

NATURE, SCIENCE & SOCIETY

K. K. KRISHNA KUMAR

(Kerala Sastra Sahitya Parishad)

1. SO MANY THINGS!

Dear friends, shall I ask you a simple question? It is a question all of you will be able to answer. Here it is.

Can you name all the things you have seen today since you woke up in the morning till you went to bed in the evening?

That's easy, isn't it? Then start thinking...What are all the things you saw when you opened your eyes this morning?

The bed, pillow, the walls of the room, the calendar hanging on the wall, the water jug, chair, table, cot, the books on the table, the bulb hanging from the ceiling, the clock on the wall, the open window, the trees beyond the window, the rising sun.... So many things!

And what did you see when you went out onto the verandah? The yard outside, the hen and its chicks wandering about...Oh, see what this naughty hen has done! She has dug up the soil under the rose stem I planted yesterday—I feel like driving her away... But then where would I get eggs from?

Beyond the yard, bushes and flowering plants —hibiscus, dahlia, rose, and jasmine. Today there are two flowers on the rose plant. I will pluck one of them.

There are so many different kinds of trees in the compound: mango, tamarind, neem, gulmohar.... Oh look! Two squirrels are running up the branches of the mango tree and there's a crow's nest on the gulmohar.

What else did you see?

When I went in to brush my teeth, the metal pipe with cold clean water coming out of it; the red bucket into which the water was falling... In the kitchen, mother making roties, vessels, and the fire in the stove, cups and plates on the stand, a procession of ants leading out of the sugar 'dubba'... that is all.

Is that all? Didn't you see anything else? What did you do after breakfast?

Oh, there were many more things I saw. After breakfast as I set off for school, there was the long tarred road with rickshaws and buses plying on it and bullock carts too. On one side of the road electric posts, beyond it green fields and in the distance, hills and forests. A railway line running across the field with a train steaming along, east. On the other side of the road a pond and some buffaloes bathing in it. I even saw an elephant, and a man with a bundle of green leaves sitting on it.

As I reached school, I saw the small shop outside the gate with different coloured glass jars. Next to that the 'chana' shop, with sweetened and salted groundnuts and many other kinds of nuts in small containers. I saw a lot of children crowding around the shops.

Once inside the gates, so many rooms. Name boards outside each classroom. In the classroom, chalk, the blackboard, maps, the globe. And then so many more things on my way back from school.

What did you see later in the day, at night?

The moon shining in the sky, many-many twinkling stars all around it...fireflies.

So you see how difficult it is to remember all that we see in the course of a day. How difficult it is to list them. And there are things we see every day. So then, it is not all that easy to answer that 'simple' question. But don't let that bother you, friends. There is nobody who can name all the things he or she has seen. Why? Because there are that many.

Soil, air, water, sky, stars, clouds, moon, trees, plants, flowers, birds, animals, fishes, snakes, insects, human beings, rain, sunlight, snow, wind...So many such things all around us. Can we count these? Would they be a hundred? Or a thousand? No. Much more than a hundred or a thousand or lakhs or crores. These things are beyond counting. And they are all part of a large, large family. Does anyone of you know the name of that family?

No?

It is THE UNIVERSE.

The tiniest of ants, mightiest of elephants, the birds and animals, and human beings among them!

The water and sands, the sky and stars, mountains and seas, flowers and bees!

The smallest of things to the largest of things, my friends and me— we all belong to?

THE UNIVERSE.

So friends, don't forget the name of the big family we all belong to: THE UNIVERSE

2. LOOKING AT THE SKY

Friends! Is there anybody among you who has not looked up at the sky at least once? No!

Okay then. What do you see when you look at the sky? If we look at it during the day, we see the sun, and may be white clouds floating around. If it is the rainy season, we see big black clouds. And what do we see if we look at it at night?

What fun it is to watch the sky on a clear night! Especially if it is a full moon day! The moon, big and round like a 'papad'. Some days we see only a small piece of the moon, like a slice of water melon. We also see a sky full of stars, glittering and twinkling. Have any of you tried counting the number of stars? If not, try one night. But you can never count all the stars. Even the stars we see are countless. Does that mean there are stars we can't see. Of course! There are many-many stars that can't be seen. Are all the stars alike? Look carefully at the sky on a clear night. You will see a lot of twinkling stars. But there are some among them which do not twinkle. The twinkling ones are called stars and the others are called planets.

What is the difference between planets and stars? There is a simple device by which you can understand this difference. All of you have seen a light bulb, the bulb we use at home at night. Stars are like bulbs. They give out light. But there is a small difference. Bulbs shine only when we switch them on; for stars, there is no question of switching them on. They always give out light.

Now place a steel vessel or a mirror on a table under the lit bulb. What happens? The light from the bulb gets reflected on the steel vessel or mirror. The steel vessel will not shine if the bulb is removed or switched off. Planets are like this vessel or mirror. That is, planets reflect the light which comes from stars. They do not shine or give out light themselves.

Now friends, can any of you tell me which star is most familiar to us?

Yes, the SUN.

And which is the planet you know best?

The Earth.

Do you find it difficult to believe that the SUN is a star? If it is a star why do we see it only during the day, while the other stars are visible at night?

During the day, because of the sun's bright light we are not able to see other stars. If you keep a small candle close to a tube light, don't you feel that the candle is less bright? If you switch off the tube light, the candle appears bright. Similarly during the day, because of the sun's brightness we do not see the other stars. But when the sun sets and it gets dark, we see the stars twinkling in the sky.

Now you may ask why it is that only the sun is so bright and not the other stars? In fact the other stars also give out a lot of light like the sun. And there are even stars which are brighter than sun. But the sun is nearest to us. Other stars are far far away from our earth. That is why the sun appears bigger and brighter to us.

Now are you ready to believe that the sun is a star?

In this Universe there are many-many stars like the sun and many planets like the earth.

How many stars and planets are there?

A thousand? No.

Ten thousand? No.

A lakh? No.

A million? No.

A billion? No.

Many-many more.

Can we see all these stars?

Not all. Some we can see when we look at the sky. But there are many stars we can't see with the naked eye. They are too far away.

There is an instrument by which we can see stars which are far away. It is called a telescope. But even through a telescope we can't see all the stars. There are millions of stars far-far away beyond the reach of telescopes even.

Now let us learn some things about our Earth.

The Earth is a——. What is it?

A Planet.

Did you know that the earth is constantly moving round the sun? And guess how long it takes for the earth to go round the sun once? 365 1/4 days. That is, one year.

At certain times of the year we feel cold. We feel like covering ourselves with blankets while sleeping, don't we? And at certain times of the year it is hot. These are a result of the earth moving round the sun. The sun gives us the light and heat, we need.

If the light and heat of the sun did not reach the earth, there would not have been plants, animals or any other forms of life on earth. There would have been no human beings.

We know that the earth moves round the sun. At the same time the earth is rotating around itself. It is because of this self rotation of the earth that night and day occurs.

How exactly?

All of you know that the earth is round like a ball, don't you? The side of the earth that faces the sun has day, and the other side which is away from the sun, has night.

To understand this let us do a simple experiment.

Keep a football - or any other ball - on a table in a dark room. Now hold a lighted electric torch over the ball. The light from the torch will fall on the top side of the football. Now turn the ball. You will see that the area which was dark earlier is now lighted and the area that had been lit in the first case is becoming dark. If we didn't turn the ball one side of it would always get light while the other side would always be dark.

Our earth is like a ball, a giant ball. Because it turns round and round different parts of it get the sun's light, that is, come under light and darkness alternately.

Suppose our earth didn't rotate? One side of it would always have day and the other side always night. Isn't that so? How boring it would be if it was always day or night! But there is no need to get worried. The earth will always rotate, and therefore day and night will always repeat themselves, alternately.

. Is there anybody to rotate the earth, like we rotated the ball? No. The earth rotates by itself. Our country, India is on one side of the globe, and America is on the opposite side.

So when it is day for us, America has night. When you are going to school, children in America will be sleeping. Funny, isn't it?

We have already seen that the earth moves around or revolves around the sun. Like the earth there are other planets also which revolve around the sun.

Does anybody know the names of those planets?

No? They are Mercury, Venus, Mars, Jupiter, Saturn, Uranus, Neptune and Pluto.

The family, to which the sun and the nine planets moving around it belong, has a name. What is it?

The solar system.

So, the earth is one of the members of the small family called the solar system and a human being is but one of the millions of living beings on earth.

Oh, yes! We had almost forgotten our friend, the moon!

The Moon is neither a star nor a planet.

Then what is it?

It is a satellite.

What do we mean by 'satellite'?

Satellites are small bodies which revolve around planets. The moon is a satellite which revolves around our earth. It is very near the earth when compared to the Sun or the planet Mars. That is why it seems so close to us, why it can be seen so clearly in the sky. The moon also rotates by itself, like the earth.

All of you have heard about the Americans who landed on the moon, haven't you? Who was the first man to set foot on the moon?

Neil Armstrong.

So, now we know that the moon revolves around the earth, and that the earth and moon together revolve around the sun.

What about the Sun?

The Sun also revolves around something—so too billions of stars in the universe. Like our Sun, they are all revolving.

When the earth moves we who live on the earth also move, also go around. We are like ants crawling on top of a big ball that is always in motion.

3. HOW FAR! HOW BIG!

Now let me ask you another simple question.

How long is a match stick? You don't know? Okay then measure it with a rule.

How long is it?

Approximately 4-centimetres.

And what is the length of a pencil? Approximately 17-centimetres.

You have all gone shopping to buy material for shirts and trousers, haven't you? How do they measure the cloth in these shops? The tailor tells you that Father requires 2 metres of cloth for a shirt and that for you 1 metre would do. So cloth too is measured in meters.

Now, how far is your school from your house?

Exactly, 2 1/2 kilometres. That we know without measuring, because there are milestones' to mark distances on the road.

How far is the nearest town from where you stay?

30 kilometres away.

What do you understand from all these?

First, that there are different types of measures like centimetre, metre, kilometre, etc. There are other measures like millimetre, furlong, mile, etc., also.

Second, measure is used for a particular purpose. The length of a pencil or a pen is measured in centimetres. Cloth is measured in meters. Distances (to school, to the nearest town etc.) are measured in kilometres. That is, short distances are measured with small measures or units and large distances are measured in large units.

Have you ever heard anybody talk about the distance from home to school in terms of centimetres? No, similarly, nobody gives the length of a pencil in kilometres.

Now don't you want to know why we started talking about measures in the first place? We have just been learning about the moon, the Sun, planets, etc, haven't we? We saw that the Sun is our nearest star and other stars are far-far away.

What exactly is the distance from the earth to the Sun and to the other stars? How far is 'far-far away'?

The Sun is the nearest star so you probably think it can't be too far don't you? Well, it is..... 15 crore kilometres away from the earth! Surprised? You don't believe me? But it is the truth! How do you write this huge figure? Put down the number 15 and then add 7 zeroes to its right like this: 15,00,00,000 kilometres.

You feel cheated don't you? You've been thinking that the Sun is our nearest star and now this nearness works out 15,00,00,000 kilometres! What a neighbour! But friends, that's the way it is with planets and stars. The word 'nearest' when talking about stars would mean some crores of kilometres. Now let us see how 'near' is the star closest to us after the Sun.

Does anybody know the name of this star?

Proxima Centauri.

And how far—sorry, near—is this neighbour of ours? Just 4,20,00,00,00,00,000 kilometres!

Good heavens! How do you read this figure?

42 lakh crore kilometres.

The very act of reading it gets you tired, doesn't it?

But remember, these are distances to nearby stars. In that case how do we express distances to stars which are farther away? It is difficult, isn't it? But scientists have devised a way to overcome this difficulty. Do you want to know how? Listen carefully.

We measure the length of a pencil in centimetres the length of cloth in metres and the distance to school in kilometres don't we? Similarly scientists have discovered certain 'units' to measure the distance to different stars.

These units of measure are called light minutes, light years etc.

What is the meaning of these terms? To understand these, we should first learn a few things about 'light'.

How are we able to see things around us? That's simple. Just open your eyes and you can see the things. But can you see at night also, if you 'just open' your eyes? No.

That means that in order to see things just opening your eyes is not enough; you need something more, the presence of light. Agreed? During the day we get a lot of light, don't we? And everybody knows where we get this light from. The Sun gives us light and heat. Now, how does light from the Sun reach the Earth? We know that when we light a stove in the Kitchen, light and heat spread to the surrounding area. Doesn't it? The Sun is continuously burning and during this burning light is generated. This light travels to the earth and that is how we get light.

The Sun, as we already know, is far-far away— 1.0 crore kilometres away, to be exact. That means the light from the Sun has to travel all this distance to reach the Earth. The next obvious question is how fast does light travel? Before I tell you that, let me ask you a few other things.

How far can we walk in an hour? 5 to 6 kilometres if we walk fast. A car or bus can travel a much bigger distance in one hour: 40 to 50 kilometres. And an aeroplane can travel even faster. It would cover 400 to 500 or 800 kms in an hour. There are aeroplanes that can travel more than 2000 kms in an hour. Have you heard of anything that travels faster than an aeroplane? What about rockets? Man travelled to the Moon in a rocket, remember? A rocket can travel more than 20,000 kms per hour. Really tremendous speed, isn't it?

Now let us see how fast light can travel. It can travel faster than buses and cars and aeroplanes and rockets! It can cover up to 108,00,00,000 kms in an hour, that is 108 crore kilometres! And 3,00,000 kms, or 3 lakh kilometres in a second! Isn't that fantastic?

Now this distance of 3 lakh kilometres which light travels in one second is called a 'light second'. One minute on our clocks is equal to 60 seconds. Therefore one light minute = 3 lakh kilometres x 60 = 180 lakh kilometres.

Similarly, the distance travelled by light in one year is called a 'light year'. Take a look at this table.

One year = 365 1/4 days

One day = 24 hours.

One hour = 60 minutes.

One minute = 60 seconds.

In one second light travels 3,00,000 kms. What distance can light travel in one year? Try calculating this. The answer is equal to $300000 \times 60 \times 60 \times 24 \times 365 \frac{1}{4}$, kilometres. Such a huge number! Now you, understand what light minutes and light years are don't you?

Now let us see how we can express distances to Sun and to Stars. Light takes 82 minutes to travel to the earth from the Sun, travelling with a speed of 3 lakh kilometres per second.

So the distance between the sun and earth is 8 light minutes. Simple, Isn't it?

Earlier, when we wrote down the distances to the Sun in kilometres we had to add so many zeroes. That was difficult, wasn't it? Now all we have to do is to, write '8' and instead kilometres we write light minutes. That is all.

So, the length of a pencil can be expressed in centimetres. The length of cloth can be expressed in metres. The distance to school can be expressed in kilometres. And the distance to stars can be expressed in light years.

Now, listen, I will tell you a very interesting thing.

We know that only when there is light can we see things around us. And how is this? The light from the sun falls on all the things around us. That light is reflected off those things and reaches our eyes. Then the eye and the brain work together and we are able to see the things around us. Does that make sense to you?

When do we see the Sun? We see the Sun when the light from the Sun reaches our eyes. We have just learnt that light takes 8 minutes to travel from the Sun to the earth. That means the light which we see now started travelling from the sun 8 minutes ago. When we look at the Sun at exactly 3 o'clock, we see a sun which existed at 2.52. That sounds funny doesn't it? There is no other way but to see a Sun that is 8 minutes older each time. Think about it. If we look at the Sun now the Sun we see is an old Sun, and if we want to see the present Sun, we have to look for it 8 minutes later!

Do you remember, we had earlier talked about one of our neighbouring stars, the Proxima Centauri? How far do you think this star is from the earth? 42,000,000,000,000 kilometres. A number that is difficult to write or read or even remember isn't it? Let us do one thing. Let us write it down in our new unit of measure. It would now read as 4.2 light years.

In other words, the light which starts travelling to the earth from Proxima Centauri when you are studying in the 1st standard, will reach the earth only when you are in the Vth standard!

We have so far talked about only two of our 'neighbouring' stars, both of which are 'close' to us. What closeness!

Other than these two there are crores of stars in this universe. With the naked eye we can see approximately 3000 stars. With a telescope we can see many more. But there are many-many more stars far away in the Universe, beyond the reach of the human eye or telescope. Do we know how many? No. All we can say is 'many, many' stars.

Some of them are hundreds and thousands of light years away. Some of the stars we can see now as we look up at the sky may not be there at all. Do you know why?

What we see now is the light from those stars which started travelling towards us thousands of years ago. That is to say, those stars were there thousands of years ago. Who knows what might have happened to them since then? Some might have exploded and got destroyed. Some might have moved from their place.

Talking about movement, I just remembered some thing. Did you think all stars are stationary? It is not so. We have already seen that the Moon, the Sun and the Planets including our earth are moving. Similarly all the stars in this Universe are also moving.

Watch the sky on a clear night. Stars are normally seen in clusters, some of which have only two to three stars and some with many more stars.

Do you know the names of some of these clusters or groups of stars?

Okay, let us name some of them : Orion, Great Bear.

One more interesting thing about stars. In certain months of the year if you look at the sky you can see what looks like a thin stretch of cloud or veil. But unlike clouds it does not move or float in the sky. Have you ever seen this? It is a cluster of stars. If you look at it through a telescope you can see that it is formed by many-many stars. This star cluster is called 'The Milky Way'.

The Milky Way is a galaxy.

That's a new word, what do we mean by it?

A Galaxy is a big group of stars. It can have millions of stars. Our Sun is only one of the crores of stars in the Milky Way. There are many galaxies like the Milky Way in our Universe. Andromeda is another for example. Thousands of such galaxies are continually revolving many-many light years away.

Do you feel a sense of fear, friends? And where are the boundaries of this Universe? That is what is most interesting. There is no end to the Universe. That is why scientists say that the universe is infinite. Infinite means without end.

So, let us not forget all that we have just learnt. There are many millions of galaxies in this Universe. These galaxies are thousands of light years away. The Universe is infinite.

What else?

Our earth is a 'tiny' planet in this vast universe. And a human being is just one of millions of living things on this earth.

How big is this Universe!

And how small we are!

But each one of us is part of this Universe.

Now friends, all of you write down your respective addresses. Like this:

First your name.

Then the number of your house.

The name of your village.

The panchayat. The taluka.

The district

The state.

The country.

The continent.

The planet we belong to

Our star

The name of our galaxy And finally, the universe.

Thus we see that in such a big-big universe we all have a unique address. How lucky we are!

In this universe are there human beings or any other forms of life any where else other than on earth? So far we do not know. How can we get such information? How can we reach each and every corner of this vast universe? It is difficult to even imagine this.

4. THE MICROSCOPIC WORLD

Okay friends, if there is anybody among you who hasn't seen an ant raise your hand.

Nobody? Naturally.

How can we not have seen ants? You see ants everywhere near the sugar tin, sometimes near the oil 'dubba', on the floor, in the soil.... It is interesting to watch them. Sometimes we see two or three ants carrying a small crystal or wheat grain and in front of and behind these load carriers many more ants move in a line like in a procession. How many different type of ants have you seen?

Black ants, brown ants, weaver ants, fighter ants, leaf cutter ants. Some ants are small. Some are big. Now, have you seen anything smaller than ants? No? Try to remember.

When you read under the light or near a lamp at night, small insects sometimes fall on to your books, They may seem like specks of dust, but in fact they are tiny insects. If you look carefully you will see tiny legs and wings, and some movement. These are the smallest insects we can see with the naked eye. Insects that we can see with the naked eye? Does that mean there are also insects we can't see?

Lots of them. Do you want to know more about these?

Most of you must have caught a cold some time or the other. A cold is a big bother, isn't it? The nose runs continuously and you feel uncomfortable. Also, it doesn't allow you to go and play in water or in the sun till it is cured.

Do you know how we catch a cold?

Cold is caused by an invisible (that which you cannot see with the naked eye) living thing which enters your nose through the air we inhale, called a Virus. A Virus is much-much smaller than ants. You can't even see it through an ordinary microscope. You need an electron microscope to see it.

Now can anybody tell me how milk becomes curd?

That's simple. When milk becomes sour it becomes curd.

But how does it become sour?

It is the work of certain organisms which we can't see. They are called Bacteria. These organisms can be seen only through a microscope.

So, Virus is a kind of micro (tiny) organism. Bacteria are also a type of micro organism.

Have you noticed a grey or black layer forming over old bread slices or spoilt pickles? It is called fungus, and this is another kind of micro organism.

There are billions of such small organisms in the water and air around us. Some of them are dangerous fellows. If they enter our body we fall ill. Tuberculosis, Smallpox, Filariasis, Dysentery, Malaria, etc. are diseases caused by such small and dangerous organisms. Organisms that cause disease are called 'germs'

Some of these germs enter our body through the water we drink and some through the food we eat.

My friends do not think that all these micro organisms are bad fellows. Some among them do good things as well. Earlier we learned about the bacteria which ferment milk. Similarly, fruits become ripe by the action of one kind of micro organism. Another type of micro organism makes the soil more fertile, causes decay and converts dead things into soil. There are good people and bad people among human beings, aren't there? Likewise there are good and bad among micro organisms also?

Do you know why we are talking about micro organisms here?

In the last chapter we discussed huge galaxies and stars, didn't we? Now we know that the universe contains not only planets, stars and galaxies but also minute organisms like bacteria and viruses. And how big are these micro organisms? One out of thousand parts of a centimetre, or some times one of tens of thousands of centimetre!

Do you have a microscope in your school? If you do, ask your science teacher to show you a drop of water under it. You will be surprised. You will see thousands of small organisms swimming and rolling in that tiny drop of water.

When we look at the sky we see a vast world. A world of huge planets and stars and galaxies. On the other hand, a tiny drop of water can contain a micro world of thousands of small organisms.

An infinite universe and within it another tiny universe of micro organisms. How wonderful! Wait. There are more surprises in store for you.

There are things even smaller than these micro organisms. We will talk about these shortly.

5. STATE AND CHANGE OF STATE

So, friends, we have now talked about a lot of things, haven't we? Let us try and recollect them.

We have talked about trees, stones, earth, sun, animals, stars, human beings, table, vessels, metals, ants etc. And lastly we talked about micro organisms which we can't see with the naked eye. Yet there are so many more things to talk about. If you try writing down the name\$ of all the things we see around us, you would need many note books. There are that many things around us. All these things have a common name. Does anybody know what that name is?

MATTER. Don't forget that name.

What is matter?

All things, whether visible or not, are made up of matter. Stone, wood, iron, soil, air, stars, the billion of things present in this 'infinite universe are all made up of matter.

And this matter has many states.

Have any of you seen air? No? We can't see air. It has neither colour nor smell. But all of us are used to the feel of air. We go out into the field to enjoy the breeze or Wind, don't we? What is this wind? When air moves, we call it wind. Air is present all around us. It is one state of matter. This state we call the GASEOUS STATE.

Can anybody name some other gas? Yes, water vapour. When we boil water we get vapour or steam. There are many other gases. You might have heard names like hydrogen, oxygen, carbon dioxide, etc. These are all gases. They are all matter in gaseous state. There is another kind of matter. Water, milk, coffee, tea, etc. What are these called? Do you know?

LIQUIDS.

Matter exists in one more state. Stones, soil, tree, ice, etc. are in this state. They are said to be in SOLID state.

So what are the three states of matter?

GASEOUS STATE, LIQUID STATE and SOLID STATE.

Now friends, let us do an exercise.

Write down the names of ten liquids and ten solids which you see around you.

Solids can be changed into liquids. How is that possible? Haven't you noticed that if we keep an ice cube in a hot plate, it starts melting? What we observe there is the change of ice which is a solid, into water which is a liquid. Like ice, there are solids which can be converted into liquid state by heating.

What happens if we heat liquids? What happens when we heat water? It becomes steam. So, if a liquid is heated it gets converted to gaseous state.

So what have we learnt so far?

All the things in this universe are made up of matter. Matter has three states: Solid, Liquid, and Gaseous, We can convert solids into liquids and liquids into gases.

Have we left out anything?

Yes, we haven't discussed the heat which changes solids to liquids. What is heat? Solid, liquid or gas?

Heat is neither solid nor liquid nor gas. There are other such things also like light and sound, all of which have a common name: ENERGY.

Heat is a form of energy. Light is another form of energy. Electricity is also a form of energy.

What is this energy?

Energy is necessary to do any type of work. To burn a lamp, energy is needed. Machines need energy to run. We need energy to walk, to play and to work.

From where do we get energy?

From the food we eat.

How does food get the energy?

From the Sun.

Matter can be changed into Energy. That is what happens when an atom bomb explodes. In the burning Sun too matter is continually converted into energy. We shall learn more about this in detail later. Now let us discuss something more about matter. We have just talked about air, water, stone, iron, food, etc.

When we say ‘air’ what comes to your mind? We inhale air, but it can’t be seen. It has no colour but when it moves we can feel it.

And when we say ‘water’? We drink water. It is a liquid without colour or smell. Similarly, when we say stone or iron, we think of their properties. These materials which can be listed according to their properties have another name:

SUBSTANCE.

We should remember that ALL THE MATERIALS IN THIS UNIVERSE ARE MADE UP OF MATTER. When we say SUBSTANCE we mean things which can be identified by their properties like stone, soil, water, sugar, etc. When we give different shapes to substances, we get ‘things’. For example, when we shape an ordinary piece of granite into a circular shape we get a ‘grinding stone’. If we shape it to look like a man we get what is called a ‘statue’. The grinding stone and statue are things. Similarly, table is a thing made of the substance wood. Chair and cot are other things made of wood.

Now friends, I am sure you have understood the difference between Matter, Substance and Thing.

Once more, MATTER IS THE COMMON NAME OF ALL THINGS IN THIS UNIVERSE, LIVING AND NON-LIVING. THINGS WHICH EXHIBIT THEIR QUALITIES ARE CALLED SUBSTANCES. WHEN WE GIVE-DIFFERENT SHAPES TO SUBSTANCES WE GET DIFFERENT ‘THINGS’.

Now friends, do this exercise. Write down names of different substances and also of two things made up of each substance.

6. A LITTLE SPACE PLEASE?

Friends, have you ever entered a jam-packed bus? When you go to school you might have noticed how very full the buses are! On some days there is hardly any space in the bus even to stand. Sometimes you tactfully manage to yourself a little space to sit by asking, “Will you spare me a little space please? Otherwise there is no other go but to stand all the way, in the space available.

So we need space to sit and space to stand. What else do we need space for? Space to keep our books, space to keep our pencils. We have used this word ‘space’ so many times. What do we mean by it?

We use this word many times daily, don’t we? When there are many guests in your house there isn’t any ‘space’ even to sleep. On some days when you get ready to go to school, you forget the place where you have kept your pencils. On days when you have to take a lot of books to school, there is very little ‘space’ for your Tiffin box in the school bag.

Friends, have you ever thought what this ‘space’ is? To keep anything and everything, we need space. We need space to play, to build a house and also for farming. The earth needs space to rotate. The moon and the Sun and everything else need space to be in. There is space between the stars. You must also note that whenever we speak of space we also mention some object, matter, person or thing.

BOOKS need space to be ‘kept

THE EARTH needs space to rotate

WE need space to sit.

If 'books' were not there how could we have talked about space for keeping books? If the 'earth' was not there how could we have talked about it needing space to rotate? If there was no 'bus' we could not have thought about the space inside the bus either. Could we say that we need space to sit and stand if 'we' did not exist?

Imagine you are sitting in a room. Then we can say that in the space inside the room there are many-many things. Likewise we can say that in the space outside the room also there are many-many objects and things. How is it that space exists inside the room? How does the room exist. Because there is a house to accommodate the room obviously. How is it that the house exists? Because we built it using mud and stones and wood and cement. This shows that we can talk of space only if we mention some object or matter.

Of what is everything in this universe made? Remember what we said about it in the previous chapter? Of Matter, of course!

So, only if there is matter will there be things and objects. In other words, matter and space are inseparable friends. In this universe, there is not only matter but also space. There can be matter only if there is space and vice versa. Let us not forget this truth, friends.

Is this the only relationship between matter and space? No. We often hear of words like length, breadth, height area and volume. What is length? What is volume? Have you ever thought about it? They are all means by which we measure space.

What do you understand by the word 'length'?

The length of an object is its distance from one end to the other. That is equivalent to the length of the space that the object occupies. What do you mean by the distance to school? It is the length of the space from our house to the school, isn't it?

What do you mean by the area of an object? The area of the space that the object occupies. That is, length, breadth, height, etc., are means of measuring space.

How do we speak of length? In terms of metres, centimetres or light years. How do we measure length, breadth and height? By using a ruler or tape, isn't it? If we simply keep the ruler where it is, do we get the length of the object? No. Then what is to be done? First, we have to take the ruler to the object and measure it; then we move the ruler to the next place. That is, we have to move the ruler to measure the object.

Coming to light minutes and light years, how do we measure these? By calculating the time taken by light to travel from the sun and the stars.

So, if we have to measure with a ruler we have to move the ruler. If we have to measure light minutes and light years, the light has to travel. In short, we cannot conceive of measuring without moving 'something'. Only if we move something, can we calculate length. Length is the measurement of space. That is, if we have to measure space we have to move matter.

Now let us go over all that we have spoken about in this chapter. Only if there is matter, can we speak of space. And we have to move matter in order to measure space. So friends, have you understood the relationship between matter and space?

7. SMALLER THAN THE SMALLEST

Have any of you been to the sea shore?

In the evening, when the sun is setting, it is very pleasant to sit on the golden sands of the beach, munching at steaming hot ground nuts. You must have played with the sand also. How many sand particles do you think there are in one handful of sand? Lakhs, may be tens of lakhs. Look carefully at a single sand particle. How small it is! Even smaller than an ant!

But have you seen anything smaller than sand? Oh yes. Dust. There are different kinds of dust, As cars drive by high speed dust flies out on to every thing around. These particles of dust float in the air, and enter our eyes or noses making us sneeze a hundred times. This is one kind of dust.

What other kinds of dust do you know of? You must have seen the turmeric powder or chilli powder used in curries. You must have also seen chalk dust falling down when you wipe the black board at school. These are dust particles smaller than particles of sand. Have you seen anything smaller than these particles even? Think.

When there is bright sunlight outside, look at a beam of light entering your room through a slit in the door or window. What do you see? You see tiny dust particles floating in the air, in the path of the beam. You can see these dust particles only when there is light: These are all minute dust particles existing in the air around us. They are smaller than particles of sand or soil. Long ago people believed that there was nothing smaller than these dust particles in the universe.

Were they right? No. There are many-many things smaller than these dust particles.

Yes, friends. Even the smallest dust particles are made up of many-many smaller particles. These 'smaller particles' are called molecules. If you look through a very powerful electron microscope you can see that even the smallest dust particle is made up of smaller 'molecules'.

You remember our talking about things, substance and matter? Yes? Good. All the substances in this universe are made up of different molecules. We see so many substances around us. Iron, gold, water, salt, sugar, etc. and each one of them is different from the other. Iron is different from gold, and water is completely different from gold. Salt is different from water as well as sugar.

In other words, each substance is unique. Why is that so?

Each substance is made up of one type of molecule. An iron rod is made up of iron molecules, salt of salt molecules and water of water molecules.

Now can you tell me what gold is made up of?

Gold molecules.

Good.

So what are substances, big or small made up of? Tiny molecules. And what are these molecules made up of? What? You mean there are even smaller particles than the 'molecule'? Of course, friends. There are smaller particles, and these are called Atoms. Molecules are made up of atoms. Some molecules have only one atom. Others have two

atoms, but of the same type. And molecules of some substances have a greater number of and different types of atoms.

Now how big do you think this fellow called Atom is? It's very interesting to describe the 'bigness' of the atom. If you were to place ten crores (100,000,000) of atoms in a line close to each other, how big do you think that line would be? Can you guess? No? Then listen. Just one centimetre.

One centimetre!

So now you can imagine what would be the size of one atom. If you divide one centimetre into 10 crore equal parts, one of those parts will be as 'big' as an atom.

Are all atoms alike?

No.

We just said that one molecule contains one or more atoms and those molecules of some substances contain only one type of atoms. Such substances have a common name. They are called Elements.

Oxygen molecules contain only one type of atoms. Similarly, iron and gold containing only one type of atoms. They are all elements.

What about a molecule of salt? It contains two types of atoms. One atom of sodium and one atom of chlorine. Sodium and chlorine are two different elements. When their atoms combine, molecules of sodium chloride, otherwise called salt, are formed. Similarly two atoms of Hydrogen and one atom of Oxygen combine to form one molecule of water.

So, what have we talked about so far?

About tiny atoms, about molecules which are formed by the combination of atom and about elements. What did we say elements were? Elements are substances which contain only one type of atom. Different elements combine to form different substances. In short, all the substances in this universe are made up of atoms.

Do you remember the common name for all the substances in this universe? Matter. So the smallest particle of matter is the atom. Everything in this universe is made up of crores and crores of atoms. Our body, stone, tree and stars all are made up of atoms.

Now what are these tiny atoms made up of? Of particles which are smaller than the atom. Think of that! There are particles smaller than an atom which is itself only as 'big' as one out of ten crore parts of a centimetre!

Yes friends. And these particles are called FUNDAMENTAL PARTICLES. Atoms are made up of three types of fundamental particles, namely, PROTON, NEUTRON, and ELECTRON.

The centre of the atom is a nucleus, which is a cluster of protons and neutrons. Have you seen a honey comb? The central nucleus of the atom is like that. Like the bees which constantly move in and out in a honeycomb the neutrons and protons in an atom also are constantly on the move, sometimes colliding against each other. They are never at rest. And what about the electrons? They are constantly running around the nucleus or the cluster of neutrons and protons. Have you watched small red ants on a lemon? They run round and round over the surface of the lemon. Electrons constantly revolve around the

central cluster of neutrons and protons in an atom in a similar way. Of the three types' of fundamental particles electrons are the smallest in each type of atom, the number of protons, neutrons and electrons differs. But all protons are alike. So too all neutrons and electrons are alike.

So, what do we have now?

A huge infinite Universe.

Billions of substances in this Universe.

Each substances contains small molecules.

Each molecule contains smaller atoms.

And each atom contains smaller still fundamental particles: Protons, Neutrons and Electrons; And all these are in continually, restlessly in motion. What a wonder this Universe is, isn't it?

8. WHAT IS TIME

Friends, all of you like to hear stories, don't you? Who doesn't? What are the stories you have heard?

I am sure all of you have heard the story of how the hare and the tortoise ran a race. Then you must have also heard the stories of Birbal, the Arabian nights, the fisherman and the ghost and innumerable others. It is great fun to listen to grandmother telling you all these stories, isn't it? How does grandmother begin these stories?

"Once upon a time, there was a fisherman..." When she begins like this, you might have asked, "when exactly was this once upon a time, grandma?" And Granny would have answered, "once upon a time means a long, long time ago". Whatever it be, when granny starts opening her treasury of tales we are not at all aware of the time passing by. Similarly when you play with your friends you do not realize how fast the time passes. But time seems to move very slowly if you are all alone at home on holidays.

If you get up late on a holiday mother says, "Look at you! You haven't realised how late it is-on holidays you sleep like a buffalo!" And you get angry with her, don't you? Sometimes in school certain classes are so boring that time seems to stand still. And /ou wish that somehow the hands of the clock would move faster, don't you? What is the general feeling during the last period in school? A feeling of relief. Thank goodness, you say to yourself. Only half an hour to go home. When the school bell rings you run to the bus-stop only to hear that the first bus has already gone. You hear someone say, "The bus went only a few seconds back! It's all right. There is another bus after five minutes". What do you think to yourself when your elder brother passes out of school and joins college? "Ha! After five years I will also pass my 10th standard and join college."

So then, with what does grandmother begin her story?

"Many-many years ago..." And what did we talk about next? Yes, about the holidays when time passes at snail's pace, about the last period in school and waiting for the class to be over in half an hour about missing one bus and waiting for another which will come after five minutes, and about many young friends among you who will pass out of school in 5 years.

Time, year, month, day, hour, minute, second. We are constantly hearing these words, aren't we?

Do you know this rhyme?

"How many seconds in a minute?

Sixty and no more in it"

"How minutes in an hour?

Sixty for sun and flower"

"How many hours in a day? Twenty four for work and play"

"How many days in a week? Seven both to hear and speak"

What are these seconds, minutes, hours, etc.?

Methods of telling the time.

How do we tell the time?

By looking at the clock or a watch.

Do all of you know to tell the time by looking at a watch. How exactly do you do that? By looking at the hands of the watch, right?

How many hands are there in a watch? Three. One is the hour-hand - the shorter one. The long hand is the minute hand. And there is one more hand, the one that moves very fast and is thin. That is the second-hand.

What else is there on a watch? Numbers, from 1 to 12. We tell the time by looking at these numbers as well as the position of the hands, isn't that so?

When the short hand is on three and the long hand is on twelve we know that it is three o' clock. In the same way if the short hand is between five and six and the long hand is on six, it is half past five.

Can you tell the time from a watch which does not work? No. How do you know that the watch is working? By seeing whether the hands move or not. Or by the ticking sound that it makes, if it works we hear it ticking, don't we?

Do you know how this sound is made? There is a small wheel inside the watch called a balance wheel. This balance wheel is constantly moving. When it moves the second-hand also moves. With the second-hand the minute hand moves and with the minute hand the hour moves. If you open up the watch you can see balance wheel ticking.

What if the balance wheel stops...? The hands of the watch do not move. And the watch will not work. That is, the clock will work only if the balance wheel runs.

Friends, you have seen a wall clock. The grandfather clock which goes ding dong ding! Like a watch, the clock also has hands. It also has something which keeps moving from side to side (oscillating). Do you know what it is called? Pendulum.

If the pendulum stops moving the clock is bound to stop. Only if the pendulum keeps going can we know the correct time.

We can also tell the time without looking at a clock or watch. Don't we often hear people say, "It is morning", "It is noon", "It is evening," "It's night," and so on? All this we say without even glancing at a clock. How is it possible?

When exactly do we say that the day has dawned or it's morning? After sun rise. In the same way when the sun is directly over our heads we say that it is noon. What do we say when the sun is going to set? That it is evening. Likewise, some time after sunset we call it night. It is dark then.

So how does it become morning, noon, evening and night? Because the sun rises and sets. Why do we feel that the sun rises in the east and sets in the west? Because of the rotation of the earth. If the earth did not rotate there would be no sunrise. If the sun did not rise we could not have said that it is morning, it is noon, it is evening, etc. So, it is because the earth rotates that we have morning, noon, evening, and night. Agreed?

The sun rises in the morning and sets in the evening. It rises again the next morning and sets again the next evening. Once again it rises and sets. This continues.

What do we call the time taken by the sun to rise and set and rise again?

That's easy. A day.

How many hours make one day?

Twenty four hours.

Now let's go over that again.

One day — Twenty four hours

One hour — Sixty minutes

One minute — Sixty seconds.

So, second, minute, hour and day are units to measure time. We earlier discussed how we can measure distances, didn't we? Small units are used to measure small distances and bigger units to measure bigger distances. Similarly, to measure small intervals of time seconds and minutes are used and to measure larger intervals of time, hours, day and other bigger units are used. Thus 12 months make one year. And at the end of one year we replace the old calendar with a new one.

With each passing year what happens? We grow older. You pass out of one class and enter higher classes. The Mango tree at your house flowers once again and bears mangoes. Festivals like Deepavali, Christmas, Eid come round once again and you have lots of fun... So many such things.

How old are you now friends? Ten—eleven—twelve?

Those of you who are ten years old will become eleven years old, after one year. Eleven year old friends will become twelve year olds and those who are twelve will become thirteen. How old is your grandmother? Around 80?

So granny was born many-many years before all of you were born, right? Your father and mother were born after your granny was born and you were born after father and mother were born.

With each passing year there are many changes that take place.

What were we talking about before this? About how second, minute, and hours, etc. are used to measure different durations of time. But how did we arrive at these units — days, hours, etc.?

To explain that lets start with day. A day is the time duration between two consecutive risings of the sun. That is the time taken for the sun to rise, set and rise again. This duration of time was further divided into twenty four parts, one part out of which is called an hour. The hour was further divided into sixty parts. One part out of this was called a minute. The minute was then, divided into sixty parts again and one part out of this was called a second.

If such divisions had not been made it would have been very difficult to tell time. A small unit is necessary to express a small interval of time. Otherwise, we would have to say, “the bus went by six parts of twenty four parts of.....etc. ago” instead of just ‘ten minutes’. Will anybody understand us if we say the former? So we need to have small units of time as well as big units. But how are we able to say all this? Because of the earth’s rotation.

The sun rises and sets because of the earth’s rotation. Suppose the earth didn’t rotate? We wouldn’t be able to measure day. Similarly if the hands in a watch didn’t move, we wouldn’t be able to measure an hour. The watch works only if the balance wheel inside it functions. Only then will the hour and minute hands move.

So, to tell the time, what is necessary?

One thing or the other should be constantly moving. The earth has to rotate for us to measure days. The balance wheel or pendulum of the clock has to move for us to know hours, minutes and seconds.

What did people do long-long ago when there were no watches or clocks?

Oh, I almost forgot to tell you that

Some people were able to tell the time by looking at the length of shadows. But for shadows to exist, the sun has to rise. And when does a shadow’s length change? When the sun moves from east to west, in the sky. Isn’t it?

Dig a hole in your garden and place an erect pole in it. Now try to observe how its shadow varies, in length and position as the day moves from morning to evening.

So if the sun didn’t move from east to west would we be able to tell the time by looking at the length of shadows? No. And why does it seem as though the sun travels from east to west? Because the earth rotates round itself. Right? So if the earth did not rotate we would not be able to tell the time . So whatever we do unless something moves time cannot be measured. And what are all things made up of? MATTER of course. The earth, the balance wheel of the watch and the pendulum of the wall clock are all made up of Matter. So, WE CAN’T TALK OF TIME INDEPENDENT OF MOVEMENT OF MATTER.

9. MOTION-MOTION EVERYWHERE

Friends, by now we have discussed so many things. We have talked about things ranging from Fundamental Particles to the Universe, from the smallest to the biggest. You must be tired now. So let’s relax and rest for a while.

Sit still. Okay? Don’t move your hands or head. Just sit still without moving even your eyelids. Let’s see how long we can sit like this. I can see one little friend’s eyelids

moving another little friend's hair is moving in the breeze... and here's a third little friend who is scratching his head...

Not one of you could sit absolutely still. But no need to worry. The task is an impossible one. Not only you children, but nobody in this world can keep completely still without moving some part of his or her body. Even if we try our best and manage to keep our hands, legs and head motionless, our continued breathing will make our chest move up and down.

Even when we are sitting still or sleeping, many of our internal organs are moving. Our heart is beating constantly. Blood is flowing to different parts of the body through blood vessels. The food we consumed is undergoing change in our stomachs. What did you eat today at breakfast? Roti and Subji? Dhokla? Whatever it is, it is undergoing change in the stomach and small intestine. The nourishment in the food is being absorbed into the blood.

We are growing also, without our being aware of it. By every second we grow a tiny little bit and when we complete one year of growth, we say our age has increased by one year. After two or three years you will become older still. You start wearing trousers and shirts or salwar and kameez instead of shorts and frocks. Thus, every second many different changes or movements are taking place in our body, about some of which we are aware and about many, unaware.

Look at that neem tree out there? Is it standing still No. Its leaves are moving in the air. Apart from that, many changes or movements are taking place within it also. So many different kinds of motion! Its roots and root hairs which are deeply embedded in the soil are absorbing water, which is seeping through the soil. The water and salt which the roots absorb are being sent up through its trunk to the different branches and leaves. And do you want to know how the neem tree cooks food?

Its leaves absorb carbon dioxide from the air, mixes it with water and salts absorbed from the soil and converts it to food with the help of sunlight. This food is sent to different parts of its body. How small that tree was two or three years back! Now it has grown and is flowering. It will grow further in the future.

So, like human beings, trees too are not static. In their bodies too numerous changes take place. New branches are formed and leaves become yellowed and fall off. In their place appear tender green leaves which gradually deepen in colour. And every year bunches of flowers appear which drop and fall off. After a few more weeks green berries are seen.

Now let us look at the soil. Is it static? No. Within the soil also many-many movements and changes are taking place. Thousands of insects and earthworms are moving within the soil. Water is seeping through the soil. Leaves and refuse are getting mixed in the soil. Through the countless pores and small spaces in it air is entering the soil. The roots of trees are penetrating the soil. New substances are being formed within the soil. You all know that we get Coal, Iron, Gold, Diamond, Copper and Petroleum from the earth. Haven't you heard of the coalmines of Bihar and the Kolar Gold mines! How are gold and coal formed under the earth? They are formed as the result of changes in the soil occurring through thousands of years.

So, there is movement everywhere-movement in soil, movement in trees, movement in our bodies, and movement in air...

To hell with these movements! Let's try and find something which does not move. There it is a big rock. It is not moving. It has been like that, the same, ever since we first saw it. We have won!

Sorry friends. The rock only seems to be motionless. In it also many movements are taking place. What is that rock made up of? It is made up of atoms, isn't it? We know that all the things in this Universe are made up of atoms. So naturally that rock is also made up of atoms. And what are atoms doing? They are continuously moving. They move without rest, for them there is nothing like night and day. They are constantly in motion.

Apart from that there are other movements as well within the rock. The rock gradually breaks down into small pieces. The powdered particles get mixed up in the soil. Somebody might break it into smaller pieces and use it for building a wall or a house.

Isn't there anything in this world which is motionless?

No. Everything around us is undergoing constant motion or change. Even the cot and the table which may appear to be not moving contain millions of atoms which are vibrating.

What are the different kinds of movements we see every day?

The Earth rotates. We all move with the earth. Not only us, but everything on this earth moves along with the earth. Houses, trees, school buildings and everything else. Because of the earth's movement we have night and day. The moon moves around the earth. The sun moves. Other stars also move. Galaxies move. In short, everything in this universe moves. From the smallest electron, neutron and proton to the largest Galaxies, everything is moving all the time.

MOTION, MOTION EVERYWHERE. NOTHING IS STATIC.

Just think. So many movements take place in our body. Atoms in the chair on which we sit vibrate. The earth on which we live rotates. Numerous movements in the soil. The Moon rotates and revolves around the earth. The Earth revolves round the sun. The sun rotates. All stars move. Galaxies rotate and move away. Motion everywhere. Amazing, isn't it friends?

Are all movements alike?

No. Some movements we can observe and some we can't. We can see things and leaves moving in the wind. We can see the movements of buses and cars. We witness the rising and setting of the sun and we know its reason. But there are many other movements we can't observe. We are unable to observe the vibration of molecules inside the rock and the table. Why is that so? Because atoms are so tiny. You remember our discussion of the size of atoms, don't you? So there are exceedingly small movements as well as extremely big movements.

Some movements we can only feel. We are not able to observe the movements occurring in our bodies. But after a long period of time we become aware of it. You grow up, enter higher classes, acquire more knowledge, start growing a beard and moustache... All these changes we become aware of.

So, even if we are not observing all changes occurring in the body instantly, we gradually become aware of them. CHANGE is another name for motion.

Everything around us changes. Look at those buildings. Two years back that was barren land. You ask your grandmother about change and she will say, “You children are lucky. When we were children there was neither a hospital nor a school near our place. There were no buses and cars at that time”. How different, how changed our lives are now. We have schools and hospitals near our houses. There are buses every now and then to take us anywhere we want to go. There are factories and movie houses... How did all this come about?

These are all the result of many-many changes that have taken place in the past so many years. Even now changes are taking place and in the future also changes will take place ceaselessly.

Is there anything which will not change?

Nothing. Everything changes. There is nothing which is ‘changeless’, or motionless.

10. THE ANT AND A STONE

Friends, you have all seen stones, haven’t you?

Yes of course, several kinds of stones.

And ants?

Oh yes.

Now tell me, what is the difference between an Ant and Stone? Sounds like a stupid question doesn’t it? Never mind. Tell me, what is the difference?

The ant has life, or is a living thing and a stone is a non-living substance. Good. Now, what is life? Let us think. Friends, all around us there are many-many non living or inanimate objects. What are they?

Stone, soil, chair, table, pencil, glass, like as many such things.

There are many living things also. What are they?

Ant, fly, worms, elephant, trees, man, etc. In short, everything around us can be divided into two groups: living and non-living. What are the main differences between these?

What is the first difference? Living things consume food whereas non-living things do not. Ants and flies and animals eat food. You must have seen ants carrying away sugar crystals and grains. Cows and chickens and cats also eat food. As for us, it needs no telling. So all kinds of living beings eat food. We have also seen how trees and plants absorb water and nourishment from the soil and how they synthesise this ‘food’ using sunlight. In short, all living things consume food. Without food they can’t exist..

What about non-living things? Can stones eat foods? Can tables and chairs consume food? No. So one important difference between living and non-living things is this.

What are the other differences? Living things grow. A calf grows into a cow. And boys grow, develop beards and moustaches and become men. Trees also grow.

Can lifeless things like stone grow? Neither can tables, or chairs or pencils grow.

That is, living things consume food and as a result grow bigger and older. Non-living things can neither consume food nor grow. Now we have learnt two major differences between living and non-living things.

Are there any other differences?

Living things can reproduce. Ants and flies lay eggs. Cows and dogs have babies. Human beings also have babies. The seeds of trees and plants fall to the earth and grow into new plants.

In short, all living things reproduce either by laying eggs or by delivering their offspring's or through seeds, depending upon what they are.

And what about non-living things? If we put a stone in the soil and water it, will it grow? No. Can tables or chairs lay eggs or produce seeds? Can a house reproduce itself?

Not at all.

If it was possible, it would have been great fun indeed. We could have fed little chairs with good food and watched them grow into bigger and sturdier chairs! But no. They can't and they don't reproduce. So this is the third difference between living and non living things.

What are the three differences? Let us go over them once more. Firstly, living things acquire food from the surroundings and consume it. Secondly they grow in size. Thirdly they have the ability to reproduce. Nonliving things do not have any of these abilities.

Combining all the above mentioned characteristics, we can say that things which can procure food from their surroundings, consume it, grow, and reproduce are called living things.

Till now we believe that living things are present only on the earth. Nobody knows whether there are living things in any other planet in this universe. Scientists are studying the matter.

Long-long ago, billions of years ago, there were no living things on earth either. The earth used to be extremely hot at that time. There was no water to drink or air to inhale. There was no soil either. Gradually rocks broke down and different kinds of soils were formed. And through many-many such changes through crores of years the earth became what we see today.

This earth existed for almost 100 crore years without any living organism on it. Then how did life begin on earth? Scientists have done a lot of research in this area. According to their estimate life evolved about 350 crore years ago.

Were there human beings at that time? No. No plants or animals either.

Then what were the forms of life?

Some microscopic organisms that was all.

We have learned about bacteria, which we can't see with the naked eye. These were the original forms of life. Crores of years after that animals and plants which we see today evolved. The minute organisms developed and gradually evolved into higher living forms.

And do you know which being was the last to evolve in this process?

The human being.

Our great great-great grandparents made their appearance about 20 lakh years ago. Were they like us in appearance? What did they do? What did they eat? How did they live? Don't you want to know all these things? That's a long story.

11. THE STORY OF OUR ANCESTORS

Friends, are all of you ready to hear the story of our great-great grand parents?

Okay. Before I start the story, let me ask some questions. Do any of you know anything about our great-great grand parents?

Who are our great great-great... grand parents? Where did they live? When did they live? You don't know? Don't worry. We shall find answers to all these questions, one by one.

Before we enter into our story, let us discuss some other things.

According to the latest scientific information our earth was formed long-long ago, about 460 crore years ago. In the beginning there was nothing living on the earth. No elephants or rats, not even ants. The first living organism developed some 100 crores of years after the earth was formed. The first forms of life were single cellular organisms—that is, organisms consisting of just one cell. You might have heard of bacteria, algae, etc. These were the kind of organisms that developed originally.

Can you guess where on earth life was formed first? Was it on land? Or in the sea? Or in the jungle? The first living organisms were formed in the sea, in water. The sea is our ancestral home, friends.

Thus, first we had only the earth. Then after several crores of years single cellular organisms developed in the sea. They were invisible. Here starts the story of evolution.

What is the meaning of evolution? Evolution means change. Then what is meant by theory of evolution? It is the story of the step-by-step changes of organisms, from the earliest forms of life in the sea to all the different forms of life we see today.

Our great-great grand parents evolved as a result of this change. Our evolution—the evolution of modern men and women began from that stage and saw many more changes.

,It is not in a few days or even in a few hundreds of years that these changes took place. They took place over millions of years. We can't even imagine the time taken for such changes.

It is such a wonderful process that it sometimes seems like magic. But-no. Animals evolved into different forms by undergoing changes to suit different circumstances. Many animals who could not modify and adapt to the changes in nature became extinct. Others who were able to change their life style survived. Gigantic lizards known as 'Dinosaurs' and the woolly elephant called 'mammoth', which lived on the earth long-long ago are extinct now. They perished because they could not adjust themselves to the changing environment.

We have already learned that the origin of life goes back to single cellular organisms which evolved in the sea, about 350 crore years ago. What happened after that?

They underwent many small changes and became organisms with two, three or more cells—this again took place over lakhs and lakhs of years.

Then came fishes and other forms of life in the sea. Fishes evolved about 33 crore years ago! (That means fishes were formed many-many lakhs of years before the evolution of human beings!) Gradually, after lakhs of years again, animals which could live both in water and on land evolved: the ancestors of our frogs. These were the first beings who had the ability to live in water as well as on land. What are such animals called? Amphibians.

About four to five crore years after that, snakes and lizards, evolved. We talked about Dinosaurs earlier, didn't we? They also belonged to the same group. Around this time birds also evolved.

Lakhs of years after this mammals and quadrupeds evolved. Till then all the beings which existed were the egg-laying kind. Fishes, snakes, lizards, birds, all these lay eggs. But most animals give birth to babies. They are otherwise called mammals, which means they can feed their babies with the milk produced in the mammary glands in the body. All of you were fed your mother's milk when you were babies weren't you? Thus, human beings are also mammals. Mammals evolved from reptiles about seven crore years ago. Rats, tigers and lions also might have evolved around this time. Thus, as a result of 350 crore years of gradual evolution, numerous life forms evolved on earth.

What happened next?

About one crore years later apes evolved. Have you ever seen an ape? If you go to the zoo, you can see apes like orang-utan, gorilla and chimpanzee. You must have seen the chimpanzee doing tricks in the circus. Did you laugh at the funny things he did? Now don't be surprised at what I am going to say. We and the apes like the chimpanzee in the circus all have a common grand parent. Yes, our great-great grand parent was an ape like creature!

And where do apes live? In the zoo? They were brought there by human beings, who forcibly caught them from the forests. In fact all apes belong to the forests. So did these ape like forebears of ours. They had been happily living in the forest ever since the time when there were no human beings on earth. They used to live on the trees, eating fruits and leaves and buds. They lived thus for a long time. Initially they were very happy to live such a life. There was no scarcity of food -of buds or fruits. They lived a merry life, frolicking around, swinging from tree to tree, eating and enjoying themselves, unafraid of other animals like lions and tigers who lived on the ground.

But gradually their numbers increased. Food became scarce. When 50 to 100 apes started living on trees where initially four or five lived, they were not able to fill their stomachs. How could they live without food? Ultimately some of them decided to leave the trees and to come down to the ground. Some of those apes who began to live on the ground gradually evolved into human beings after hundreds of thousands of years.

Listen carefully while I repeat the story of our evolution.

Around 4 crore years ago, monkeys used to live happily on trees, eating fruits, leaves and buds which were available in abundance. Then gradually their numbers grew and food became scarce. So some among them came down to the ground in search of food.

They underwent further changes over hundred of thousands of years. Some of them ultimately evolved into human beings. .

But friends, in all this there is one point you must always remember.

All this didn't take place in a few days or in a few hundred years. These changes took place over hundreds of thousands of years. This point you should never forget.

Now to go over what we have discussed. Earth was formed about 450 crores of years ago. Forms of life came into existence about 350 crore years ago. These life forms/single cellular organisms/evolved into multi-cellular organisms, then fishes and other aquatic animals. Then came the amphibians and later, after a few more crores of years, reptiles like snakes and lizards. Then birds, mammals, monkeys and apes. Then the apes came down to the earth from the tree tops.

Now in the next chapter we are going to hear another interesting story—'What happened to those who came down from the tree?' The story of transition from Apes to human beings.

12. HOW DID APE BECOME MAN?

We have just heard how a group of apes were forced to leave the trees and how they started living on the ground in order to survive.

What were the conditions on the ground then? Any idea? Can you guess? The poor apes had a hard time. Life on the ground was very different from life on the trees. Why was that so?

It was not easy to procure food on the ground. They had to satisfy themselves with fallen fruits and buds and fruits on the bushes. And even these foods were not always available, because there were other animals living on the ground, who were dependent on similar food: animals like rats, rabbits and hares, the clever jackal, his cousin the fox, etc. There were also lions, tigers and panthers, who were predators, always lurking around to taste 'ape meat'. Giant rhinoceroses and elephants also lived on the ground. Apart from all, this natural forces like thunder and lightning, storm and rain created *terrific fear* in the ape. Therefore initially these apes lived in great fear.

These 'ground apes' are called as ramapithecus by scientists and these apes lived fourteen to eight million years ago spread across Africa, Asia and Europe. Many fossils of these apes are found in our Shiwalik hills near the Himalayas. Slowly these apes underwent changes. We do not know precisely how. May be when one of you grows big you might find out the answer. In the meanwhile, the guess of our scientists about the changes these 'ground apes' underwent is like this...

These apes started using their hands differently from the way they did when they lived on tree tops. Their hands underwent very important changes. When they were living on trees they used to walk on all four (legs). At the same time they also used their front legs (arms) to do acrobatics like hanging from branches, etc. That means there was some difference even then between the use of the front legs and the hind legs. (You might have noticed that there isn't much difference between the use of front legs and hind legs in cows or dogs). After many years—maybe millions of years—these apes who had come down on the ground began to walk on two hind legs, like human beings.

There are many advantages if the hands are free. Just think. Suppose we were to walk like cats or cows with both legs and both hands, could we then do any other work with the hands? Could we write or hold books? It would be extremely difficult.

First, slowly they began standing and walking on two legs. Second, as a consequence, their hands became free to do work which otherwise they had not been able to do. Millions of years passed by before these changes took place. By this time our ground apes no more even looked like apes. They did not look like us either. They had moved halfway up the bridge between ape and man. They had become 'ape men', to put it in a crude way.

This 'ape man' also had to face a lot of problems. The main problem was that of food. He could not climb trees like the agile monkeys. So it was difficult to pluck fruits. But he could hold a twig or a bone in his hand and knock down fruits and nuts from the trees and also dig for roots. Not only that, he could also kill and eat smaller animals like rats and wild hens.

It is like this that our ape man began to use tools; he used stones, broken twigs and pieces of bone as tools to procure food. Thus the procurement of food became easy. One more thing happened. Earlier he had been afraid of lions, tigers and other carnivorous animals. In order to protect himself he began to move around in groups. (Whenever we feel afraid to walk alone we move in groups with our friends, don't we?).

With, increasing threat, these groups became closely knit and gradually became well defined. That is to say social groups evolved.

Thus our great grand parents began to use tools and also began to live in social groups. Then other needs arose. It was necessary to exchange ideas within the group, also during hunting, which was being done collectively by this time, it was necessary to communicate between the members. (Earlier, when they were apes, they used to communicate by signals using peculiar sounds). Thus language began to evolve. Language is more than just sounds; it is ordered pronunciation, which in due course is followed by a script.

Animals have their own kind of language. The calf calls its mother when it feels hungry. Birds signal other birds. They communicate in their own way. But these means of communication are completely different from the way we communicate. This is because animals do not have that many ideas to communicate.

Thus our great-great grand parents, over many-many years learnt to make and use tools, developed into close knit social groups and also developed language to communicate. That is how they, became human beings.

So when did these ape men become real human beings? WHEN THEY BEGAN TO MAKE TOOLS, LIVE IN GROUPS AND DEVELOPED LANGUAGE. When they began to use tools and live in groups their abilities and intelligence also increased. They could hunt in a better way. They could eat good meat, and in general better food. That led to the development of their brain. The labour they did with their hands, their ability to do collective work and their ability to communicate using language led to the further development of their abilities and intelligence.

Thus man became more capable than all other animals. But it took many more years, tens of thousands of years, for man to reach his present state. That is another story.

Scientists believe that beings which can be said to resemble man evolved almost about 24 lakh years ago.

All of us know how to tell our ages accurately, by months and days. Don't we? But that was not the case with primitive man. Why so? We shall discuss that in the next chapter.

13. THE EARTH-A BIG BOOK

Dear friends, we have just heard the story of how tree dwelling apes evolved into human beings through gradual changes occurring over many millions of years.

But while listening to that story some of you might have wondered whether all that really happened or not.

How do we know about these things that took place lakhs and lakhs of years ago? There was no writing or reading at that time. There were no books which tell us about what happened then. Then how do scientists know all these things?

Are you interested in knowing how?

Then listen.

The earth on which we live is a big book. Each and every particle of sand on this earth has a story to tell. The remains of thousands of animals and plants which lived on this earth long-long ago and became extinct later, are still lying hidden under this soil.

Fragments of bone, skulls, remains of plants and trees, stone tools which our great-great grandparents used, pieces of earthen vessels, coins, old grains, scripts on stones, temples....many such things are lying under the surface of the soil on which we tread! All this have thousands of stories to tell. Stories about the nature of plants and trees in those days, the ways of life of our great-great grandparents, about the tools and weapons they used, etc. These remains lying under the soil have another name: FOSSILS

There is a group of scientists who explore, unearth and study these things. They are called palaeontologists and their branch of science is called palaeontology. It is through the discoveries of palaeontologists that we learn about the different kinds of living things that existed on the earth crores of year ago, about their evolution and about how tree-dwelling apes evolved into human beings. Now let us learn a little more of about some of these people who discovered important facts which we now know about our ancestors.

In 1857, some scientists discovered the skulls and bones of a strange kind of human being in the Neanderthal Valley of Germany. On examining these carefully the scientists came to know that they were the fossils of beings that were not yet completely human. They called this species 'Neanderthal Man'. They understood that the features and appearance of the Neanderthal people were very different from those of modern man.

In 1892, in Java which is an island in Indonesia, some other skeletons and skulls were unearthed. These were discovered by Dr. Yugini Duboi, a Dutch scientist who had gone to Indonesia to look for fossils of our ancestors. Duboi knew that those were the fossils of a people who lived far earlier than the Neanderthal people. He also came to know that this species could walk erect like man. We can call it Java Man.

Some years later, in 1926, a scientist named Prof. Davidson Black discovered some more skulls and bones from the Chou-ku-tin caves near Peking in China. After close examination the scientists came to the conclusion that these were the remains of beings similar to Java Man. These were given the name Peking Men. The Java Man and Peking Man belong to types of creatures very close to us they are homo erectus. The name means man who walks erect.

In 1924, some skulls were unearthed from the Kalahari desert in the southern part of Africa which belonged to a species called AUSTRALOPITHECUS who are in between apes and human beings. But in 1961 came the most exciting discovery. Two palaeontologists Louis and Mary Leakey discovered the fossils of a creature in a place called Olduvai in Tanzania. This creature not only walked on two legs like Australopithecus, but also had a big brain. And this creature also made tools with stones. Do you know what name the Leakey family gave this creature? *Homo habilis*. This creature who lived about twenty lakh years ago in Africa is the oldest member of the family of human beings. Not long ago, in the seventies a little before many of you were born many more fossils of these *Australopithecus* and *homo habilis* were discovered in southern and eastern Africa, telling us much more about the lives of these links between modern man and apes.

Already in last century, in 1868, some skulls had been discovered in the Cro-Magnon caves of France, which were of beings very similar to man in appearance. These Cro-Magnon people lived 35,000 years ago. Scientists believe that the Cro-Magnons were a species of man much abler and more intelligent than Neanderthal man.

Friends, are you tired of hearing these unpronounceable names of our ancestors?

How many names have we heard? Let us name them according to age.

The oldest known is *Homo Habilis* who lived 20 lakh years ago. Then came *Homo Erectus* whose fossils were found in Java and Peking and later other places also. The oldest is already 15 lakh years old. They were between apes and modern man. *Homo Sapiens* came later. Then came Neanderthal man, type of a *Homo Sapien* very similar to modern man but still different. After that Cro-Magnon man who is almost completely like us in appearance. The modern man made his appearance about forty thousand years ago.

These names are difficult, but interesting as well, aren't they? Don't forget them.

There are many more facts about our ancestors which are yet to be discovered. Many more facts are yet to be known. Scientists the world over are working hard to know more and more.

14. HOW DID OUR GREAT GRAND PARENTS LIVE?

So friends, now it is time to know more about how our great grand parents lived. Where did they live? What type of work did they do? We have to find answers to all these questions. Scientists believe that 'human-like' beings evolved about 20 lakh years ago.

What were half human like in appearance? Can you guess, friends? Very similar to apes. A conical face with the jaw jutting out, a body covered with hair, long nails, long

hair and beard... They moved about without clothes. Didn't they feel any sense of shame, you might ask. No. They did not know anything about clothes, you see.

Don't you want to know where these primitive people lived? They lived in caves and under stone ledges. They lived in groups and knew only one kind of work- What was that? To procure food. Their life was not easy. They had to be careful about wild animals. They had to face thunder, lightning, storm and rain. They had to wander through thick jungles in search of food. Their lives were very difficult indeed (How comfortable our life is. Isn't it? All we have to do is to buy the things we need from the shop and cook them in the kitchen).

Primitive people did not live in families like us. They lived in groups in order to protect themselves from wild animals when they went out to collect food and to hunt. A group consisted of individuals related to each other by birth and others who used to hunt together.

And whatever they got they consumed collectively: hunted together and made tools together.

Ah, that reminds me of something. Do you know what is meant by a tool? Knife is a tool. We use different kinds of knives to cut vegetables, to cut grass, to break the coconut, etc, don't we? Similarly, spoons and ladles are also tools. We use spoons to eat with, ladles to serve curry, etc.

There are many more tools, we use. What are the other tools you know about? The chisel which we use to cut and shape wood, the hammer which we use to drive a nail into the wall, the screw driver, spanner, axe, hoe, etc. all these are tools.

Suppose these tools were not there? How difficult our lives would be? We wouldn't be able to powder grains, split logs for fuel.....in fact, we wouldn't be able to do most things.

So, tools make it easier for us to do different kinds of work. Our great grandparents became human beings because of the use of tools.

Can you tell one major difference between animals and man? Man can make tools. Animals cannot. That is why some scientists call man the 'Tool making animal'.

We have just said that our great-great grand fathers became men because they used tools. In the beginning they used ordinary stones as tools. For a long time they knew only to use stones and twigs. The ape became man by learning to use stones as a tool. Archaeologists have discovered many stone tools and weapons which were used by our great grand fathers.

In the beginning our great-great grandfathers used to just pick up stones from the surroundings as they were and used them to break hard nuts, etc. Scientists named this period, in which stones from surroundings were used as they were, the OLD STONE AGE.

Several thousands of years passed like this and then gradually primitive man began to make different tools using stones: stone axes, stone knives, etc. Stones were used in this fashion only about 10,000 years ago. This period in history is called the NEW STONE AGE. Let us stop the story of stone for now.

We were talking about primitive men who lived in clans or groups. Many years passed like this during which many changes took place. Primitive man became more intelligent.

They began to make better instruments. Arrows and bows were invented. They could hunt better and they learnt fishing. They learnt to make clothes with the skins of animals. They also learnt the use of fire. With the help of fire they were able to cook their food. Until then they were eating raw meat.

Do you feel disgusted when you hear that our great-great grandparents used to eat raw flesh? But that was how it was.

What was the result of this change in food habits? Your brain develops..... And that is what happened.

Gradually some changes took place in the social life of these primitive people. What were these changes? Clans which lived near each other began to interact more closely. With interaction increasing among those who had a common language or living near each other tribes were formed. Thus man began to live in tribes.

Gradually changes came about in their methods of procuring food also. Earlier they could only hunt small animals like rats, rabbits, etc. They did not have proper weapons or the collective strength to hunt larger animals. They began to stay in clans and tribes, their collective strength increased and they learnt to make better tools and weapons. They were now able to hunt huge animals like woolly mammoths without difficulty.

We must remember that during that period man was still only ‘collecting’ food—fruits, nuts, roots, etc. It was only after many more years that he acquired the ability to produce food. It was with the discovery of agriculture that man began to cultivate and produce food.

The social life of man during this period was organized under Primitive classless society. Under this system there were no classes of people—all men were equal. The members of the tribe shared equally the food that they procured collectively. The food collected in a day was just enough for all. So there was no question of saving the balance, or storing some for the next day. All had the freedom to go anywhere to collect food. But gradually it became difficult to collect food. Why?

If you continuously pluck fruits and berries to eat after some time they won't be available any more. Similarly if you continue to hunt animals in one region the number of animals there is bound to go down.

Thus, time passed, food became a major problem. People began to die of lack of food, of starvation.

15. ORIGIN OF AGRICULTURE

Friends, we were talking about the difficulties our great-great grand parents faced due to scarcity of food.

As time went on, and as food became more and more scarce people were left with no other choice then to look for new ways of procuring food, for new sources of food.

This search led to the discovery of agriculture.

We do not know exactly where and when agriculture started. But we do know that it is not more than 8000 years since agriculture became widespread. It was not something discovered by somebody one day. Long-long ago, nearly 40,000 years ago people used to

eat wild grasses. Our great-great grand mothers used to take their children and go out to collect fruits, roots, berries and also seeds of wild grasses. They saw that these seeds when they fell on the ground started sprouting green shoots of after a While. At first they did not take this observation very seriously. Later when food became scarce and was threatening to kill people, people started taking note of this. Slowly they learned how to plant the seeds of grain and collect the grains that were produced. Now they were able to obtain much more food than they were able to get by simply collecting in the wilderness. Wheat, barley and other such grains were the first to be cultivated. We have to thank some of our old-old great grand mothers for this very important development in human history. With agriculture, human beings changed from food gatherers to food producers. This led to many other changes in people's lives

What were those changes?

To cultivate you need land, water, tools for ploughing the land and animals to pull the plough.

What else?

The land should be looked after constantly. Sufficient water supply, protection from wild animals, etc. became necessary. In order to ensure this people began to live permanently near their agricultural lands. Until now our food gathering ancestors had been used to wandering in the forest. They were always moving to new areas in search of fruits, roots and animals to hunt. But agriculture changed this mode of living. In order to take care of their agriculture land and products, they began to stay permanently at one place. For this they needed houses. This they began to build houses to live in.

When they saw that they needed animals to plough the land they began to tame different kinds of animals and rear them in their homes. This is how animals like cows, oxen, dogs and horses became domestic animals.

New tools were also necessary for better cultivation; so man began to make new tools..,

But friends, don't think that all these changes took place all at once. It must have taken place over thousands of years gradually, step-by-step through trial and error.

Agriculture depended on nature for rain, heat, etc, For a long time man did not understand natural forces and phenomena. This led to the emergence of superstitions and rituals. Man used to pray collectively to nature for they believed that nature ruled over them by its forces such as thunder, lightning, rain, wind etc; They prayed to nature for better harvests, and easier lives. These prayers and other rituals gradually led to the formation of religions and religious beliefs.

Agriculture brought man closer to nature. Until then all he did was to gather fruits and roots and consume them. With agriculture he began to keenly observe the changes taking place in nature.

Why do you think he did so?

Because agriculture made it necessary for him to know when it would rain, when it would be extremely hot and dry when water would be scarce, when it would snow, etc. He came to know by observing nature that seeds planted during heavy rains tend to rot, that the crop is damaged if it is too hot, and so on. He also came to know that it does not

rain all the year round, that the sun shines brightly only at certain times, etc. That is he slowly learnt about weather, climate, seasons... We take these for granted in our daily lives don't we? But man took a long time to initially observe these regularities or regularities in nature. Thus his knowledge about nature went on improving.

16. CITIES AND KINGS

Agriculture continued to develop and with the progress in agriculture, fighting among the people also increased. Why was that?

Even before agriculture started, when our great-great grandfathers formed clans and tribes, occasional fighting used to take place between the various tribes. The fights were sometimes over a hunting area, sometimes over the killing of a wild animal. Even now, we the so-called cultured people fight over many silly things, don't we? So there is no need to be surprised to know that our great-great grandfathers fought over such matters.

These quarrels between tribes later developed into bigger fights, mini-battles involving many more people. And in such battles, the victor normally killed their opponents. It is believed that occasionally they even ate the flesh of those they killed. Disgusting? But true all the same.

Agriculture gave new causes for fighting. Now fights took place over agricultural lands, and domestic animals. Sometimes severe battles broke out between the tribes. But that situation changed with the coming of agriculture. They lost their freedom to procure food at will, for everybody could not reap the harvest of what had been sown by one person. Earlier there was no restriction for the collection of food. The men hunted and the women collected food wherever they could. But with the coming of long agriculture, they lost their freedom to procure food at will for everybody could not reap the harvest of what had been sown by one person.

Thus each tribe began to develop their own cultivable land. That was the beginning of private property: Tribal wars became more frequent and more severe. But one change took place. Now those who were defeated in a war were not killed but were taken as prisoners.

What caused this change in attitude?

The victors realised that they can make these prisoners slaves and make them do work on the land, so that they themselves need not work. All the work was done by these prisoners and the victors were able to relax for some time. Earlier all of them had to work to produce enough food for all to eat. But now the slaves were made to work hard on the land and the others—the slave owners—did other things, relaxed and enjoyed themselves.

Some of these men who could become free from labour who had the time to do other things became artists, sculptors and scientists. Gradually art, literature, science and architecture developed.

With the further development of agriculture, man began to look for more fertile land and a better supply of water. Thus they settled down, on the banks of rivers and large agricultural lands began to take shape. With such progress also many other needs came

up. Dams had to be built across streams and rivers for storing water and canals had to be dug.

In order to do this type of work, a lot of people were necessary. Thus different tribes from different villages began to get together and work together. They worked to make stone houses together to make big canals, huge granaries to store grains, etc. They made new temples. The priests of these temples became the leaders of the people in the tribes. New towns developed around these temples and granaries—Towns in which people began to live, together.

These towns were the centre of many great river valley civilisations which developed later. The Mesopotamian civilisation developed on the banks of the Euphrates and Tigris rivers. The Egyptian civilisation developed on the banks of the Nile River. Our Indus valley civilisation developed on the banks of the Indus. And so on. Have you heard these names before? No? Well, now you know, don't you?

City states developed around the cities or towns. Kings were chosen to run the affairs of these city states. Priests and merchants also came up. Many such great changes took place.

This period in history is known as the period of city state civilisations. With the development of cities many kinds of activities other than agriculture came into being. Cities need buildings, don't they? And buildings need to be built. So masons were needed to make buildings in the cities. Carpenters and Potters were also needed. Thus some people stopped cultivating and became masons. Some others became carpenters; others took over weaving to make clothes, etc.

Soon after agriculture developed, man discovered metals and their use. Can anybody tell me the name of the first metal used by man? Copper. A little later he learned to mix copper with tin to make bronze, and to make tools and vessels using bronze. Thus man, who until then knew only to make tools out of stone, began to make and use tools out of metal. This happened around 5000 years ago.

Scientists have recovered bronze tools used by ancient man from many places including Egypt, Mesopotamia, the Indus Valley and China.

Earlier we talked about the Old Stone Age and the new Stone Age didn't we? The Stone Age was that period in history when stone tools were used. Similarly there is a name for the period when bronze tools were used. I am sure you can guess what that is. Yes. The BRONZE AGE.

Almost 1500 years after bronze was discovered man discovered Iron, and before long Iron became widely used. This period is called the IRON AGE by scientists. The importance of science and technology in the history of civilizations is seen in these names — Stone Age, Bronze Age, Iron Age. With the availability of Iron tools, man became very powerful. Agriculture developed further and fast with the invention of the iron plough

Man could now clear whole forests and bring more land under cultivation.

All this development is very nice, isn't it? But were there no problems? Of course there were.

You remember that in the old society people were equal, everyone had to work and there was solidarity. But now the society was split. People were split into masters and

slaves. Also there was another big division which is continuing even today. Men and women did different work in the old society. The food collected by women was very important for the survival of the whole tribe and men and women were more or less equal. But with the development of agriculture, the invention of the plough and private ownership of land all this changed. The work done by women was not any more public, it was not for the whole tribe but private, to support the family. Man became dominant over woman. Although she still had to work hard, she had to be dependent on man, to listen to him. In the house she was a little bit like the slave in the field. So friends, our society was split in many ways with our progress. Tell me, have things changed much? Shall we not keep the progress, but heal these wounds, these splits in our society? But before we talk about that let us see what happened to the slaves?

17. FEUDAL LORDS AND CAPITALISTS

The condition of slaves was very pathetic. The slave owners tortured them and treated them badly. They made them work day and night. They whipped them mercilessly and chained them so that they may not run away. The owners treated the slaves like animals. They used to buy and sell slaves like cattle. How terrible, isn't it?

When kings came into being the slave's condition became worse. The kings used them to build huge palaces and monuments. You have heard of the giant pyramids of Egypt, haven't you? These are the tombs of the kings of Egypt. These pyramids were built by thousands of slaves who were made to work day and night! Poor slaves! They got very tired carrying huge stones and digging the earth. Many of them died. It is said that the kings enjoyed watching them die.

Many kings also made the slaves provide them with horrible entertainment. Would you like to know about one kind of entertainment that existed in ancient Greece and Rome? The kings and lords of these countries enjoyed watching a slave fighting with a lion! Once it was decided to have such entertainment, a huge lion would be kept in a cage without food for a few days. The slave who was chosen to fight it was also kept in a cage, but fed well. The fight used to take place in an open place called an arena. The king and his courtiers and relatives used to watch the fight from a safe place.

The slave would be made to stand at the centre of the arena and the hungry lion was then freed from its cage into the arena. It would rush at the poor slave, and the fight followed with the slave trying to save himself and the lion trying to tear him to pieces. This was the kind of entertainment the king and others liked! Thousands of slaves died like this. What a horrible sport, isn't it?

The slaves lived like animals. If they tried to rest, tired after hours and hours of work, the king's soldiers would whip them. Initially they put up with all these sufferings without protest. Why? Because they thought that even though they were whipped and tortured, they need not die of starvation. They thought that getting whipped was better than death, or maybe they were unable to think a way out.

But this attitude didn't continue for long. Unable to bear the beatings and torture the slaves began to protest. They began to disobey their owners. And groups of slaves became ready to fight against the king. Have you heard of a great slave leader called SPARTACUS? He was a brave slave who fought against the Roman Empire. Gradually,

as these protests began to spread the lords and kings began to be afraid. They realised that they could not make them continue to work like in old the days. If the slaves refused to work agriculture would fail. No other work could take place either. The lords and owners would have to starve. They realised that they had no other choice but to give more freedom to the slaves.

Until then the slaves had been allowed to do only one thing work like animals. For the owner a slave and an animal were alike. When slaves began to oppose them, the situation changed. Slaves got more freedom. The responsibility of cultivating the lands was given to them. A small part of the crops they cultivated could be taken by them but the remaining bigger share would go to the owner of the land. That was the contract. Thus the slaves became serfs. The slave system came to an end and a new social system came into being: the system of land lords and serfs. These land lords or zamindars were also known as feudal Lords. And this new system is known as feudalism. There were kings during feudalism also. The king had many friends who were rich owners of land. These were the feudal lords. Everything happened according to the wishes of the lords.

And who worked on the land? The serfs. They worked hard and produced a lot. They had a certain amount of freedom. They were no longer beaten or whipped like slaves with their changed status. These ex-slaves were happy and they worked with enthusiasm. During this period many great developments took place. Though agriculture continued to be the main activity, trade and handicrafts also developed. Small industries came into being here and there. Paper, printing and gunpowder were discovered during this period.

Time went by. The serfs worked harder and harder and produced more and more. The lords became richer and richer. They built huge mansions and lived happily.

Some among them became merchants. They began to explore new lands to carry out trade. Many of them set out on adventurous journeys into unknown lands either over land or by sea.

New continents and countries were discovered. The voyages of Christopher Columbus by ship and Vasco-da-Gama's arrival in Calicut, India, belong to this period.

More and more came to be known about other countries. The merchants tried to bring rare and good things from other countries to their own country to sell them and make profits.

The Portuguese, the Dutch, the French and the English came to our country .at this time. It became common for them to take spices, textiles, etc. from our country to their countries. Gradually these people who initially came to trade with our country conquered us. That is how we came under British rule many other countries of Asia, Africa, and South America were also enslaved by the British, Portuguese, Spanish French, and other European countries.

During feudalism the most powerful countries in the world were some Europeans countries. During the same time people started small industries. The progress in agriculture created the need for more and more tools and equipments. Some people made use of this opportunity establish industries which produced agricultural equipments. Some others started textile mills and others established factories making iron goods.

Thus a new group of people come up in society, a group of newly rich people — merchants and industrialists.

Who were the most powerful people in society during feudalism?

The feudal lords. Their word was law. Nothing went against their wish. Whoever dared to oppose them were given severe punishment.

But this new group who had become very rich began to oppose the feudal lords. Many of them were richer than the feudal lords. Thus small fights began to break out between the feudal lords and the newly rich merchants and industrialists.

In such fights the serfs who worked on the lands of the lords joined hands with the opponents of the lords. They were begging to get angry with the lords. These small quarrels increased with time and gradually led to major wars.

Initially the feudal lords had the upper hand but later the situation changed. Haven't you heard of the famous French Revolution? France is a country in Europe. The fighting took place between the kings and feudal lords on one side and the common people, the newly rich merchants and industrialists on the other. This ended in a revolution in 1789 which resulted in the overthrow of kings and lords. A government came into power made up of representatives of merchants, industrialists and the common man.

Thus gradually the power of the feudal lords reduced and the power of merchants and industrialists increased. Ultimately the old feudal lords lost all their power. Feudalism came to an end in Europe and in its place came up a new social order called Capitalism. Both industrialists and merchants may be called capitalists. The social system called capitalism is led by them.

Thus capitalism replaced feudalism. During feudalism the farmers or serfs were the most important section of society because it was they who helped the lords to become richer and richer. But capitalists paid more attention to trade and industry. They were not that concerned with agriculture. The power of these capitalists increased more and more.

18. THE PROFIT MONGERS

So friends!

Where did we leave our story? We had reached the stage where the feudal lords were replaced by merchants and industrialists, haven't we? Do you know how long it took for this change to take place of years!

Do you remember where exactly we began this long story? With our great-great grand fathers! You remember the story of how our fore-fathers used to roam around in the jungles surviving only on raw meat and wild fruits don't you?

Gradually, changes began to take place in the life style of our great-great grand fathers. They started living in groups in caves, used stones and twigs as tools. As language developed and after many-many years they started cultivating crops. They started settling in one place and building houses.

What else did we say? We talked about slaves, feudal lords and now we have started talking about merchants and industrialists. I hope you haven't forgotten how the new rich capitalists comprising of merchants and industrialists started overthrowing the feudal lords and smashing their power and influence.

It was at this time that in Europe, especially in England, tremendous changes occurred; the Industrial Revolution.

Friends, do you know what the Industrial Revolution is? No? Then listen.

Long ago, even in the times of the feudal lords there were certain small industries like textile making, iron smithy, etc. In the beginning the products of these industries were mostly hand made or made by using small implements. Hand made goods take up a lot of time, don't they? To complete making a shirt by hand it may take two days but if the same shirt is machine made, how easy and quick it would be!

If manufacturing is done manually, there would be a limit to production. All if only a small number of goods are produced and sold, it means only a small profit for the producer of the goods and the trader. To solve this problem, they tried to find out new methods to produce more goods quickly. They invented machines that could spin and weave and therefore make cloth more efficiently and quickly. The spinning jenny which speeds up spinning and the flying shuttle which speeds up weaving were inventions of this period.

The steam engine which worked on steam was also invented during this period. It was James Watt who invented it. You might have seen the steam engine. It pulls many of the trains in our country.

Apart from new machines, methods of making many new objects were also found at this time. The process of steel making was discovered by Bessemer.

All these discoveries and inventions took place in the eighteenth and nineteenth century. As a result of these industries expanded. Manufacturers started producing large quantities of goods within a short time, which resulted in increased profits. Merchants could also profit from this. In a short period of time the whole face of the industry changed. This change is called the Industrial Revolution. We call it a revolution because big changes took place in a short period of time.

The Industrial revolution helped the new capitalists to multiply their power manifold. They became richer and richer and the power of the feudal lords became less and less.

Agriculture was the main activity during feudalism. But slowly industries gained dominance, and became more important than agriculture. With the increase in industry profits also increased. During this period, a lot of new things were invented. After this also many-many new inventions started coming up. Electricity brought about big changes. Edison invented the electric bulb and Alexander Graham Bell invented the telephone. Marconi invented the radio.

The capitalists' greed for profit created new problems. When the capitalists got some profit, they wanted more. And their wanting had no end. More and more industries were established. The number of workers increased. They began to stay around the industrial units. When the area got crowded new problems cropped up. The scarcity of clean water threatened the health of the workers. Facilities were lacking. Many-many problems like this came up.

At the same time the number of poor people increased. On the one side were rich people and on the other side were extremely poor common people. On the one side villas and mansions, on the other side unhygienic slums. The rich led luxurious lives and the poor

starved. The capitalists produced goods which were necessary as well as unnecessary. Production went on without any planning whatever brought more profit was produced. No attention was given to producing things essential for the common man. They were more bothered about the production of luxury items which brought more profit.

The manufacturers and merchants tried their best to increase profits by adulteration, by black marketing and creating price rise. The poor people suffered more and more.

Many new machines were introduced which made people jobless and the number of unemployed went on increasing.

Agriculture also came more and more under the influence of profit making. Many of the peasants, the farmers with small pieces of land, lost their lands to the big landlord. And these landlords did not want to give jobs to all the people. So the people started migrating to the cities to look for jobs. Many times they did not find any job and they had to live on the pavements and in the slums.

In many countries, when the situation became unbearable, people started protesting. The capitalist system started cracking up. People began to feel that the system should change. Today this change is taking place.

In our country also, with the development of capitalism, most of the people continue to be poor and ignorant. Mahatma Gandhi has told us that unless the lives of our poor people improve, Our nation cannot progress.

19. A NEW HAPPY WORLD

So friends, what were we discussing?

We were talking about the selfish owners of industries who care only for more and more profit and the common people who are plunging further in to poverty.

Today, in this world thousands of people live in extreme poverty. Can you imagine little children like you working unable to go to school and unable to get your daily bread! How many people are suffering slow deaths, unable to treat their illness? Thousands of people cannot find enough to meet their minimum needs they have no jobs. So many people live on pavements and in slums. Many became beggars and those who have work, in spite of working day and night, are not able to get sufficient money.

There are thousands of such serious problems. Should these problems not be solved? Should the problems of illiterate, starving millions of people in our country and other countries be allowed to remain?

Definitely, this situation should change. How can this happen? Can we do it? Certainly, yes. Science and Technology have made many of these changes possible in other countries. There is no reason why the same should not be possible in our country. But the present mad rush for profit should stop and things needed by the common people should be produced more and more. The gap existing between the rich and the poor must vanish and for that people should work together.

You take part in games don't you? In football and volleyball? How does a good team play? All the members of the team play untidily. Only then can they win the game. Instead this if one man moves alone with the ball, without passing it to others, what will be

the result? That team is bound to fail in the game. Then that member of the team have to be thrown out of the team.

Our society is also like that. When a small number of people live with all comforts and the majority of the people are in utter poverty, co-operation between them is not possible. Can there be a society where all live alike, cooperating with each other? Can any one of you given the name for such a society? Socialist Society.

We have heard of the word 'Socialism'. Real socialism will come into being only when all people work together like equals, rejecting the blind rush for more money. In a socialist society there won't be big millionaires and poor beggars. All the people will have the opportunity to live happily and to work together. Everybody will get the chance to study and everybody's health will be protected. All will have good houses to live in. Won't it be a good life, friends?

Thus a socialist society is a society where everybody will be equal. Our aim should be to build such a society. And each one of you little friends should be able to play your role in this.

20. THE STORY OF SCIENCE

Children, we are coming to the last part of our story. Only one more point remains to be told. It is about Science.

Have you heard the term 'Science'? Of course. Many times. You study many science subjects in your school. What are they? Physics, Chemistry, Biology, Mathematics. What is physics about? About light, heat, electricity, about natural forces etc. And Chemistry? In chemistry we learn about the structure of different substances, about properties of metals, the change of state of substances. In biology we study about plants and animals.

What other sciences have you heard of? Have you heard of Medical Sciences? What is-medical science? It is that branch of science which tells us about the human body, about disease and how to prevent it or treat it. And there is Astronomy, Psychology, Technology, Economics, History, Geography many-many such subjects.

Science constitutes all these subjects. Just wait, we just said that science means the knowledge of all matters about nature. How did people come to acquire all this knowledge?

Did our great-great grand parents who lived 20 lakh years ago know all these things? No. They did not.

Earlier they were afraid of things which they saw around them in nature. They were afraid of rain. Feel like laughing; don't you?

Why were they afraid of all these things? Because they did not know anything about them. Are you afraid of rain? No. Why? Because we know how they happen. We know that water from sea and rivers evaporates and goes up in the air as vapour. When this cools, it forms clouds and when clouds get cooled further, the water comes down again as rain.

Our great-great grand parents did not know all these things. But gradually they began to observe the nature around them. They observed the rain fall, the alternative changes of

day and night, and the lightning. They also saw the trees grow and flowers and fruits develop. Initially they did not understand it at all. But gradually they began to understand all these things.

And it is during that period that some of our great grand fathers and grand mothers invented that great thing called the tool.

What was the tool that our great-great grand parents used first? Stones - by the use of stone tools that they became human beings, they began to use tools and also observed the nature around them. Gradually their knowledge increased. With the use of stone it became easy to collect fruits and to kill animals. This led to the search for newer and better tools.

Initially they used whatever stones they came across as tools. They threw these stones at fruits and used them to crack open nuts. What is the name of this period? The Old Stone Age.

Later they began to sharpen these stones. Thus people began to use sharpened stones like knives and chisels, later people improved their tools further and began to make stone axes and knives. This period is called the New Stone Age.

What have we discussed up to now?

About new discoveries, new knowledge and how our ignorant great grand parents developed into human beings. Later they discovered fire. They began to cook their food. They learned to make pots. They learned to make clothes out of animal skin. And they discovered bows and arrows and the catapult.

The bow is the first machine that man made.

Gradually knowledge increased. Did all this happen in a day? No. It did not occur in a day or in a month or not even in hundreds of years. It is through tens of thousands of years that people acquired this knowledge.

Later man learned to separate metals from ores and to make tools of metals. What were the metals used by our great-great grand fathers? Copper and Bronze. The period when men used bronze is called the Bronze Age.

After a few hundred years the Bronze Age was succeeded by the Iron Age. The Iron Age was the time when iron was most widely used.

Thus the knowledge of human beings went on increasing and they became powerful. They, who were afraid of natural forces earlier, now began to control them.

With passage of time agriculture started. Don't you remember how it started? When agriculture started men understood more and more about climate and about the growth of plants. This knowledge later created the branch of science called Botany.

It was necessary to measure agricultural land. This led to the beginning of mathematics. Don't you study geometry in your class? What is the meaning of the word geometry? 'Measurement of land'. Then they built small dams to provide water to the agriculture lands. They learned to build buildings and they invented wheels with which they began to make small chariots. They began to make large boats and to navigate the rivers.

In an earlier chapter we discussed that among Primitive people all had to work to collect food. With the beginning of agriculture some people got more time for rest. The slaves laboured in the fields. Those who could relax, tried to learn new things. They began to think about stars in the sky, about our body, about nature etc. Then onwards there was an increasing flow of new knowledge.

Thus time passed and men learned a lot about this universe. It is during this time that we learned that the earth revolves around the sun and that the earth is round like a football. Do you know the name of the scientist who discovered that the earth moves around the sun? NICOLAS COPERNICUS.

During the slave system and the feudal system people acquired more and more knowledge. Thus the knowledge we possess is a collective knowledge which our ancestors acquired through millions of years. This knowledge is the result of the collective labour of billions of human beings. By the time of the merchants and industrialists our knowledge had increased tremendously.

How many new inventions! And how much more new knowledge!

Science is a collective name for all this-knowledge.

So what is the meaning of science? Science means knowledge? Is it just knowledge? No. It should be a knowledge which is well established, and systematised.

What do you mean by well established? If somebody gives you a cup of water and tells you that it is sweetened water will you agree? No. Then? We will taste it and if it is sweet, we will agree with him, isn't that so? Like this scientists also do experiments and make observations and then establish things.

So science means knowledge which is established through experiments and observations.

Science is knowledge, but knowledge about what? It is knowledge about all the things around us. What is the name for all the things around us? NATURE or UNIVERSE.

Science is knowledge about this universe, established through observations and experiments.

Okay, now what is this science for?

What a question!

Without science there wouldn't have been buses, there wouldn't have been trains, and there wouldn't have been electricity....

Oh! Life would be really difficult.

Science has given us the smallest pin as well as the biggest rocket which carries them to moon. It has given us houses, roads, cinema and radio, plastic and steel vessels, etc., etc.

It is science which tells us about the stars, about our earth, and about our great-great grand parents who lived long ago.

If medical science was not developed how difficult it would have been. So many people would have died because of diseases. But today new medicines are being invented for

almost all diseases, and public health measures and vaccines are preventing so many diseases.

Science is such a good thing!

Wait, it has a bad side to it also? What is the bad side of science? It is because of science that some people are able to make the deadliest of weapons. Haven't you heard of Hiroshima and Nagasaki where lakhs of people were killed using atom bombs? Haven't you heard of people killed J& wars by use of poison gas?

Who is responsible for this misuse of science? We ourselves.

Industrialisation without planning has brought about severe destruction of the environment. The polluted waters from many factories are dumped into nearby rivers. The fishes die and people who drink water from these rivers fall ill. Reckless deforestation causes changes in climate.

Then that is the solution?

Science should be used carefully. It should always be used for human welfare. It should be used to solve poverty and starvation and unemployment.

So many people in our country live steeped in superstition. To change all these things everybody should acquire scientific-knowledge, and a scientific way of thinking, a scientific temper. Everybody should know about things around us, and try to understand them.

What is the reason for poverty? Why do poverty and superstitions exist in this world, even when science has advanced so much and we are capable of landing on the Moon? All this we should understand. How do we do that?

We should become scientifically aware. Is that sufficient? No. We should try to get rid of poverty and ignorance.

So friends you should remember this always. You should think about it again and again.. And you should learn more and more.

Science for Social Welfare. Science for solving Unemployment.

Science for Eradication of Poverty. SCIENCE FOR SOCIAL REVOLUTION.

End