immense globes, some of them larger and some smaller than the Earth. All of them revolve, as though hung on an axis, like the Earth, some in a longer and some in a shorter time—and all of them travel, like the Earth, in great orbits round the Sun.

*See the paths or orbits of the planets, represented on the picture.*

5. Jupiter is the largest of all the planets. Let us represent him by a moderate-sized orange; then a small orange will represent Saturn, the next largest; a plump, round cherry will represent Herschel; Neptune is a little larger than Herschel. Two peas will represent Venus and the Earth; a large pin's head, Mars; a grain of mustard seed, Mercury—and grains of sand will represent Juno, Vesta, Ceres, Pallas, and the other asteroids. Our moon, which appears almost as large as the Sun, is in reality not so large as Mercury, the smallest of all the planets visible to the naked eye. She appears large because she is near us.

6. The Earth is so far from the Sun that, if you should fly day and night, as swift as a cannon-ball, you could not reach the Sun in eleven years. Mercury is about three times nearer the Sun than the Earth, Venus a little more than twice the distance of Mercury, Mars considerably less than twice the distance of the Earth, Jupiter about five times, Saturn about nine times, Herschel or Uranus about nineteen times that distance, and Neptune about twice as far from the Sun as Herschel.

7. The planets nearest the Sun require more time to revolve on their axes, and less time to go around the Sun, than those farthest from him. Those nearest have the longest day, and those farthest off the longest year. Mercury, Venus, the Earth, and Mars have about twenty-four hours, each, for their day, and Jupiter and Saturn not half so many. Mercury's year is about one fourth as long as ours; Venus' about three fourths, Mars' almost twice as long. Jupiter's year is equal to twelve, Saturn's to thirty, Herschel's to eighty-four, and Neptune's to one hundred and sixty-four, of our years.

8. You cannot understand in what way many of the things which I have told you in this lesson have been discovered, until you advance farther in the study of Astronomy.

## QUESTIONS.

1. How does the Earth appear at the other planets?
   Is the Earth a planet like Jupiter or Venus?
   What makes you think it to be a planet?
   What makes the Sun, moon, and stars appear to move over our heads through the heavens?
2. How often does the Earth revolve on its axis?
   Which way does it revolve?
3. What other motion has the Earth?
   What do astronomers call the path in which the Earth travels round the Sun?
   What is a year?
   What effect has this motion of the Earth upon the Sun and fixed stars?
   While the Earth thus travels

round the Sun, what becomes of the moon?

4. What is the shape and size of the other planets?
   In what respects are they like the Earth?
5. Which is the largest of all the planets?
   If we represent Jupiter by a moderate-sized orange, what will represent the other planets?
   How large is our moon compared with the planets?
   Why does she appear so large?
6. If you should fly day and night, swift as a cannon-ball, how long would it take you to reach the Sun?
   Which planet is nearest the Sun?
   How much nearer to him is it than the Earth?
   How much farther off is Jupiter, Saturn, and Herschel?
7. Which planets require the most time to revolve on their axes?
   Which require the longest time to go round the Sun?
   Which have the longest day?
   Which the longest year?
   How long is the day of Mercury, Venus, and the Earth?
   How long is that of Jupiter and Saturn?
   How long is Mercury's year?
   How long is Venus'?
   How long is Mars'?
   How long Jupiter's, Saturn's, and Herschel's?
   How long is Neptune's?

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# LESSON THIRTY-FIRST.

## THE SOLAR SYSTEM—CONTINUED.

### ROTATION AND REVOLUTION OF THE PLANETS.—THEIR CAUSE AND EFFECTS.

1. Of those silent, mysterious forces which cause the planets to revolve on their axes, and hold them, and carry them, in their orbits around the sun, I have said nothing. The subject is difficult for beginners.

2. Look at the picture of the Solar System, page 131, and imagine to yourselves thirty planets, revolving on their axes, including twenty-two moons revolving about their primaries, and all revolving around the sun. Observe too, that of the twenty-two moons, each revolves around its primary, in the same period of time, and that each planet always performs its revolution on its axis, in the same number of hours, and its revolution around the sun, in the same number of days or years.

Whence this unerring, measured movement of the heavenly bodies, without collision, each, in its own orbit, and in its own time, so harmonious that it has been likened to music,—sometimes called the Music of the Spheres?

Addison speaks of the stars as *singing*. He says:

> "What though nor real voice nor sound
> Amid their radiant orbs be found?
> In Reason's ear they all rejoice,
> And utter forth a glorious voice,
> Forever *singing*, as they shine,
> 'The hand that made us is divine.'"

It is to these harmonious movements that Kepler refers, when he says:

> "Praise ye the Lord, ye Heavenly Harmonies."

3. Beginners though you are, you will ask me, What is the cause of these wonderful motions? Why do the planets turn on their axes? Why do they move in such majestic, harmonious measure around the sun? I answer:

The Almighty Hand that made them created *two forces*—one which set them in motion in a straight line, called the *Projectile Force*, and the other, called the *Force of Gravitation*, which embraced them the very instant they began to move, changed the straight line into a curve, and so carried them, and ever carries them, in perpetual revolution on their axes, the moons around their planets, and both moons and planets around the sun. This you may not fully understand now; but it will become clear to you as you advance in the study of Astronomy.

4. The *Projectile Force*, in kind, is like that which a boy gives his ball when he throws it. The moment that the ball leaves his hand to move off in a straight line, the *Force of Gravitation*, which draws all matter upon the earth towards its centre, lays hold of it, bends the straight line into a curve, until the ball reaches the ground.

To compare great things with small, in like manner the Almighty Hand first set the planets in motion, in a straight line, by a *projectile im-*

*pulse*, which line, without revolving on their axes or around the sun, they would have pursued forever, had not the same Almighty Hand, at the same instant, arrested their progress by the *Force of Gravitation*, changed the direction of their motion into a curve, and thus compelled them to turn on their axes in perpetual rotation, and at the same time to move in perpetual revolution, in great orbits, around the common centre. The combined action of these two forces, constituting *one force*, in constant operation, is the answer to your question.

5. Kepler learned to measure the Force of Gravitation, but did not know that it was of the same nature as that which attracts bodies on the earth to its centre. About fifty years later the great Sir Isaac Newton made that discovery. Observing an apple fall from the tree to the ground, he conceived the idea, as if by a sublime inspiration, that the force which attracted the apple exists everywhere in the material universe, and is the cause of all the motions of the heavenly bodies, —an idea now universally admitted to be true.

6. To the rotation of the earth on her axis, and to the revolution of the moon around the earth, I need not say, are due all the wonderful *phenomena* of light, in all its manifold variations,

from the blackness of midnight to the splendor of noonday—from the freshness and beauty of the morning dawn to the calm glories of the evening sunset. You are familiar with these *phenomena*, so familiar that, perhaps, you do not often think whence they come.

7. I have explained to you, in Lesson Third, how the revolution of the earth in her orbit around the sun causes the seasons of the year. This orbit is so marked out by the Great Creator, that the earth, as she moves through it, always presents her surface to the sun so as to receive his beneficent rays in the exact measure necessary for summer or winter, spring or autumn. During a part of her course, her position with reference to the sun is such, that his rays come to her full and direct, and during a part such, that they come to her obliquely and scattered. *See the figure, page* 13.

8. In the rotation of the earth upon her axis, and in her revolution in the great pathway ordained for her, lies the fulfilment of the promise in Genesis viii.:

"While the earth remaineth, seedtime and harvest, cold and heat, summer and winter shall not cease."

What is true of the earth, it would seem must be true of the other bodies like her, in the Solar System.

## QUESTIONS.

1.–2. How many planets in the Solar System?

How many of them are *primaries?*

How many of them are *secondaries?*

Do both the primaries and the secondaries revolve on their axes and around the sun?

What planet revolves around the earth, and at the same time around the sun?

Is it a *primary*, or a *secondary?*

What has the harmonious movement of the heavenly bodies in the Solar System been likened to?

Addison speaks of the stars as *singing;* recite his lines.

To what does Kepler refer, when he calls upon the Heavenly Harmonies to praise the Lord?

3. What makes the planets in the Solar System turn on their axes?

What makes them revolve around the sun?

What makes the moon revolve around the earth?

What is a *projectile* force?

In what kind of line does it cause a body to move?

In what line will a body projected move, when attracted by the force of gravitation?

4. Give an example of *projectile* force.

In order to arrest the action of a *projectile* force, and carry the body round in a curve, towards what point must the force of gravitation attract it?

5. Who measured the force of gravitation, before its nature was known?

How long afterward before its nature was discovered?

Who discovered it?

How did the idea of its nature occur to Sir Isaac Newton?

What idea as to the cause of the motions of the heavenly bodies did the fall of the apple suggest?

Is this idea now universally admitted to be true?

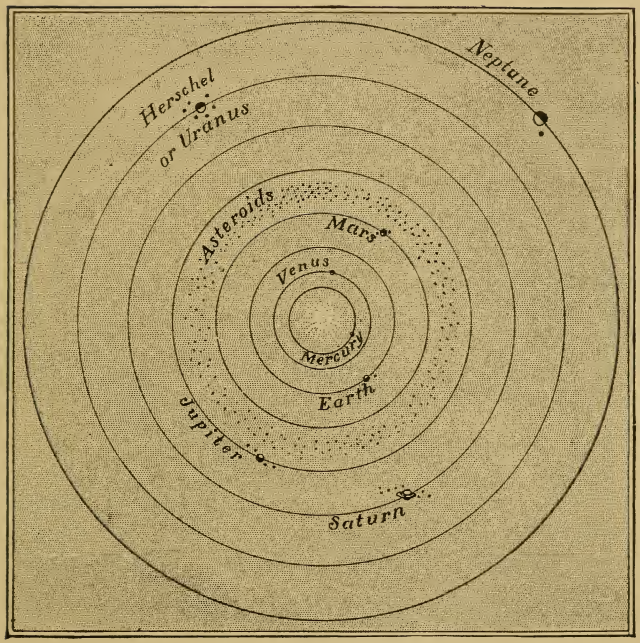
6.–7. To what cause are the *phenomena* of light due?

What causes the seasons of the year?

8. Recite the promise in Genesis viii.

In what does the fulfilment of this promise consist?

Do the same causes, which produce day and night and the seasons on the earth, have the same effect on the other heavenly bodies in the Solar System, which are like the earth?




THE SOLAR SYSTEM.

## LESSON THIRTY-SECOND.

### HISTORY OF ASTRONOMY.

In the earliest ages of the world, men were very ignorant of Astronomy. They thought that the earth was a vast plain, above which the heavens were spread out like a tent.

When the sun disappeared in the west, they imagined he had gone down to bathe and to sleep in the ocean, from which he came forth again in the morning, in the east. The moon and stars, as they supposed, did the same. Some thought that the stars were divine beings; others, that they were the abode of such beings.

Some Greek philosophers believed that the stars were made of air and fire; others, that they were solid bodies surrounded by fire. One of them thought that the sun was a great, red-hot stone.

Some taught that the sun, moon, and earth were flat; others, that they were cylindrical. A few, like Anaximander and Anaxagoras, entertained more correct opinions.

Pythagoras secretly taught the diurnal and the

annual motion of the earth, but dared not declare his opinions openly, for fear of the people.

Ptolemy, a very distinguished Greek Astronomer, lived about seventy years after our Saviour. He taught that the earth was at rest, while the sun, moon, and stars revolved round it. This doctrine was generally believed until the time of Nicolas Copernicus—more than a thousand years.

Nicolas Copernicus, a Prussian, lived about three hundred and fifty years ago. This man relinquished the study of medicine, to devote his life to the study of Astronomy. He wrote a book entitled *The Revolutions of the Heavenly Orbs*, in which he showed that the sun and fixed stars were at rest, while the earth revolved round the sun, and also turned round every day. This system is called the *Copernican System*, and sometimes the *Solar System.*

Copernicus knew that few would believe that the earth moved while the sun stood still, and for some years taught his system only to his friends. At length he permitted his book to be published. But the very day it was to come from the press, he was taken very sick. As he lay upon his couch, with his disciples around him, a friend entered the room with the first printed

copy of the work. Copernicus bid him place it before the window, where the light might fall upon it. He did so. Copernicus turned his eyes to behold it—took it in his arms—pressed it to his bosom, and soon after died.

Galileo, an Italian, was the first who surveyed the heavens with a telescope. Turning this instrument to the sky, he beheld mountains and valleys on the moon, Venus exhibiting phases, a ring around Saturn, four moons revolving round Jupiter—things which no mortal eye had seen before.

Galileo was convinced that the system of Copernicus was true, and taught that the earth moved. For this, at the age of seventy, he was summoned to Rome, and put in the dungeons of the Inquisition.

After a time, he was brought before a court, composed of seven Cardinals. They condemned him to fall upon his knees, and solemnly to confess that the earth did not move. But as he rose from his knees, stamping on the floor, as if angry at what he had done, he declared, "But still it does move." For this he was again sent to prison.

Of Tycho Brahe, Kepler, Newton, the Herschels, and others, I cannot tell you now.—I

trust, however, I have said enough to make you desirous of knowing more about this wonderful science.

In this age, many skilful and patient eyes are ever watching the heavens to discover new wonders. The telescope is ever busy with the sun, moon, and stars, to ascertain their nature, magnitudes, motions, and distances. Those mysterious double stars, and those wonderful nebulæ, are subjected to its untiring scrutiny.

Within the last fifty years, more that two hundred asteroids, two satellites of Mars, and one more satellite of Saturn have been discovered. Most wonderful of all, the telescope has reached that far-off planet, Neptune, and added him, with his solitary moon, to the Solar System.

Still there is no end. The science of Astronomy will ever continue to advance, and yet it will ever be true, that "these are but parts of the ways" of the Great Creator!

THE END.