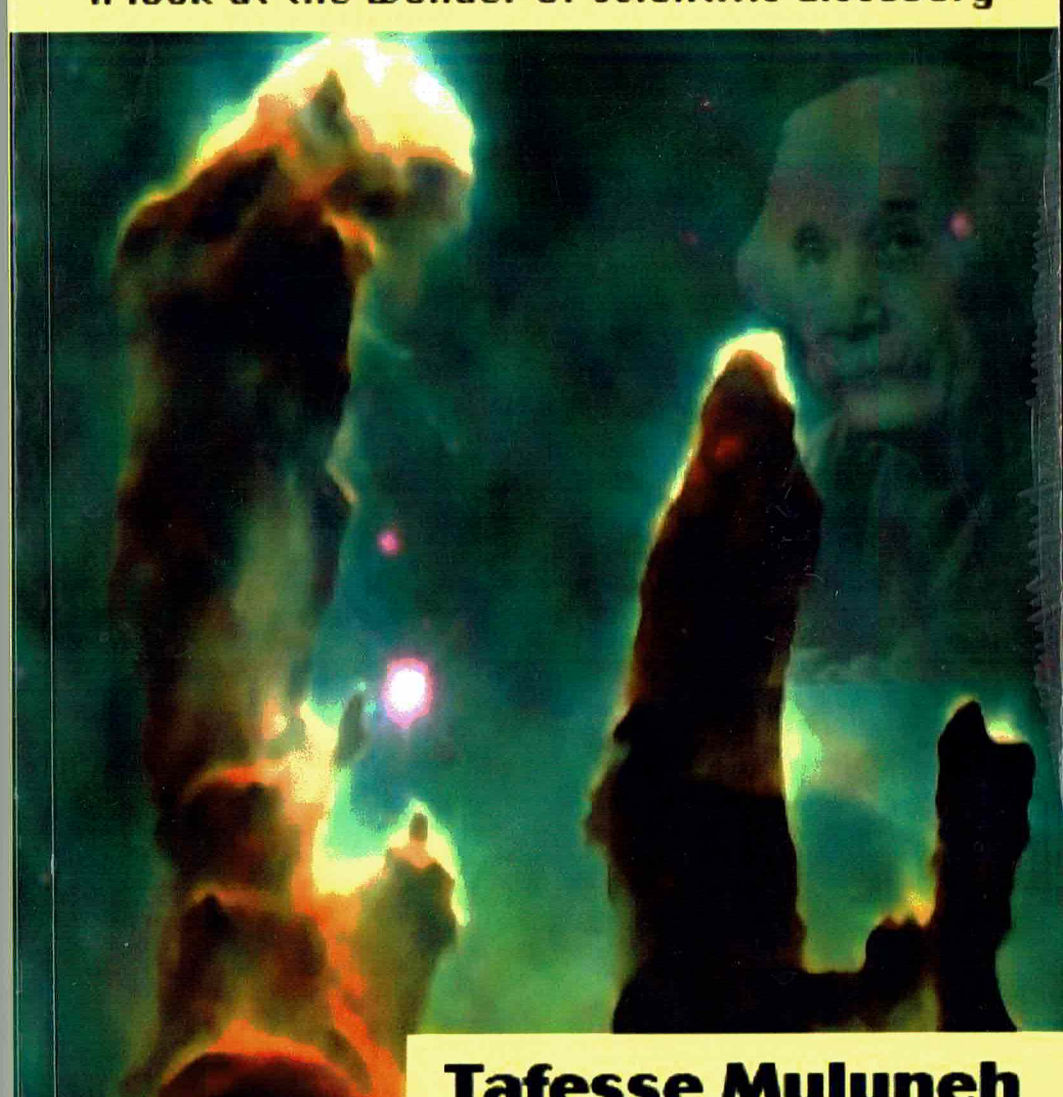
PILLARS of CREATION

A look at the wonder of scientific discovery



Tafesse Muluneh

PILLARS OF CREATION

Cover Picture

"Pillars of Creation", as this group of stars is known, is 7000 light-years distant from us; and is seen shrouded in thick cloud and dust. Inside it, a lot is going on by way of stars forming, erupting, exploding, etc., and perhaps forming planets and even life.

As it is, we cannot see the specific details inside, but only wonder "What in Heavens is going on?" as we stare at the glow of activity depicted at the top of the picture.

In like manner, looking out at us from that side should puzzle the observer there (if any). Various wave signals (radar, television, radio) emanating from here and streaming out, and the various construction/destruction activities here may make one wonder "What on earth is going on?"

All activities, that got us from the Stone Age through the Industrial Revolution to the Computer Age, were ushered in by the creative endeavors of our scientists - our Pillars of Creation - the face of one of them is also depicted at the top of the picture.

By
Tafesse Muluneh

Pillars of Creation

Originally prepared in Amharic under the title:
Scientists:
The challenges of their times
And
The fruits of their labours

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PREFACE

Of course, we all labour to earn a living. We sweat at it from dawn to dusk. But in spite of it all, our standard of living is far below that of developed countries. Why?

The answer is simple: - they make better use of science and technology. It takes one of their farmers just a few hours to till a field. Our farmers would take the whole day to plough it.

One loader operator hauls a pile of building blocks easily in a few minutes. The same load would take 30 of our labourers an entire day to transport it. It is even harder to compare air freight with horse-pack or computer operators with the abacus.

But why has science not found a fertile "field" in our place? Some answers are suggested in this book; but the main study is how other people in those times and under those circumstances happened to develop the sciences – what helped them? And what occasions prompted development? Of course, no claim is made to have traced the history of the development of science in this small book, yet I believe that case studies of some scientists and their experiences can serve us a good lesson. To cite a few examples: Gregor Mendel was a monk; he was also engaged in a teaching profession to subsidize his living. In his spare time, he did some research on growing plants and their cross-breeding. Today it is considered that his work marked the beginning of genetic engineering, and Mendel's name became

famous. Louis Pasteur too, began his investigations when confronted with the problem of cattle and sheep being wiped out by anthrax, and even people perishing of various contagious infections. As a result of his effort, children today are protected by vaccinations, and the menacing rabies is under control.

Other examples have been cited in this book. The point is to encourage the youth to ponder riddles and investigate things on their own. Obviously, schools are the source of trained manpower for the country: and student-teacher relationship influences enormously the proper development of the student. Hence, the teacher has to consider carefully his approach to, and the handling of his students. For example, say, the subject matter at hand is chemistry and the teacher is discussing the intricacies of the Periodic Table. Now the students may simply get bored and drowsy. However, if the clever teacher related to the class how Dmitry Ivanovich Mendeleyev managed to be accepted at the St. Petersburg College, thanks to his mother's unrelenting efforts to get her son from Siberia to the heart Russia while dying of a terminal illness, then the story becomes quite interesting and everyone in class will stay awake.

Such stories will alert students of the difficulties one may often encounter when striving towards finding answers, which could promote progress while making better use of science and technology. These tales may also help the distracted student to follow the subject matter with more understanding of the men behind the studies. This book helps in such respects.

The teacher can also help students in some other ways. For example, remembering that the great scientist, Albert Einstein, had, at one time in his younger days, failed school examinations in language and history courses, and had been dismissed from the school, he will realize the fact that not all students should be gifted in all the subjects taught in their class.

Once other readers learn, how the scientists-to-be surmounted adversities early in their lives and finally made it to the peak of their careers, they can actually *create* their future and make a success of it. They will realize, by nurturing their talents, or pursuing their hobbies or studying the environment and considering what they can do on their own or in association with others, they can achieve untold successes.

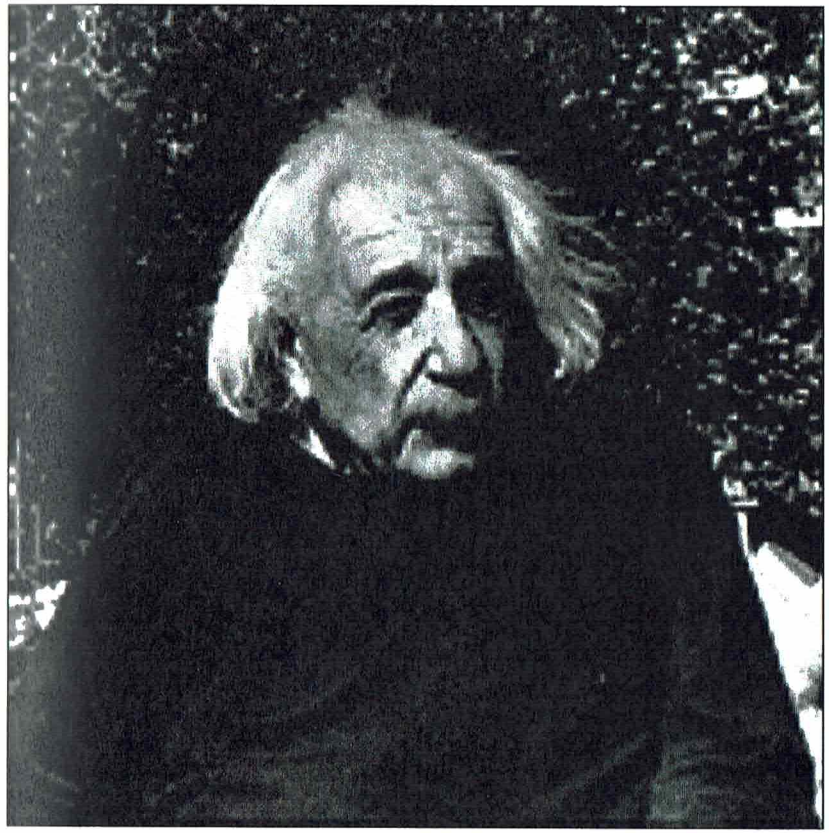
Science research has its own ups and downs. It has its own stock of frustrations and it demands a lot of patience. Most of the time, it turns out that the result of all the research is a mere waste of effort. Authorities must make allowance for this possibility. Yet the researcher too has to be careful in choosing the line of research that is most likely to bear fruit.

Finally, to keep the balance between the main three branches of science (physics, chemistry and biology) roughly equal number of scientists have been chosen and presented in this book. Thus, the impact their contributions made in the fields of health, education, defence, religion, or philosophy on the public, and their consequences have been outlined. The starting point of some of the most famous technologies (e.g. Atomic energy,

missile technology, genetic engineering) and their ensuing results has also been discussed to some extent herein.

Considering the short development period (less than 150 years) in which the Western World achieved such enormous progress, we realize that countries under development could catch up with the developed countries – if they seriously tried. Otherwise, they will quickly fall farther and farther behind, hence the grave responsibility that rests upon the shoulders of this and the coming generations.

Chapter One



Albert Einstein

1879-1955

The worth of education

"There comes a time when the mind takes a higher plane of knowledge but can never prove how it got there. All great discoveries have involved such a leap. The important thing is not to stop questioning."

When scientists are mentioned, the name that leaps to my mind is Einstein. Other names come only later. This name is not only famous for me or for those of us engaged in the study of physics, but for all scholars of science. Most scientists gain prominence only after several years of hard work, and later reviews of scientific progresses due to this work; so that the scientists concerned may not get the recognition in their lifetime. Einstein however, was able to get this chance early in his life. How could this happen? Well, before we deal with this, let us go back in time to see what the man had to go through.

Einstein was a Jew born in Ulm, Germany.[1] Born in 1879, he grew up and went to school in Munich. At the age of 15, he was reported weak in history, geography and Latin and so was dismissed from school. (His teacher had remarked, "He will never amount to anything.") Einstein indeed was slow; even in learning to speak – he stammered a little.

Later he went to school in Switzerland and somehow managed to enrol in college. He graduated in 1900 (reportedly with the help of a student friend) and became a mathematics

[1] (3) No.6; (6)

teacher. Shortly afterwards he joined the Swiss Patent Office. It was here that he had the opportunity to pursue his studies in his beloved subject – physics. He published his works in 1905, which provoked a sensation overnight. Hesitation, doubts and confusion reigned among the scholars of the time; but all chose to remain quiet until the theory was proved or disproved. Einstein's brain-power however, and his theory proved indisputable.

He began to receive requests from universities to lecture in their classes and thus moved around for a time to settle later as a fellow of the Science Academy in the University of Berlin.



Albert and Mileva

Einstein's life met a curious turn when his Yugoslav wife and close collaborator in his research, Mileva Maritsch, who was also a physicist, took their two sons on a holiday to Switzerland whereupon the First World War broke out and prevented her from coming back to Germany. The marriage had to be dissolved after several years of forced separation.

Einstein later married Elsa, while he pursued his research. In 1916, he published his works on the general theory of relativity. This again was another milestone.

But there was no peace in Germany then. Einstein felt the hatred expressed against his Jewish race. He felt that the political climate in the country was leading to inevitable war. So he began to give addresses at every platform he found and aired his views in an attempt to bring about understanding and tolerance. Yet, he was met with more hatred and hostility.

"The big political doings of our time are so disheartening that in our generation one feels quite alone. It is as if people had lost the passion for justice and dignity and no longer treasure what better generations have won by extraordinary sacrifices."

By this time, Einstein had become a world renowned figure. Einstein's fame encouraged a group from the British Science Academy to undertake a mission to the island of Principe to verify his theory. There was a solar eclipse downing on the island and the group decided to check if light rays really bend around the sun on

their way from the stars beyond. Alas! Einstein's prediction was correct!

Overnight Einstein became a celebrity. His name became a household word. Soon jokes about him started to circulate. Of course, the theory he propounded was not easily understood by most people and certainly not by the uneducated one. One of the jokes run as follows:

"One dignitary was told that there were only three who understood Einstein's theory, whereupon he asked in surprise, who the third was! The two he knew were Einstein and God."

Meanwhile the Nazi hostile attitude toward the Jewish population throughout Europe, and Germany in particular, became worse by the day. All the while Einstein made his position clear that he was against war; and he urged others to take a similar stand. As a result, the Authorities despised him. His close friend, the Foreign Minister, who was also a Jew, was assassinated by anarchists and it was rumoured that Einstein was next on the list.

It seems Einstein himself had foreseen what was likely to come when he had commented about his situation even 11 years before Hitler came to power:

"These days the Germans consider me a German, but the French consider me a Jew. But if my theory proved wrong, the Germans are going to consider me a Jew and the French are going to consider me a German."

Einstein once went on a mission to the United

States, and he learnt that during his absence, the police had been to his home to conduct a search. Actually, he was campaigning in the States for all Jews to return to their homeland-Israel – and build it up. He urged them to establish a university at home and teach their children in their own language and culture. Incidentally, when Israel was finally established, he was offered the presidency but he declined on the grounds that politics was not his profession.

Back in Germany, the attitude towards him got harder. At one point, even his physics theory was barred from being taught in schools. The German politicians of the time began to draw a line between German Science and Jewish Science. It was this attitude, which the Swedish Nobel committee foresaw as early as 1922 when it awarded him the prize. The committee concerned lest they be charged with political alignment against German Government inscribed the citation to the effect that the award was given not for the Relativity work that gained him world-wide fame, but for a previous rather insignificant work (Photoelectric effect) and merely generalized the rest as theoretical physics.

Einstein was finally publicly accused by the German authorities for *"having failed to promote the good name of his country in the course of visits abroad as it was his duty, as a citizen to do so."* However, Einstein remained steadfast and responded that by no means would he ever be supportive of the Nazi regime and cruelty towards other people and decided to give up his citizenship and to settle in the United States.

"My political ideal is democracy.
Let every man be respected as an individual and no man idealized."

When Hitler finally started the war and set Europe ablaze, Einstein could no longer stay aloof. He reminded everyone he met during public speaking engagements and in private circles that it was their duty to stand up firm against Hitler's inhuman and vicious attack against peace-abiding people.

History records that it was Einstein who wrote a letter to President Roosevelt in 1939, which persuaded him to allocate funds for the development and construction of the Atomic bomb to settle the conflict. The bomb was actually constructed on the basis of the theory he had formulated years earlier. The formula related mass to its energy equivalence as $E=mc^2$.

Earlier, however, Einstein had put forth various other postulates as well. Now what were these postulates that brought him fame in the first place? It is hard to present and explain these theories in such a small book; but then it will not help to popularize science if we completely leave out the subject and confine ourselves merely to exhort Einstein's fame. So we will attempt to discuss at least one of his postulates – Relativity.

Before Einstein came on stage, it was the belief that Quantities simply added up in the conventional manner. For example, 2+3=5. This is a formula. Speeds too can be added up in the same manner. So if a train travels along a straight track at a speed of 50 kilometres per hour and if a passenger on board runs in the

direction at a speed of 15 kilometres per hour, the total speed of the man with respect to the ground is 50+15=65 km/hr.

Again, if a man riding a horse threw a javelin in the same direction, and if a man standing stationary on the ground also threw a javelin, the two javelins won't achieve the same speed; that of the riding horse will gain the speed of the horse on top of the rider's throw. Now that was all clear.

But Einstein came forward and declared that this was not valid in every circumstance. He was not concerned about people's feelings; he just boldly announced "that is not correct!" and that was that! He explained that when dealing with speeds of travel, one cannot keep on adding numbers one on top of another. What's more, one cannot attain speed faster than that of light. Therefore, one cannot add speed on top of that.

He further explained that measurement of the speed of light remains unaltered regardless whether it was measured from a speeding carriage or from a stationary place. Therefore, speed of light is invariable in every condition of travel. This is one of his starting points.

The other one is that natural laws are the same under all conditions of constant motion. For example, a man standing on the side of the road can read a book calmly or pass a thread through the eye of a needle. Also, a man aboard an airplane or a train passenger riding along a straight track can read a book or stick a thread through the eye of a needle. As long as there is no change or variation in speed of travel, the passenger can throw dice or jump a rope as easily as a man on the side of the road does. Indeed the

passenger may not even be aware of his travel unless he looks out of the window.

Starting from these two hypotheses and using them in his calculations, Einstein stated the following three postulates;

1) When an object moves at high speed, its length shortens,

2) When an object moves at high speed, its mass increases,

3) For any one moving at high speed, time lapses slowly i.e., time slows down.

These conclusions are easily deduced from his two hypotheses and basic transfer equations. Now the question arises: what are the practical implications of these postulates? And can they be verified by actual experiments?

The first postulate did not appear to worry anybody. If, say, a car is traveling at a speed of 100 kilometres per hour and one has to cover this distance by measuring only five times, then one's measure (ruler) has to be 20 kilometres long. Now if the car's speed is to be measured by an observer from another car traveling a bit slower than the first car, then this car does not, relatively speaking, run fast. It appears to move slowly with respect to the train. Therefore, to measure this shorter distance by again measuring only five times, then the length of the measure (ruler) will be shorter than 20 kilometres. If say the car were moving at a speed of 10 kilometres with respect to the observer on the second car, then for the observer to cover this distance by measuring five times, his ruler has to be 2 kilometres instead of twenty. Only that way can the measure of the speed of the car remain the

same regardless of the speed of the observer.

In this argument, Einstein was not in conflict with any system of faith or belief; so people just let him have it his own way.

The second postulate was easy to verify. In previous times it was noted that electrons could be pushed by electric forces to attain high speeds; but then once they got to a certain level of speed, it was harder and harder to get them moving faster with the same force application. This, at the time, was a puzzle. However, once Einstein made it clear that as the speed increased, the mass of the electron also increased, the puzzle was solved. Even the increase of mass was calculated according to the suggested formula, and it tallied with the experiment.

The third postulate is the one that created the most controversy. How does the passing of time depend on the speed of persons, i.e. slowing down for one, and speeding up for an other? It should pass on independently of the observer's state of motion!

Yet, according to Einstein's equation, if the speed of light is 100, and a person travels away from the earth at a speed of 86, his life-span interval will be reduced by half. Therefore, if the person returns 10 years later (according to his count) he will find his twin brother on earth to have aged by 20 years since he left him.

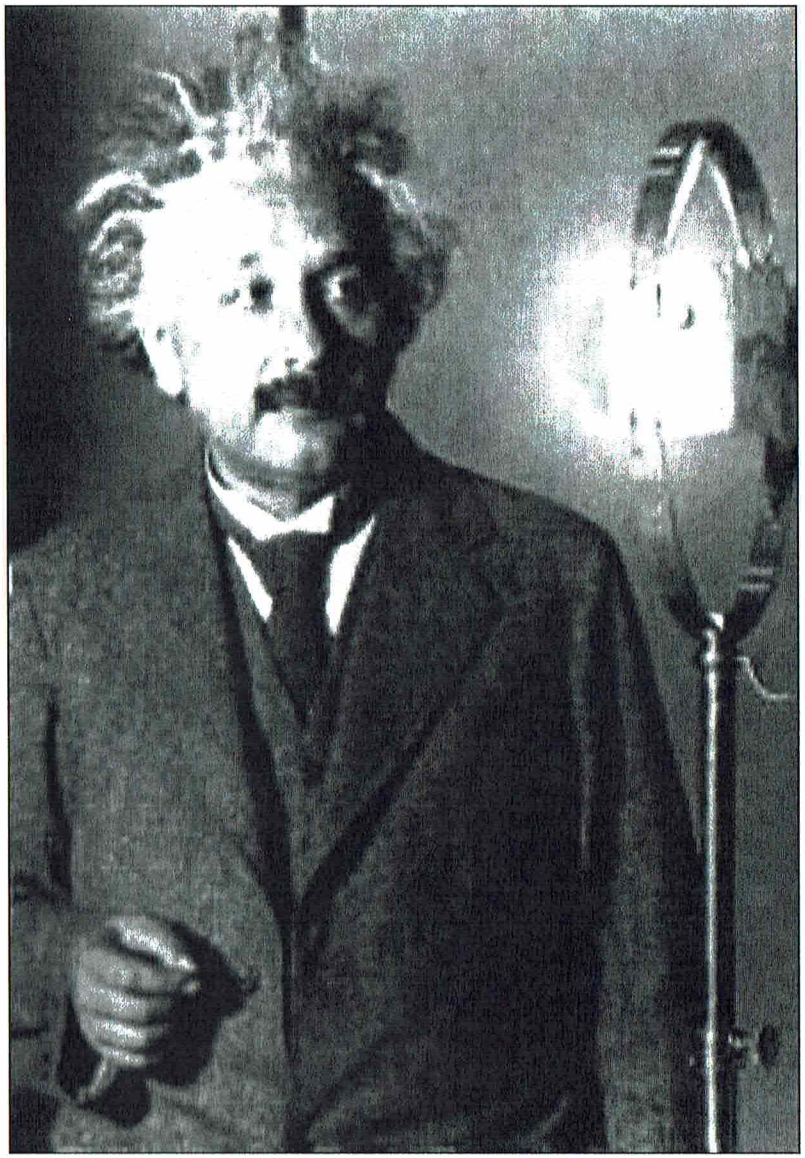
Again, if the observer traveled at a speed of 99% of that of the speed of light, a period of one year according to his reckoning will be equivalent to 50 years on earth. Therefore, a 30-year-old traveler leaving his newborn baby behind, after a one-year journey, will find his baby to be a fifty-

year-old man. This means the returning father is now 31 years old and the son is 50 years old.

That conclusion was incredible! Every one was puzzled and amazed. "How," they retorted, "could time pass at different rate for different people?" People talked and wondered. Einstein began to be regarded as a wonder. Jokes continued to circulate. He became popular everywhere.

The wonder of it all is that nobody to date has been able to disprove his postulates. In fact, some of the earlier theories now got explanations and became clear. Let us mention one such case: mesons are physical sub-particles that have a life-time of less than one second – they disintegrate. But mesons reach us here from the skies. How could they manage it if their life time is that short? This was a puzzler. Yet, now according to Einstein's theory, because they travel fast, time passes slowly for them. In fact, the time lapse for the magnitude of their speed was calculated using Einstein's equations, and it was found that indeed the time according to the traveling mesons themselves is less than one second! This was a convincing experimental result in favour of Einstein's argument and it also followed that if one were able to travel at the speed of light, time would come to a stand-still. This was a revolutionary thought that opened an entirely new vista.

Einstein remains to this day a towering genius.



A towering genius

Corollary
Space-travel

"Would Einstein's postulates help us in space travel?" is the question drawing attention these days.

The theory has been shown to be valid for elementary particles-electrons and other small particles, which are indeed governed by these rules. So as their speed of travel increases, so does their mass, etc. Now if the theory applies equally to large bodies, such as ourselves, that will bring us a step closer to the possibility of space travel. Consider the following:

Mankind has been exploring space for quite some time now. What are we? What is the basic natural law that governs everything? Where does it all end? These are some of the questions yet to be answered. The search continues in every direction. Man has set foot on the moon. He has also brought back stones and soil. But he failed to detect any life or for that matter even any sign of water there.

Now just as the Earth and its moon revolve around the sun, so there are other eight planets (most of them with their moons) that revolve in the same way we do. They have their own days and nights, seasons and years. But there is apparently no life on them, and the atmospheres do not seem able to support our type of life.

But what is there beyond our solar system? Other stars have their own planets. What is it like over there? We have been using telescopes and radio wave dishes to study the nature of these

far-off places, but now we find that space travel could also be a possibility. But "how and when do we get anywhere?" is the big question. Space is so vast that even light rays take years to get from one star to another.

One set of trials conducted this last quarter of century appears very discouraging. For example, a satellite (Pioneer 10) was launched on March 2, 1972 to explore the neighbouring planets. It was forecast that eventually it will travel out of the solar system. In the event of that happening, it may travel into deep space where it may ultimately be picked up by civilized societies. In that event, a gold plaque depicting the figure of man and woman and the location of our earth and sun were placed in the satellite.

True enough, Pioneer 10 managed to move beyond the solar system. Today it is 10 billion kilometres away and continues to travel at a speed of a million kilometres a day. It is the first manmade object to go beyond the solar system, and will also manage to pass beyond the Milky Way – our galaxy – that contains the sun and millions of other stars besides. It is heading towards the neighbouring galaxy, Andromeda, and it is expected to reach a star, named Rose 248, in that galaxy after 33 thousand years.

Another satellite on a similar long journey is Voyager 2, and it is heading in the direction of Sirius, the brightest star we see in the sky. To fly past this star, it would take Voyager 358,000 years. To get to the next star on its path, Lambda Aquila, it would need a travel period of four million years. The question is: if these satellites had human passengers on board, how many

generations would it require getting there? And would we ever manage?

But Einstein seemed to weather the problem a bit. If space travelers can move fast enough, time will be shorter and they would not age that quickly. Therefore, barring any problem of acceleration/deceleration, man's dream of traveling to other worlds is not to be set aside entirely.

This opens up new horizons for mankind. Today experiments are being conducted by simulating biosphere in space and in enclosed isolated conditions on Earth to enable man to produce his own food from the plants and animals around him as he travels boldly into outer space. Thus, perhaps one day, he may reach somewhere beyond the horizon.

It is a common belief (and it seems in instances to be a fact) that there are indeed planets around other stars. But still there is no sign of life anywhere. If that is so and we are the only intelligent life in the universe then may be it is our destiny to go forth, inhabit other planets, and multiply.

Lucy and her group that lived 2½ millions years ago in the plains of Afar-Ethiopia gathering fruits and digging up roots to sustain their lives may have thought that was their destiny and that their descendents would be confined to that way of life forever. Today we ask ourselves if, though we have to toil for our daily bread, this is to be our fate forever. Would the planetary systems of the other stars be doomed to lifeless barren existence and God's miraculous creation of life remain confined in this world of ours? Or does

our existence have a meaning transcending the trivialities of our common life? We the descendents of Lucy have managed to get thus far today; and then who knows what the future may still hold in store for us?

Chapter 2



Wernher von Braun

1912-1977

Research and the moral question

"Research is what I'm doing when I don't know what I'm doing."

The misery and suffering that World War II brought upon mankind is immense. The former Soviet Union alone lost 20 million people. England, France and several other countries have been subjected to the horrors of the Nazi Regime prior, during and for many years after WWII. All in all no less than fifty million people have perished. About 100 million have been maimed.

The extermination of the Jews was especially horrendous. Under the pretence of giving them work, they were rounded up from various cities and towns and were then gassed. About six million of them have perished in this war. Now it is obvious that the German Nazi leader Adolf Hitler was responsible for all this devastation and crime. Of course, Japan's monarch Hiro Hito and Italy's Fascist leader Benito Mussolini were his collaborators in organized genocide. Ethiopia, it will be remembered, was one of the early victims of this world war as well.

But these three were merely the political leaders. The people who actually provided the force and muscle to the war effort, who provided the necessary ammunition and other equipment to the fighting forces were the technologists and engineers. One of these engineers and scientists who played a very decisive role on the side of Hitler was Wernher von Braun.

It was the rockets designed and constructed by

this man and his subordinates that brought destruction to several English and other European cities and towns. It was these that spilled the blood of children and other innocent victims in their own homes. What did von Braun think of it all in retrospect? Did he express any regret? Did he spend any sleepless nights? The answer happens to be in the negative.

Wernher von Braun was caught by the Allied Forces and carried off to the United States. There again he applied his talent to develop the same weapons for the US Military. However, the war was won, peace was established and America turned its attention to space exploration. At this point, it was the former Soviet Union (later engaged in Cold-War with the West) that started the race rather dramatically by launching the first man-made satellite to earth orbit and von Braun became indispensable. He built various rockets, improving them at every stage, and it was finally his rocket – the huge Saturn rocket, that carried man to the moon.

Now considering the sum total of his activities, is this man, von Braun, to be praised? Incriminated? Or, is a scientist responsible for the consequences, which his inventions and developments have brought upon people whether they are good or bad? This is a moral question.

But let us return to von Braun's history for a moment. Wernher von Braun was the son of a minister of State. His father had wished for him to become a diplomat like himself and was sad when he learnt that the boy had decided to study engineering. "A Noble man should choose to be a lawyer, a judge or an administrator but not a

mechanic," grumbled the disgruntled father.

Von Braun was rather a weak student in his early days. He did not do well in physics and mathematics, which was cause for concern regarding his future. But, as destiny would have it[2], he was presented with a gift, which was a book, entitled: "rockets and space travel". He was excited about it, but could not follow the calculations to understand the mechanisms introduced to him throughout the book. So he settled down to serious studying on the subject. It has been reported that he became a leading student in his class ever since.

At the age of 18, he joined a voluntary organization called the Amateur German Rocket Society. This is a normal practice in Europe and other countries: Volunteers gather together, raise some money and organize themselves to pursue some project or any other activity that maybe worthy of interest. This could take the form of swimming club, flying club, rocket club, motoring club, astronomical society etc. Thus, some fields of activity in which the government is not interested or inclined to spend money, can be pursued by volunteer groups even by employing experts and building laboratories. This helps advancing research, in promoting vocational training, and sometimes even in developing some unique processes to enable the group to establish enterprises and factories. Ultimately, this is a contribution to the country's development itself.

Von Braun's Rocket Society was actually able to fly some rockets. Mixing alcohol and oxygen

[2] (3) No.18; (6)

and igniting it produces large quantities of gas, which if ejected through a narrow hole at high speed, pushes the rocket in the opposite direction. This is still the general principle of rocket propulsion.

Von Braun co-operated with the other scientists in the group to develop the rocket. Still a student, he managed to learn how to pilot an aircraft and accumulated various other experiences with the group. He graduated from the university in 1932 with an engineering degree whereupon he was invited to continue his research on rocketry for a Ph.D. degree. But this was not accidental or a chance affair.

Germany, which had initiated and lost the First World War, was under the obligation, according to the Treaty of Versailles, of not producing or storing any form of armament or weaponry for fear that it would yet spark another world war. Germany, which was now looking for a loop-hole in the treaty, found that rocketry – a new field of science – was not included in the list of forbidden exercises. So an engineer soldier by the name of Dornbeger was assigned by the government to develop this weapon secretly. Now Colonel Dornbeger (later General) was searching everywhere for talent and found Wernher von Braun. He approached him, persuaded him and provided him with the funds necessary to work on his doctorate in rocket research. This he did, and in 1934, Wernher von Braun was finally awarded his long coveted Ph.D. He was then assigned to continue the same work in the military.

Von Braun took on the task and immersed himself into it. He reportedly worked day and

night to develop efficient rockets; he launched them to the sky and measured the height they attained, the load they could carry and the way to guide them. By this time and since the rocket-power and von Braun's research was progressing in leaps and bounds; it became difficult to keep the project under cover.

So von Braun went about searching for a safer place to test his rockets. After a while, he spotted a protected area near a lake and surrounded by thick forests. He figured that if he shot the rockets along the length of the lake, it could travel 400 kilometres without the risk of being detected beyond the lake. So he arranged it with the government's assistance and obtained funds to build a secret military base in the area. Laboratories were constructed. Runways, oil depots and other necessary facilities were also built. This is the famous 'Peenemünde' where rockets were designed, built and launched. Needless to say, scientists and engineers worked on the project day and night, and they managed to produce results. One such experimental rocket fired along the lake traveled over 300 kilometres at a fantastic speed of over 500 kilometres per hour. It was the first man-made object that traveled faster than the speed of sound.

Von Braun now wanted to impress Hitler with his achievements. He filmed the launching site, the huge engines and the launching scene. Hitler was indeed impressed. He boasted that *"Europe and the world will be too small from now on to contain a war. With such weapons, humanity will be unable to endure it."* Von-Brawn was duly awarded his professorship.

This took place some time in July 1943. But unbeknownst to the Germans, the English had learnt of the existence of this military base, from secret reconnaissance flights and suddenly arrived in August to destroy it. It was a complete devastation.

Yet von Braun did not give up. He gathered up the remaining staff and started building an even more powerful rocket. They named it "Revenge" and worked on it to perfection. They were thus able to use it to rain bombs on Europe's cities. London was showered with 2000 explosives at various times of day and night. The English found it practically impossible to defend themselves against this rocket attack, mainly because it was built in a secret underground base and then moved about on mobile trucks, and also because these rockets traveled faster than sound, they arrived at the scene before they were detected. Each rocket weighed about 12,000 kilograms and carried *one thousand kilograms* (one metric ton) of explosives. Such a huge rocket flying to the enemy camp with such speed was really very scary.

As planned, the rockets brought terror and destruction to ordinary peaceful citizens. But did von Braun regret his actions and the role he played in the war? He wrote:

> *"With the tight press censorship imposed, the abuses of Hitler's regime were not known there. I never realized the depth of the abyss until very late and particularly after the war. I felt that while Hitler was unquestionably an aggressor and a conqueror, this put him more in a class with Napoleon than with the*

devil incarnate. However I felt that, like it or not, it was my duty to work for my country at war:" [6]

After the defeat of Germany, von Braun gave himself up to the American Forces. He and 127 rocket scientists under him traveled to the United States and again continued to work under the armed forces there.

This was of enormous benefit to the Americans. They gained the knowledge painfully accumulated over several years in Nazi Germany. Even some rockets were collected and shipped to the states. There von Braun dismantled them and explained the details of the work to the new 'ballistic scientists' of the era. Further improvements were made to these rockets and it is now commonly accepted that the late Pershing Missiles that were installed in Europe were near replica of these rockets.

Von Braun's engagement has admittedly been put to good use as well. It is understood that a rocket group under the wings of the army and navy attempted back in 1954 to launch a spy satellite to orbit, but was unable to do so because of lack of funds. When, however, the former Soviet Union launched a satellite on October 4, 1957 (Sputnik), the Western World was shocked; and the United States immediately allocated funds for von Braun to speed up his work.

Later the famous NASA (North American Space Agency) was established and von Braun duly transferred to their headquarters. There he began building huge rockets like Jupiter. Finally, he built the famous Saturn Rockets, one of which carried man to the moon. The early Saturn

Rockets weighed as much as 500,000 kilograms and were three or four storey high. He used just eight motors in tandem to lift such heavy load to earth orbit, and when he first achieved that on January 4th, 1962, it was considered a near-miracle. He was simply adored. The United States felt confident that it could make space-travel possible and the people were exhilarated beyond expression.

A few years later (in 1969), the United States managed the first moon-landing by man. It was unanimous; this was all made possible due to von Braun's talents and toils. In recognition of his achievements, he was bestowed with more than 20 honorary degrees. He also received numerous awards and presents from various national and international organizations.

It was based on von Braun's own design that Apollo 11 (the satellite that carried man to the moon) had been built with three 'stages'. The 1st stage contained food and fuel, the 2nd was the command module that housed the astronauts, and the 3rd was the lunar module that landed on the moon surface. Upon return, they left the lunar module behind in lunar orbit, then discarded the 1st stage in Earth orbit and landed in the 2nd. The total weight of the three stages was 40,000 kilograms. The rocket (Saturn 5) that carried up the satellite was 100 meters high and weighed three million kilograms. This project alone cost the United States 24 billion dollars.

It is difficult however, to estimate how much resentment and hatred has been bestowed upon him by the millions of people whom he subjected to misery and death through the successful

launching and subsequent ravages from his German V-1 and V-2 rockets. He was repeatedly asked about his role in the war and the remorse he felt (if any). Even 20 years later, his stand was unshakable. He wrote:

> *"What is a man's duty, who loves his native country, sees that it has fallen into evil hands, but also that its very survival is at stake? --------- quite a few of my German friends and relatives who fought in World War II won some of the highest decorations in combat. Yet several of these same men were later executed for their part in the abortive attempt on Hitler's life, while the rest kept fighting the external war. All of them undoubtedly thought they were just doing their duty ---------- I thought and still do, that under the circumstances, I did what was my duty."* [6]

Is this argument right or wrong?



Wernher von Braun – 1970

Corollary
Rockets

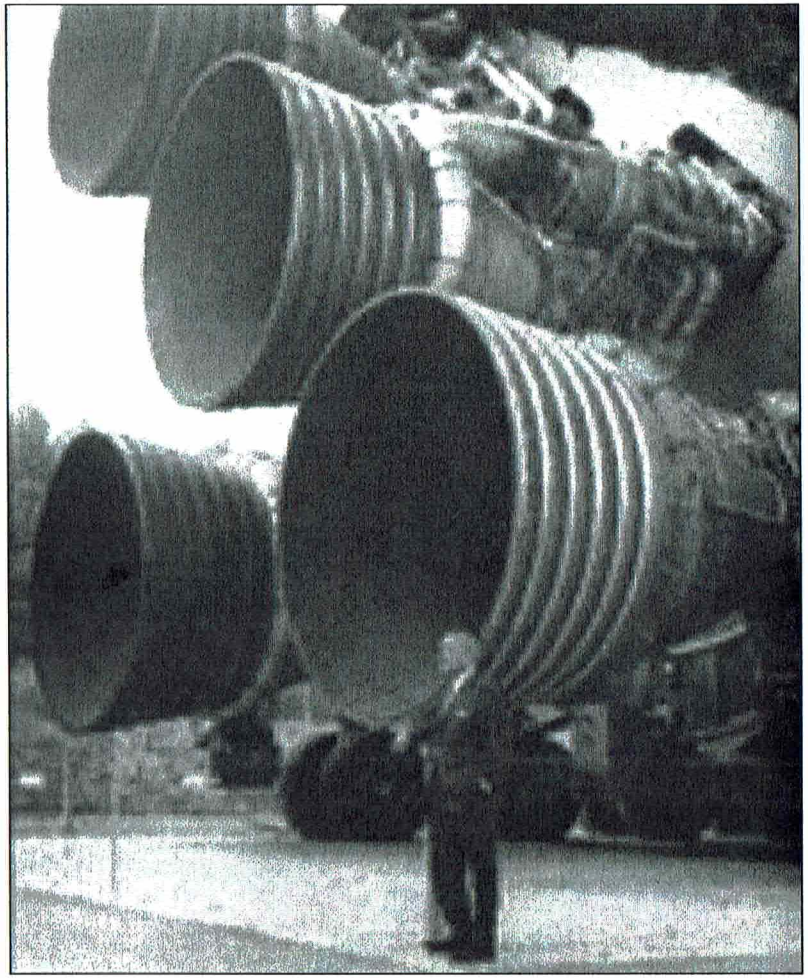
Rockets operate more or less on the same principle as jet airplanes. The jet uses pure kerosene for fuel. When this fuel is mixed with ordinary air, which is sucked-in and compressed by the motor, the mixture, upon ignition, explodes, producing gas and steam under very high pressure. Now this is allowed to escape backwards through a 'jet', and this causes the plane to be 'propelled' forward – thereby the name: "Jet Propulsion".

A rocket differs from the jet mainly in that it has to carry along its own fuel and air since when it travels in space, it cannot find any air to activate the propulsion in outer space. So it usually carries chemicals and oxygen cylinders with it.

A rocket journeying into space, or around the earth as a satellite, requires to reach and maintain a high traveling speed (as high as, or more, than 28,000 kilometres per hour). To accomplish such a feat it requires a lot of energy to lift a rocket and accelerate it to the necessary level of travel speed. The trick is to build the rocket in three parts. The first part lifts it from the ground and takes it up to a certain height, then drop off or burn out in the atmosphere. The second part takes over and with the now reduced total weight of the satellite and thinner atmosphere can push it up considerably farther. It then falls off too, and the third stage can easily get the satellite to the desired speed and height.

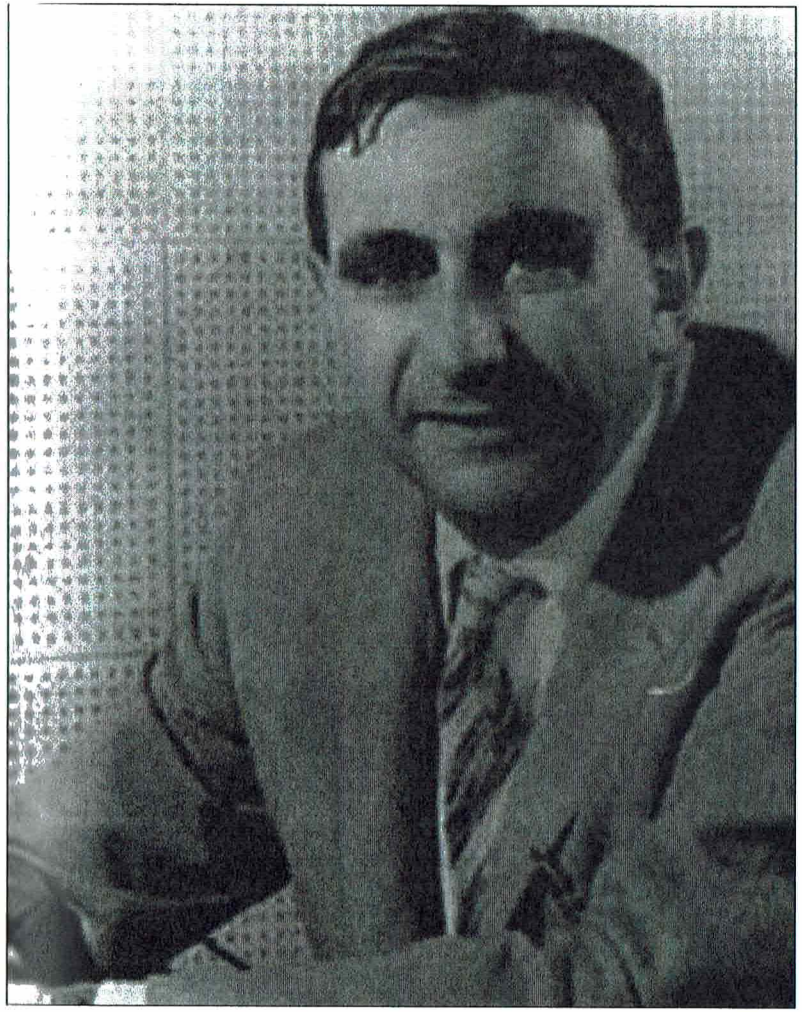
The rocket fuels (liquid oxygen and liquid hydrogen or a combustible chemical) are placed separately in large tanks and brought together through pipes into the ignition chamber where they are used. The combustion of the mixture produces huge amounts of gas, which, as we often see on television when a satellite is launched, gushes down to earth as it pushes the satellite up.

As additional force to help boost the satellite, two solid fuel rockets are installed on either side of it. Solid fuel can provide very powerful thrust, but has the disadvantage, when compared to liquid fuel, of not being easily switched off or closed down so that it is not reliable for sustained use. On the other hand, liquid fuel is so easily combustible that it can not safely be kept indefinitely in missile engines; and in time of need (say war) there is no time to refuel these missiles; so for such rockets it is always the practice to use solid fuel. Thus, there are different kinds and sizes of rockets in the world today.



Von Braun beside Saturn SC-1

Chapter 3



Edward Teller

1908-2003

Peace and the atomic bomb

"My experience has been in a short 77 years that in the end when you fight for a desperate cause and have good reasons to fight, you usually win."

Some people are just lucky to find themselves at an opportune moment in History. But then, rather than stand witness to some critical events unfolding on the stage of history, they manage to play an active role, to become actors themselves and change the course of history one way or another. Edward Teller was one such people. In order to grasp the picture of the various circumstances that propelled him to the front, it is necessary to go back in time and note a few things.

Mendeleyev had previously charted the periodic table and according to that chart, the last element on record (the 92nd) was uranium – the last heaviest element.

At that time, in their never-ending efforts to acquire more knowledge about nature and natural forces, the scientists tried to introduce forcibly, the known atomic particle (proton) into a uranium atom to see if they could build the 93rd element. They did not succeed. That was because they could not manage to produce a proton of sufficient kinetic energy (speed) that could dig its way into the heavily charged uranium atom.

But just a short time earlier an English scientist (by the name of Chadwick) had discovered that an atom comprises not only protons and electrons, but also contains a neutral

particle, which he called neutron, in the nucleus of the atom.

And because a neutron has no charge of its own and therefore cannot be repelled by the nucleus, scientists found it possible to get into the uranium atom via the unresponsive neutron. It was the German scientists who tried it first. But when they analyzed the results, they found that instead of building a 93rd element, the atom had simply disintegrated into smaller parts! The scientists were not prepared for this kind of phenomenon; and puzzled by it, simply announced their discovery to some of their colleagues.

This was the secret behind the atomic bomb; and the period was the eve of the Second World War.

This work was later repeated by other scientists to check the earlier findings. It was true that the atom did split. Calculations showed immediately that there was energy release in the break-up. Of course, the amount of energy so released by only one atom is very minute. But considering the number of atoms contained in say, one kilogram of material, the energy total of these atoms is enormous – even earth shattering (literally). What actually happens in the process is this: the neutron, upon penetrating the uranium nucleus, causes it to break up into two smaller particles and release two neutrons. These again enter neighbouring atoms releasing four other neutrons. These, in their turn, go on and release another eight, etc. The process continues until all the atoms are covered, and the total energy thus made available is simply colossal. Obviously, this

process can produce a tremendous explosion. When European scientists realized this fact, they became terrified. If German scientists built such a bomb, Hitler could not be stopped. He would bring the world under his thumb!

Jews of those times were being harassed and harshly treated by the Germans, so that the scientists and many other Jews who could, were leaving the country and seeking refuge in the rest of Europe and in America.

In Britain, it was two such refugee scientists who first realized the possibility of making a bomb.

In America too, it was the refugee scientists who had fled from Hitler's terror who came to learn of it, designed the weapon and finally built it. Edward Teller was one of them.

Teller is a Hungarian Jew by birth. He had come to Germany to pursue a higher education and to obtain a doctorate degree. Upon completion, he had stayed on to teach at the university. Then when anti-Jewish sentiment got worse and worse under Hitler's government, Dr. Teller simply moved to the United States in 1935 and took up a teaching post there.

When Hitler started invading neighbouring European countries, Edward Teller rightly shared the fear of his fellow scientists. Unfortunately, America had not yet joined the war then, and the project to build the bomb would require millions of dollars (actually it took 15,000 million dollars to complete it). So how would they persuade the government to allocate so much money to a war-effort in which they didn't participate at that time? Besides, Edward Teller and colleagues were

foreigners. In fact, in Britain, it was forbidden to employ foreigners and to let them delve into such sensitive issues. Professor Joseph Rotblat's situation is a case in point. He was a prominent scientist and later a Nobel Peace winner (1995), and even sometimes represented Britain leading delegates to other countries (he was this author's lesson supervisor and external examiner). But he was not allowed to work on the atomic project. His specific request to serve in his capacity was decidedly turned down. He was born of polish parents. He traveled to Britain seeking higher education, but when the war broke out, he was forced to remain there.

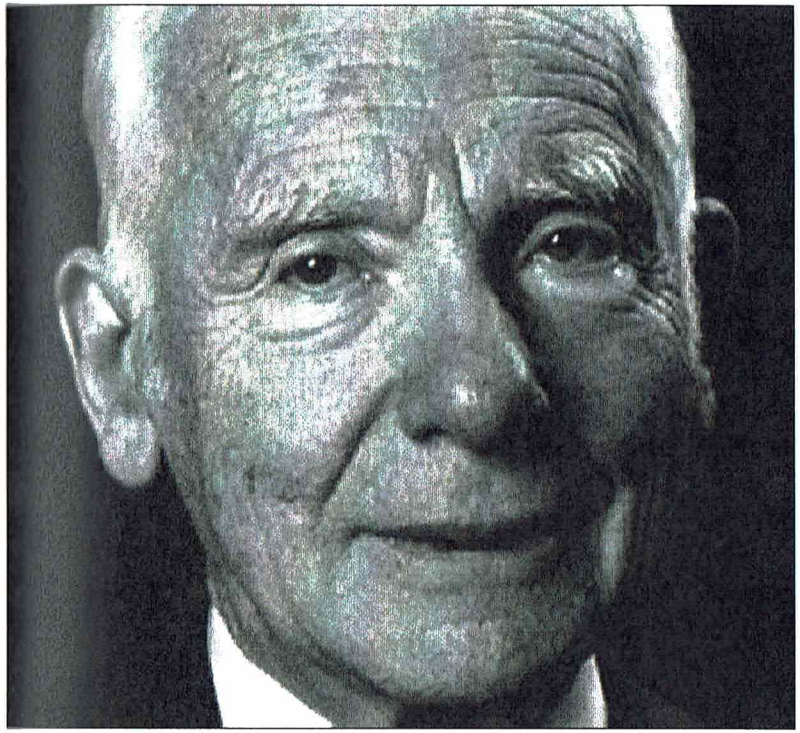
So, to get round this problem, Edward Teller in America devised a plan with fellow scientist Szilard (who actually suggested the idea first) to get the famous Albert Einstein to write a letter addressed directly to President Roosevelt himself and to warn him of the impending danger.

Edward Teller and company went straight to Einstein's residence and managed to persuade him to write the letter. This was done, and the president was convinced. The project had begun!

A short list of scientists recruited to kick off the research included Edward Teller. So he picked up his bag, greeted his family, and left for the project site. Soon Joseph Rotblat and other promising British scientists came to join them, and the work started full-speed ahead.

They worked day and night. This was an urgent task. It concerned freedom of mankind and world peace. The threat was that if Hitler got the bomb before everybody else, he would use it to conquer the world or to destroy it in the

attempt. They noted that all publications concerning uranium had been suspended. "Why?" they asked each other. One can not help wondering how they noticed a missing item out of all the multiplicities of publications in the scientific field. To follow up on any number of publications on a daily basis is in itself difficult, but to be able to notice what is missing demands alertness. The Germans, once they had discovered the 'secret', had forbidden any further publication on the subject. Soviet Union and France had done the same. So everyone had been the wiser somehow. Hence the urgency to complete the task and own the bomb before everybody else did. It was usual to work 18 to 20 hours a day. Race and nationality were not of great concern in America. Everybody who could join was invited to participate. That was how Joseph Rotblat and company came to be included in the project.



Professor Joseph Rotblat

At last, the bomb was ready. It was given field trial on July 16th, 1945 and it was perfect! There was jubilation and even ecstasy among the scientists present. They had indeed succeeded in unleashing the energy out of the atom. The quantity of uranium utilized in that test was a mere one kilogram. But the energy released was equivalent to that of seven million kilograms of coal in the kitchen stoves. Indeed the scientists deserved to congratulate themselves for their insight. But the purpose for this exercise was not to be set aside by the politicians. Two bombs were

dropped on Hiroshima and Nagasaki (Japan) and that, of course, ended the war immediately.

Edward Teller, however, was not to settle for this. He decided to build an even more powerful bomb. So he went around convincing colleagues. He then started an open campaign to get as much priority for the Hydrogen Bomb project as for the previous one.

Initially he was met with some strong objections. The scientists having witnessed with horror what the explosions caused to Japanese cities and citizens found no justification in constructing yet another more powerful bomb. There were those who had retired even before the atomic bomb had been completed when they had seen the trend of the war and the inevitable collapse of the Hitler regime (e.g. Joseph Rotblat who partly on the strength of that action recently won his Nobel Peace prize). So Teller began to be regarded as war-monger.

But he did not give up. He decided to go at it alone if necessary. At this juncture, the former Soviet Union conducted its own test of Atomic Bomb explosion. It too succeeded in making it!

And tension rose again. To make matters worse, it was revealed that some of the scientists engaged in these secret projects were actually sympathizers of communist Soviet Union and quite a number of them were spies! These latter ones were apprehended and their actions confirmed. They had already sold secret documents to the 'enemy'. This caused fear and worry. The Soviet Union would not stop at atomic bomb but would go on to make the more powerful Hydrogen Bomb.

This clinched the argument; Edward Teller's claims were paid attention to, and the work on the development of Hydrogen Bomb went ahead in earnest.

Yet, what is the theory behind the working of the Hydrogen Bomb? The key to the answer to this question came from the sun. Not long ago, it was a quandary; how the sun could pour forth such an enormous amount of heat and what is the mechanism behind such an outpour of energy? The sun emits energy into space at the rate of 90 trillion times trillion calories every second!

It has continued to do so for the past five billion years. Why is it not exhausted or at least weakened in power over such a long time? This riddle was solved in or about 1938. 80% of the sun's composition is hydrogen. When two hydrogen isotopes are forced to fuse, the two of them will make one helium atom. When one helium atom is compared to two hydrogen atoms, there is a loss of weight. Where is the missing part gone? It is now understood that the 'missing part' has been converted into energy in the process of fusion. This is a lot of energy. If one kilogram of hydrogen atoms is fused in this manner, the amount of energy obtainable is equivalent to that of burning 3 million kilograms of coal.

It became immediately obvious, therefore, that if we could manage to fuse hydrogen atoms in the same way here on earth, we could benefit from a lot of available energy. When one realizes that hydrogen is extractable from water and that water is readily available even in poor countries, it is

very tempting to try and develop the technology to tap this source of energy. This possibility was discussed with enthusiasm in various countries. It is recorded that at one time, a Russian scientist (by the name of Gamow) presented this possibility to a group of authorities, whereupon Bukarin – the mayor of Moscow – jumped up and offered him the use of the electric power station for Moscow every night. Gamow declined the offer on the grounds that even the electrical energy output of the entire country could not suffice to produce the heat requirement (of hundreds of millions degree centigrade) to facilitate this fusion experiment.

This was the very problem with which Edward Teller was wrestling. But when the atomic bomb was built, he realized that this part of the fusion problem had been resolved. The heat released in the process of atomic explosion was sufficiently high to enable hydrogen atoms placed therein to fuse together thereby releasing even more heat and explosion.

So it was clear now that who ever managed to build the atomic bomb could also build the Hydrogen Bomb.

Edward Teller's ambition and urge was to build the bomb ahead of the Soviet Union. To that end, he traveled the width and breadth of the country to recruit capable young scientists from various colleges. He then established the laboratory and set every one to work.

Today Edward Teller is recognized as the "father of the Hydrogen Bomb". This is not only because he was the instigator and the spirit behind the work, but also because it was he who

first arrived at the way the thing could be made while expressing his findings mathematically so that other scientists or even lay persons were able to understand and be convinced enough to launch the project.

The Bomb was finally made and assembled. It was tested on November 1, 1952 on an island called Elugaleb and to the surprise of every body; the island disappeared into the ocean. That explosion had a force of 15 megaton of T.N.T., which is 750 times more devastating than the Atomic Bomb.

Edward Teller had, at last, fulfilled his ambitions. But then the Soviet Union too demonstrated its capability by exploding one of its own on 12-8-1953. Thus was created the balance of power, and the so-called Cold War started.

Of course, one cannot convincingly argue that, had America not built a Hydrogen Bomb, the Soviet Union would not have done so. Building the Hydrogen Bomb seemed a natural step after the Atomic Bomb. In fact, research on both fronts was being conducted simultaneously. That apparently saved development time.

What was not obvious at that time was that so many bombs would be built in the following few years to the point of presenting a threat to civilization and even human existence. Both United States and Soviet Union competed with each other in making the bombs and loading them into missiles. On each side, airplanes armed with the weapons always stood ready for combat. Ships and submarines treaded the oceans – poised to send their missiles at any time into enemy targets. This build- up was so intense that

by 1970s the number of explosives was said to be sufficient to wipe out human race seven times over.

So whenever regional crises erupted anywhere and the two Super Powers took sides, there prevailed in the world tension, fear and worry.

Now what can be said of the role of science in this? If there are scientists, who would refrain from basic research for fear that it would lead to such a crisis, then their number must be few; and even these must be having faith in other scientists.

But Edward Teller had remained steadfast in his conviction; that America must stay ahead of the Soviet Union and it should be ready to sacrifice anything to that end.

That was why he again brought up another idea in the 1980s to shock the world. In his capacity as scientific advisor to President Ronald Reagan, he persuaded and convinced the president to launch another build-up in armament under the name "Star Wars". It was this new race that scared the world and prompted millions of people in Europe and elsewhere to stage public demonstrations in the 1980s.

What was the idea behind "Star Wars"? As presented by Teller, the idea was to strengthen the defence system against in-coming enemy missiles. If, say, World War III started, then bomb-laden missiles would start rushing towards the enemy camp. The intention was to intercept these missiles in their tracks and burn them up. One of the mechanisms suggested was to load bombs into satellites. When the bomb was made to explode, the immense radiation out-put was

then directed by lenses or reflecting mirrors focused and directed towards the enemy missile. Lasers are known to be powerful cutting tools, so that if, say, x-ray lasers are directed towards missiles they would burn them into cinders instantly. Another alternative was to send up laser beam from ground base and arrange a reflector on a satellite so it could be re-directed towards its target. It would be easy to manoeuvre the mirror to target any object anywhere. Missile trajectories are classified into three different phases, and the defence mechanism varies accordingly.

The initial phase is when the missiles are starting from their bases and climbing up. Here the laser beam will be employed. The missiles are most likely the MIRVS (multiple independently targetable re-entry Vehicles) which carry up five to ten independently targetable missiles and once in space, send them in different directions. It is intended to destroy the MIRV before it releases the missiles.

Enemy missiles, that manage to pass through this phase, will be tracked in space and blasted out with missile bombs at a distance between 500 and 1200 kilometres away. If any missiles still manage to get through then hunter rocket can be sent up where upon reaching its target will spread out its special net to make certain that it will not miss it – thus diverting its direction and destroying the target. Other special rockets are also designed to shoot at the target and destroy it at a distance of 10, 100 or even 800 kilometres away. By this means, Teller believed he could put full proof anti-missile screen around his country

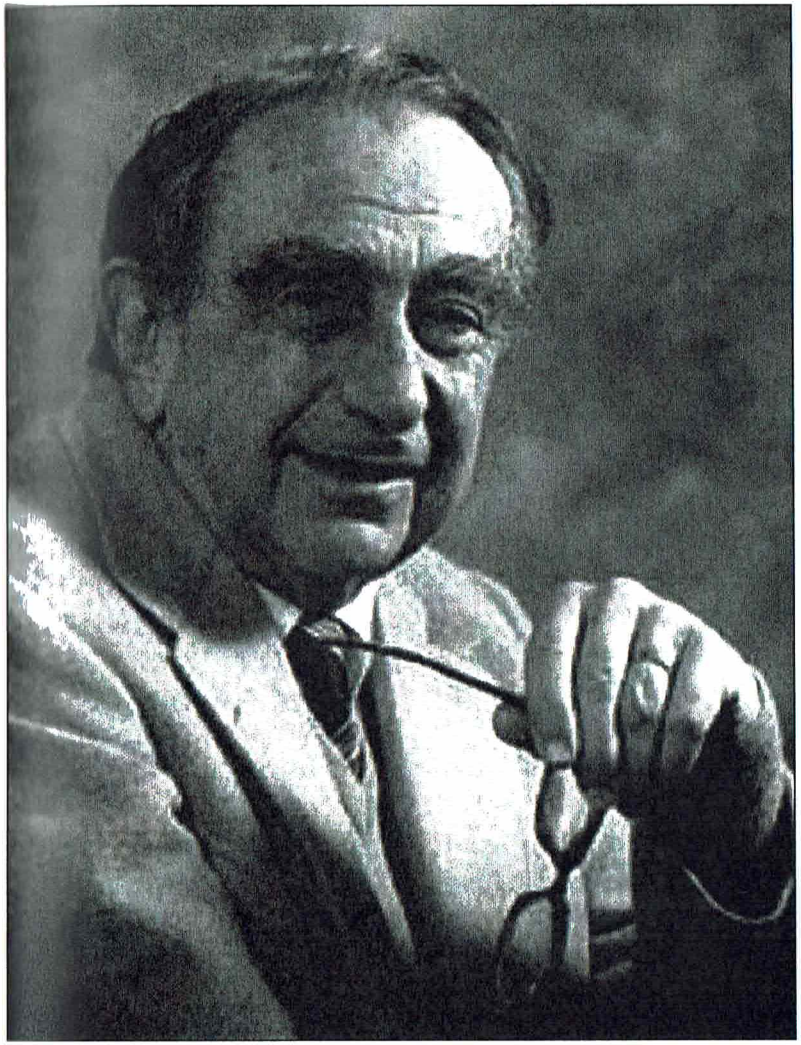
and other allies.

This project, at the start, required 60,000 million dollars. This clearly is a lot of money, which if applied to developing some regions of the globe could do a lot of good. But Edward Teller never listened. He was adamant that the project should go on.

Of course, the Soviet Union could not ignore this development. It too had the duty to protect itself and its allies, thus the pressure on the USSR was immense. Its economy could have been seriously strained if it attempted to answer tit-for-tat.

At any rate "perestroika" started in the Soviet Union. It then spread to neighbouring countries and very soon, "The Iron Curtain" collapsed. Western-style governments sprouted everywhere, and the threat of nuclear war subsided at least for the moment.

It is difficult for me to argue that these two phenomena are "cause -and-effect"! However, I think History is yet to judge Edward Teller and his role in the drama of this last half-century.



Edward Teller

Corollary
Thermo-nuclear energy

Edward Teller is recognized as the Father of the Hydrogen Bomb mostly because it was he who formulated the method and showed the way to go about building it. The fact that the fusion of hydrogen atoms does yield energy out-put has been known for quite some time. The sun emits radiation energy at the rate of 379 $x10^{21}$ Kilowatt every second for the last 5 billion or so years. It has been doing so by just this method of fusion of atoms. What is required is to create sufficient pressure and temperature to force atoms to come together and fuse. The sun, by virtue of its enormous size (it is larger than the Earth by a million times) has sufficient depth and pressure to accomplish this, the temperature at its core is estimated to reach 15 million degrees centigrade.

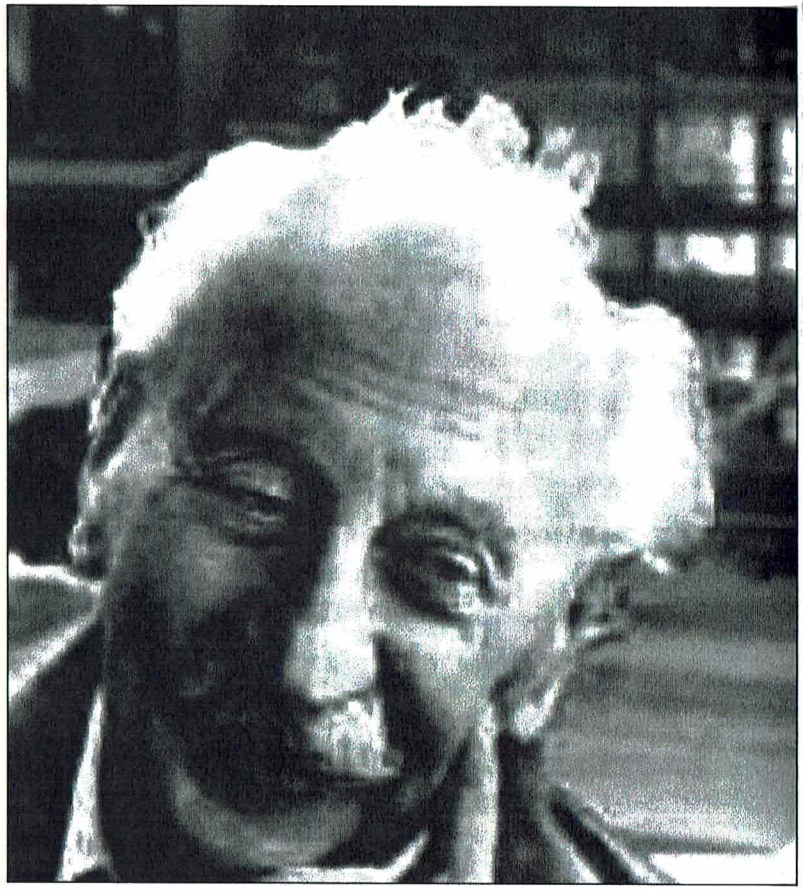
The problem with us earthlings is that we can not create these conditions here. Of course, it has been possible to explode the bomb. That could be achieved temporarily by using an auxiliary exploding device to initiate it. But to obtain a sustained output for peaceful use of the energy has not been possible yet. The benefits to accrue from fusion power are indeed very tempting. We have mentioned earlier that one kilogram of hydrogen when fused completely can yield an energy output equivalent to that of burning three million kilograms of coal. Besides, hydrogen is available in all the waters of the rivers and seas.

But the problems, associated with the production and containment of such energy, are

not easily surmountable. To begin with, one has to produce heat measuring in millions of degrees. May be here superconductors can aid a lot. However, how to contain this plasma? Under this temperature, containers themselves melt away or at least reduce the temperature. The trick to get round this problem has been to use magnetic forces to rotate the plasma charges round and round and thus avoid containers. But the history of fusion experiments so far only reveals that as one problem is solved, another one pops up immediately.

Nowadays laser beams are increasingly being used to bring the gas under high pressure and temperature and some promising results have been achieved. The sustainability and profitability of producing energy by any method tried so far is a big question. The struggle continues though, and perhaps by the first quarter of the 21st century, we will reap the fruit of the labour of our scientists and engineers.

Chapter 4



Abram Ioffe

1880-1960

Cultivating the young generation

"Absence of evidence is not evidence of absence"

The Scientists' great challenge and endeavour is to study the unknown, discover its behaviour and reveal it to the public. To discover a new thing through one's own effort is a source of great satisfaction. To publish findings for people to read and to understand and then to be able to make use of it gives the scientist, I think, the justification for having existed.

Many a time, famous scientists are appointed to be directors of research centers. That is intended partly so their fame could rub onto their subordinates and onto the youth, who then would be inspired and encouraged to take on further challenges. But of course, not-so-famous scientists could also be recruited for the top job. This could be because of their talent and ability to inspire others to get results.

Basically, it is a prerequisite to cultivate young scientists if science and technology is ever to take root and flourish in the country. Educated man-power is the essential wealth of any country, and to develop this requires close attention and planning.

Abram Ioffe was one of those far-sighted scientists who laid the basis for science in the former Soviet Union. He may not have been a shining scientific discoverer himself and he is known mostly in the East. This, in part, may be due to the polarization of East and West, but for our purpose, I believe we can learn a lot from the

strategies which he devised to train scientists.

In the former Soviet Union as in other countries, it is a great honour to be nominated a member of the Science Academy. Abram Ioffe was not only able to be a member himself but also managed to qualify his students to achieve results so that 15 of them were made full members and another 30 of them reached the status of associate-members of the academy. The question is 'how did he manage it'?

Ioffe was a simple director of a faculty in the polytechnic institute of the former Leningrad (now St. Petersburg).

The lessons given in this faculty consisted mainly of physics, mathematics and engineering. It was Ioffe himself who laid the groundwork for the establishment of this faculty. He then carefully selected talented lecturers to teach even the newcomers (usually called 'Freshmen'). Some of the courses, he handled himself. He was of the conviction that one has to lay the groundwork very carefully in order to reap good harvest. So he arranged for scientists to come down and work with junior students in order to stimulate them.

Students too, were not assigned arbitrarily. They are carefully scrutinized from the very first year of college to identify those with talents for theory or those gifted for experimental research.

To Ioffe it was not of much concern if such students failed to pass in some of the tests in the classes. On the other hand, he encouraged all students to pursue their research or follow their special interests in their spare time.

Researches were conducted in all different fields in his faculty. Every weekend he held a

meeting to review the week's progress (this is a routine practice in Europe). At this meeting, researchers come forward and present their achievements for the week, or any problems they encountered in their work. Besides which, popular scientific publications around the world were studied and reviewed and important topics are selected for presentation and discussion at the meetings. Ioffe always presided over all such meetings and found that he had to deal with very many topics every week. He finally summarized and commented on all of the topics under discussion and gave directives as to which subject required immediate attention and further investigation.

This approach to training has proved very useful to young scientists. Usually during the first exposure to these types of meetings, students find it hard to follow the agenda and are sometimes bored. Then they start to sense the excitement of front-line research, and as they understand the subject, they begin to be absorbed in it, and to figure out where their special interest and talent lie. This arrangement, where a broad field of activity is provided to students, gives them ample chance to find out what exactly they are good at and what they can do.

Students are also taken around to visit the laboratories and facilities available. In the days of Ioffe most of the equipment available was made by hand or in the nearby workshop. As a result, these machines were not even remotely approaching the highly refined and sophisticated instruments that we find in our laboratories today. They appeared crude and drab. Yet, that

was the only way possible to be self-sufficient as was dictated by circumstances. Everyone made his own tools or arranged to get it installed somewhere in order to acquire the necessary set-up for his experiments.

Research went on for long hours day after day. The topics that were dealt with varied from atomic physics to sound, magnetic theory, electromagnetic waves, heat, x-rays, radio engineering and many others. Ioffe in his capacity as the director of the faculty, had to direct the researches, and therefore had to follow each activity. He managed to do so, and even went further to make it his duty to present his findings in simple terms to the students so that they could grasp the essence (or difficulties) of it all.

Ioffe also made it his concern to promote relationship with other European countries in the field of science. Once he played host to European and American Scientists who came to attend a conference of Physicists Associations.

The meeting was opened in Moscow University, but was later shifted to other universities in turn. The trips were arranged carefully to include travel by car, train and boat.

In the course of the trips, playful competitions, games, jokes and other entertainments were staged. The participants found all this to be relaxing and enjoyable.

In the meantime, he made sure that promising students and young researchers had the opportunity to attend most, if not all, of the proceedings. From hindsight, scientists today admit and appreciate the fact that those events were important landmarks in the history of their

development in the profession.

Ioffe has other achievements to his credit. He believed that for science to flourish in a country, every region must be given the chance to develop; so he established polytechnic research centers in various parts of the country. Of course, the regional research centers pick their specialization and pursue that field of research rather than duplicate other works. So if one center was studying radio engineering, another one would concern itself with, say, low temperature physics, and yet another one with plasma physics etc. In this way research were carried out in many fronts of science.

To give a good start to each of these regional research institutes (as this is important) he transferred the best scientists from his Leningrad staff to one or the other of these new centers. These scientists took on the challenges of their assignments and persevered to achieve results. For this purpose, they had to recruit promising students and train them in the discipline. Thus, they each served as nucleus around which training of scientists and development of research activities sprouted and flourished.

That was how Ioffe and his Soviet Union laid the ground work for the speedy development of science and technology.

Finally, one lasting contribution for which his country owed him gratitude is the establishment of laboratories for research in nuclear physics. He took a firm stand (for which he was later to be blamed) that research and development in this field is something one cannot ignore at all.

So having to start from scratch, he went

around visiting some laboratories and persuaded the leading scientists to switch to nuclear physics. He then arranged for his former student, by the name of Igor Kurchatov, to re-arrange his laboratory and make it a center to co-ordinate the works of the others.

He then convened a special conference in which they collected and reviewed all the known publications in this field. Realizing where the world was heading, to convince his colleagues as to which direction their field of research should take, became easy for him.

As a result, the country was able, in a very short period of time, to catch up with the rest of Europe. Thus, the basis for the development of science had been firmly laid down.

It turned out though that not all scientists had given him support in his endeavour. In fact, he was discredited a few years later. At a congress of the Soviet Science Academy held in 1936, Ioffe was publicly censored and scorned for having wasted precious money on such unimportant projects. The congress was advised that Ioffe had caused a lot of money to be squandered and had wasted the time of several professionals by tying them down to useless laboratories that he had established at his own fancy.

However, it became clear later that when the Second World War broke out, and the United States and Germany were readying to build the Atom Bomb, the Soviet Union would have remained helplessly and hopelessly behind had it not been for Ioffe's foresight. Without trained man-power and without any laboratory, it would have been too late to start and achieve anything.

Things were made worse when sanctions were imposed on this type of research later during the war and after. So after the Hiroshima and Nagasaki bomb explosions that brought the Second World War to an end, the threat to eliminate Communism together with Nazism would, they say, have definitely been carried out. Considering the deep hatred that the then British prime-minister Winston Churchill had for Communism and later the doctrine of McCarthyism that prevailed in the United States, it was certain that an attack on the Soviet Union was inevitable and that, to them, would have been disastrous. Soviet historians later acknowledged Ioffe's efforts with gratitude.

It was thanks to his efforts that qualified labour and laboratory were already available and so his team of researchers was able to carry on and build the Atomic Bomb in time. When America came up with the Atomic Bomb in 1945, the Soviet Union followed suit in 1949. Again, when America built the Hydrogen Bomb in 1952, they did too in 1953.

The man responsible for achieving this feat is Igor Kurchatov – one of Ioffe's disciples. He was so dedicated that he searched the laboratories, recruiting capable people; organized and directed the job, secured the necessary budget from the government and did all the right things to finally get the job to completion in the nick of time. He is now recognized as the 'Father of the Atomic Bomb' in the East.

The primary mover in all these fields of activity is Abram Ioffe. Many of the famous scientists that wrenched the country out of backwardness and

propelled it into a super power status owe their achievements to his training. Alikhanov, Kikoin, Alexandrov and Artsimovich are just a few of the several scientists that reached the summit of fame in the country. As mentioned earlier, 15 of his students got to be members of the prestigious Science Academy and about 30 of them became associate members. Some of them were even presidents of the academy, and still some others had research centers named after them.

Thus, it was Ioffe who laid the foundation for progress. He organized and developed science and technology in the country. Just like sports coaches tour the country looking for talented sportsmen, pick them up, train and get them to win world records, Ioffe went around looking for talent among the young, then trained them to be scientists and enabled them to achieve results. He played a major role in helping raise the country to a 'super power' status, whereby the 'balance of power' was restored in the world and peaceful competition was made possible in such fields as space travel, nuclear energy and computer technology for peaceful purposes. This is no mean achievement on his part. The current situation in his country is of course a consequence of the political trend chosen and followed rather than of lack of training in science. Today it is more than ever clear that if we have to take our societies out of superstitious beliefs and into the scientific way of thinking, and if we have to develop Science & Technology to the present day world standard, there is no other way for us to proceed than to train and engage our man-power wisely. The problems third-world countries face today are

more or less the same as what Ioffe then faced in his country. For example, the standard of education (especially in Science) is very low and laboratory wares (even the simple ones) are most of the time imported using hard currency (if and when available). The technical know-how is so limited that even simple know-how's in industrial processes remain hidden in foreign hands (patented or licensed etc.).

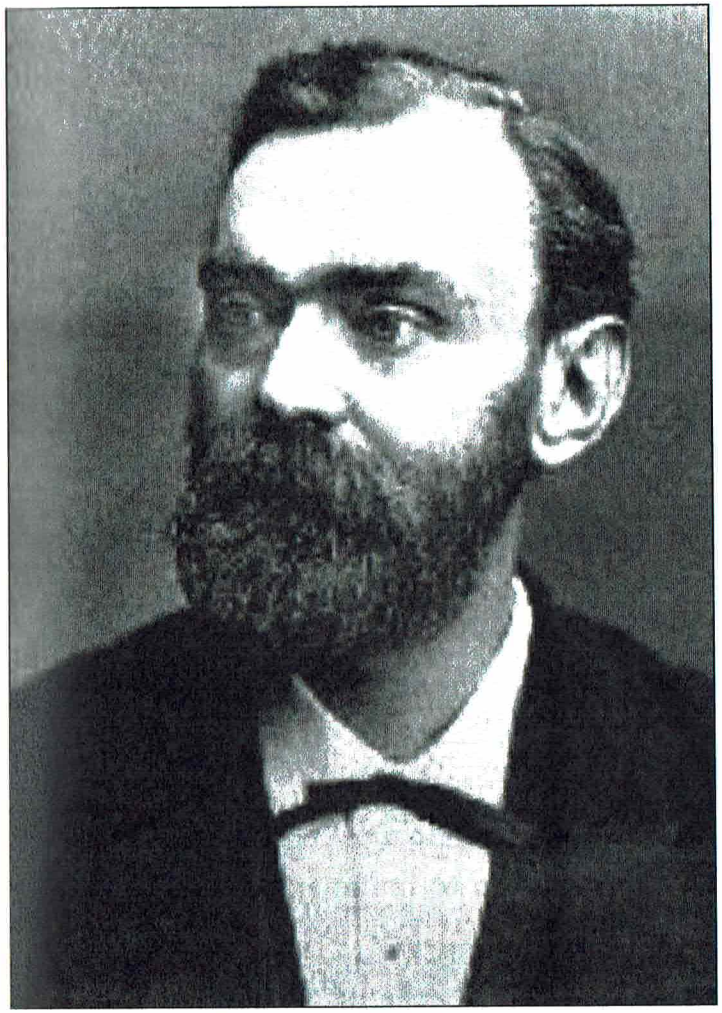
Today, it is regarded that in the United States, the depth and breadth of Science and Technology among the population is so low that it is said to be alarming. Well, what can we say of these other countries?

In this regard, it is indispensable that we have to improve the standard of education; the whole depth and breadth of it. Specifically, science & technology courses should be of high concern in both Elementary and Secondary schools! And also, conditions should be made favourable for maximum utilization of the creative power of citizens and the development of their science culture. Leading scientists of the calibre and devotion of Abram Ioffe are very essential for, among other things, selecting appropriate foreign technologies and introducing them into the country, and for devising a balanced self-supporting scheme of development in which the youngsters could be stimulated to participate effectively.



"The main scientific achievements of Ioffe relate to crystal physics (electrical, photoelectrical and mechanical properties) and X-ray structural analysis. As far back as the beginning of the 1930s, Ioffe settled on studies of semiconductors. This field has become one of the leading directions of research at the Ioffe Institute."

Chapter 5



Alfred Nobel

1833-1896

To make up for the damage

"If I have a thousand ideas and only one turns out to be good, I am satisfied."

When Nobel's name is mentioned, what usually comes up in our minds is the famous Nobel Prize. This prize has now reached beyond the million Marks in dollars, and is always the scientists' dream, since winning it guarantees him or her with the recognition and fame for great achievements.

But what sort of person was this man Nobel? How and why did he establish the Prize-awarding institution?

Nobel, to start with, was a Swedish citizen born into the upper class society. His father was an inventor and an engineer. Formerly he was a building contractor, but his business collapsed in 1833. Nobel junior was born in the same period

The father tried his hand at various odd jobs to recover past fortunes, but it was of no avail. Finally, he decided to build an armament industry. He tried to make explosives to sell to the army. But again, he was not successful so left the country and went to Russia.

The Russians received him with open arms. The minister of defence immediately recognized the importance of this man's works and made arrangements for him to get the necessary funds to establish the factory. So it turned out that when Russia went to war against Turkey in 1854, it was the anti-tanks, guns and other

ammunitions supplied by this factory that played a decisive role in Russia winning the war.

As a result of the demand and market opening his products created, Nobel Sr. became very rich. Having thus decided to expand the business even more, he re-invested all of his gains into the project. But unfortunately for him, the war ended abruptly and his services were no longer required. Nobel Sr. became bankrupt again.

The junior Nobel grew up through all these ups and downs. Later when he returned with the family to Sweden, he too started doing further research on explosives. He figured that if they could put to practice what they had learned from their investigations and experiences in Russia, the family could manage to stand on its feet again.

So, they rented a house and began experimenting again. But they did not seem to master all the intricacies of the art or science of it. In the course of one experiment, the material at hand suddenly exploded. It was so violent an explosion that the house collapsed, the technicians died and Alfred's little brother too, was killed. The father went insane and remained thereafter a sick man.

The government reacted immediately by forbidding any future experimentation with explosives in residential areas including even transportation or storage of the same. The neighbours and the people at large all hated the members of the family for the so called 'dirty work' in which they were engaged.

But Nobel Jr. had no intention to retreat. Of course, he was physically a weak person. He was

also poor in social relations and remained a lonely and aloof person. But then he was also mentally and intellectually gifted with fierce determination and courage to pursue his goal alone. So he hired a boat, went out to sea and proceeded to carry on the experiments by himself.

By this time, Lady Luck turned her gaze on him. He discovered that glycerine when mixed with nitrate salts was a good and somewhat reliable explosive. So he took out a patent in his name and started mass-producing this liquid. His product was then used to crack open rocks in quarries and also to dig tunnels through mountains and hills to lay railway tracks. So Nobel became successful and rich again.

Later still, realizing that this product in its liquid form is not prone to easy transportation and storage and is also liable to occasional explosion (as did happen a few times), Nobel proceeded with further research and experimentation, finally obtaining a solid product. He named this version 'dynamite'.

Now this was 'hot cake' on the world market. Soon, he established factories in Germany, United States, Britain, France, Italy and scores of other countries. And when World War I broke out, feuding parties on both sides were fighting each other with his armaments.

Germany in particular, had several factories that enabled it to get ample stocks. On the other hand, France, which unfortunately had earlier declined to permit Nobel to establish factory, was now without the means to produce the goods. It was faced with a crisis. However, France was able to win the co-operation of the Nobel Prize

Foundation to establish the factory in time. Its ally, Britain, which had its own factories, however, fell short of the raw material to produce dynamite, because German forces had cut off its link from the Latin American country, Chile, which was the primary source for the material. So it looked like Germany was heading for victory in the war. It was at this crucial stage that Winston Churchill was appointed Head of the Admiralty in Britain, whereupon he gathered all his forces and led an attack on German navy and won back the supply from Chile.

Now Germany faced the prospect of defeat. It appeared just a matter of weeks before it surrendered, but its scientists came to the rescue. They had earlier done some research on these materials and on the strength of that, were now capable to extract the necessary components from atmospheric air and make ammonia out of it. They made the nitrates out of this, and were thus able to continue the war.

The end result of all this fighting was that no less than 10 million people perished in the war.

Finally, after four years of bitter struggle Britain and its allies managed to prevail over Germany. This was made possible partly due to the fact that the British were able to improve over the process of dynamite production. They had managed to substitute one of the major raw materials by extracting acetone from maize crop in the laboratory. This was achieved in 1911 by a teacher called Chaim Weizman. This person, a Jew, because of this contribution to the war effort, became famous and popular among the Jewish society. He then went on to campaign for

the rights of Jews to resettle in their historical homeland, Palestine, and finally succeeded in his endeavour.

It is worth noting here, that he finally ended up as the first president of the new state of Israel, a situation that precipitated the Middle East crisis that goes on even today.

The major weapon employed in the 1st World War was dynamite. Nobel's factories were busy in the major warring countries working day and night to manufacture these weapons and arm the fighting forces on both sides of the 'front'. The revenues collected from the war ravages were from people's blood and flesh.

The contradiction in Nobel's characters and deeds is that he was personally a peace-loving person who despised war. People say that he was against any trade deals involving weapons. But his deeds stand in stark contrast to his beliefs. On the one hand, he is an apostle of peace, and on the other, a dealer of arms of destruction.

Nobel had his own reply to this. He argued that if he improved on his weapons sufficiently enough so that their destructive power is well assured, then wars will cease to be fought. If each of the warring parties fully realizes that the enemy's fire will destroy its army immediately, then no one will dare to wage war. This reminds us of the fear of assured mutual destruction between the superpowers and the resulting "peaceful co-existence" principle that prevailed during the 'cold war' period of the last 50 years or more.

Whatever the argument was, Alfred Nobel managed 355 patents registered in his name. He

was thus able to accumulate a fortune in a relatively short time. But sadly, enough, Nobel, in spite of his riches, was not a happy man. He had neither a wife nor a family of any sort. He did not have an heir. So he lived a lonely and bitter life and finally was bed-ridden. He could find neither medicine for his illness nor comfort from close friends. At last, he died a lonely death in 1896. But the will he left behind in writing made his name immortal. He had bequeathed a capital of about 33.2 million kroners (Swedish Currency) to be invested, and the profits or interest thereof to be distributed annually to persons outstanding in their contribution to the welfare of society. When one examines Nobel's testamentary requirements in detail, the award money is to be divided up into five equal parts; three of which shall be awarded to persons who made important discoveries or improvements in the fields of physics, chemistry and physiology (or medicine). The fourth award shall go to the person who produced the most outstanding work in literature; and the fifth award to the person or organization that did the best work to promote fraternity among people.

In 1968, the Swedish parliament established the sixth award fund to be provided by the national bank and awarded for Economics. This was implemented in 1969.

Nobel's beliefs and actions may still be a subject of discussions among historians, but the Nobel Prizes continue to play their role in promoting peace among people and in stimulating

scientists to make discoveries or inventions.[3]

[3] Today a Nobel award winner can receive as much as 1.12 million dollars.

Corollary
The Nobel awards

Nobel Award ceremonies are always conducted with great fanfare. The Nobel Peace award is presented by the Norwegian government while the other five awards are presented by the Swedish government.

The Nobel Prize fund was instituted in 1900 after settlement of litigation, which Nobel's relatives had brought to court in order to claim their inheritance immediately after Alfred Nobel's death in 1896.

The Board of Directors of the Nobel Prize Foundation has a duty to administer the Foundation and to nominate persons deserving of the awards.

The Board has five committees each of which has five members comprising it. There is now a sixth committee since 1969. Each committee has the responsibility to nominate worthy persons (or organizations as the case may be) in their field of research or endeavours.

The committee in the course of its duty and in the obligation to discharge its responsibility can solicit advice or recommendation from relevant sources. These could include;

a) Famous university professors,
b) Former Nobel Prize winners (laureates)
c) Parliamentarians (for the peace award)
d) Chairmen of Authors' associations (for literature) and any others.

The people invited to submit their recommendations (and any others who want to express their wishes) should do so before

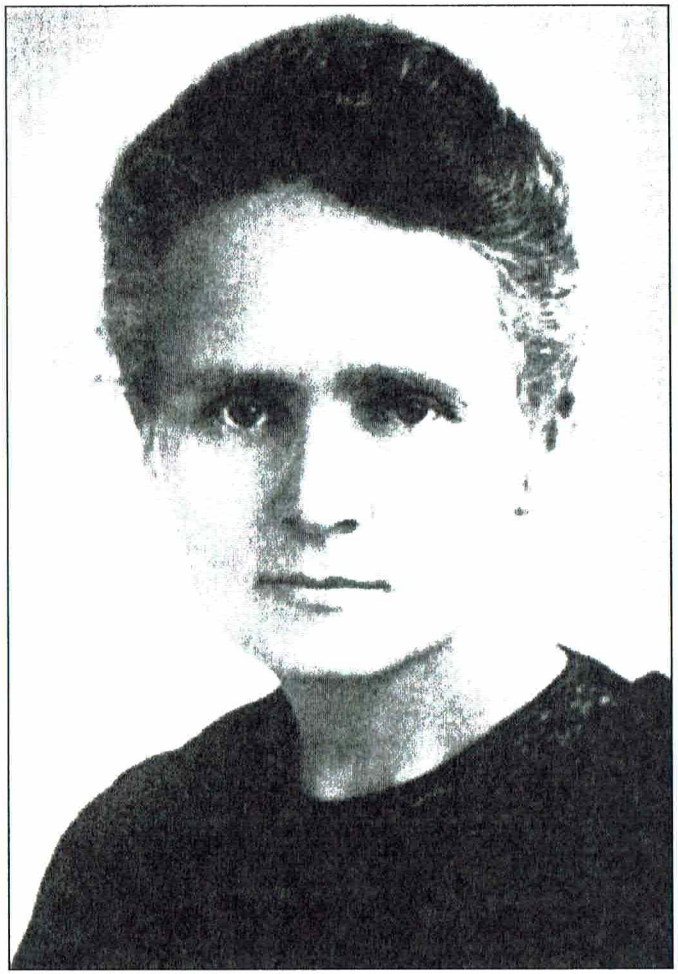
February 1 of each year and they can do so not in the name of their organization but in their own names as individuals.

The committees then, taking these opinions into consideration, conduct their own research and investigations. Finally, they submit their findings together with the supporting evidence to the Board. This should be completed by early October.

The names of the winners may be announced starting as early as mid-October. The prize itself is awarded on December 10; the anniversary date of Nobel's death. The presentation is made by the reigning King of Sweden. (In Norway, the Peace Prize awarding ceremony is conducted in the Oslo municipality).

Needless to say, the awards are presented in a grand ceremony.

Chapter 6



Marie Curie

1867-1934

Learn and let learn

"You cannot hope to build a better world without improving the individuals. To that end each of us must work for his own improvement, and at the same time, share a general responsibility for all humanity, our particular duty being to aid those to whom we think we can be most useful."

Some of our prominent scholars today are known to have started very low. They came from the poor peasantry in remote rural areas where they began taking their lessons under the feet of priests in the local churchyards. They may have even gone around begging for food, as is customary in many places. Today they are able to help other relatives in turn, to learn and help themselves.

Marie Curie had a similar history. Even in her college days, she had to make do with bread and tea alone. She had no other means of subsistence. However, she pursued her studies with diligence. Even when sleep tended to overpower her, she put her feet in cold icy water and kept on working. It is this fierce determination that helped Marie Curie to succeed and, to some measure, helped her to enhance France's reputation in atomic and medical research.

But to begin with, Marie Curie was not even French. She was Polish. Born in 1867 in Warsaw, the capital of Poland, she went to school and completed high school there. She was only 16 years of age, when she graduated with Honours

and when she was awarded a gold medal. But she could continue no further in her studies. It appears that women were not allowed into Warsaw University in those days. At any rate, her father, the only breadwinner in the family, went broke in a failed business deal, and so it fell to her lot to work and support the family. She became a teacher.

However, Marie had no intention of staying put that way. She sought a way to resolve the problem, and she devised one. She saved some money, with difficulty, and used it to send her sister abroad for training, in return for which her sister undertook to send for Marie to teach her.

So when her sister completed her schooling in Paris it was Marie's turn to go back to school. She joined a prestigious university and settled down to the challenges of hard work. She worked almost day and night. It is on record that once she even fainted of hunger and exhaustion. Finally, though, she made it and graduated in physics ahead of her class. Again, a year later, she won another degree in mathematics.

But Marie was not to stop at that. She continued to pursue her education towards the Ph.D. degree. In the meantime, she got married (1895). Again, there was no money. So the bride and bridegroom had to do without a wedding gown or a wedding ring.

Now, as regards the researches, X-rays had just been discovered in Germany in 1895 and the nature of the rays was being intensely investigated. It is known that although these rays are invisible to the eyes, they are capable of passing through human body and other objects.

They could also pass through film packages to darken the photographic films as though the films have been exposed to light.

It was at about this time that a colleague of hers by the name of Professor Henry Becquerel suffered a loss of his films to exposure. He did not know the source of exposure, but later noted that the film package had been lying near a uranium salt. Upon further investigation, he came to the conclusion that the uranium salt did emit invisible radiation that was capable of penetrating objects. He won a Nobel Prize for this discovery and a unit of measurement of radiation activity was named after him.

Marie Curie took this as a starting point and sought to discover other sources, and to study the nature of radiation.

Uranium, she knew, was extracted from pitch blend, so she arranged with some external help, to get tons of the material from abroad. Pitch blend emitted radiation even more powerful than that observed from the extracted uranium. It was therefore obvious to Marie that there existed another element in the pitch blend that emitted it. She laboured at this task and finally managed to extract an element. This was a new and previously unknown source of radiation. She named it "polonium" in honour of her country, Poland. She earned her doctorate degree and also won the 1903 Nobel Prize for physics, which she shared with her husband professor Becquerel. It was the first time that a woman was awarded a Nobel Prize.

Now Marie Curie became famous around the world. But that did not hinder, or distract her

from her work. She continued with her research and again managed to extract yet another element. She named it "radium". Marie won a professorship in the faculty and again another Nobel Prize (this time for chemistry). It was the first time that a person was awarded Nobel Prizes twice. Today her name is associated with a measure of radioactivity. To note, 1 curie is the number of disintegrations per second in one gram of radium. (The number is 3.7×10^{10}). Again, Marie Curie's name has further been immortalized by being given as a name to an element (curium 96).

Having gone thus far, Marie did not rest satisfied with herself. She trained her daughter, Irene Curie, and enabled her to become a doctor. Irene became professor in her own right and went on to win a Nobel Prize jointly with her husband in 1935. Marie Curie could justly be proud of herself as a successful mother.

Marie had other accomplishments to her credit. When the First World War broke out in 1914, France & Germany were among the major antagonists. Marie was basically not French, so if there were any neutral person in the war, it was expected to be her. But she was not. Peaceful as she was, she could not accept what she regarded as German aggression, and she believed that if one did not fight for the principles one stood for, principle alone is valueless. Therefore, when the government appealed to its citizens to raise money and specifically asked for gold for foreign exchange purposes, Marie donated her Nobel Prize money, which was still in Sweden then. She also offered her Nobel Medals to be melted down.

Then again, she set up several clinics equipped with the newly discovered rays to treat war victims. She arranged mobile services (one of which she drove herself) and moved about in the battle field helping people and the cause of war. Over a million victims are said to have received treatment at the clinics she was managing as a director.

Today radium rays are being used in hospitals, industries, research centers and other places. To consolidate the services, Radium Institutes have been established in France, Poland and Various other countries.

After the war, Marie returned to her research. In cooperation with her daughter and the latter's husband, they conducted an investigation into the fission of uranium atoms, and it is said that they were able to recognize that such fissions produced energy and also additional neutrons that went on to multiply by cascade and thus bring about explosion. However, concerned lest this would lead to making a bomb that would be dangerous to humanity, Marie simply informed the government of this possibility and let it lay as a secret. Indeed, France was, soon after the Second World War ended, in a position to further the research and become another world power in 1948.

Marie Curie's contributions had various facets and were forcefully exemplary in many ways.



Marie Curie in her laboratory

Corollary
Women in Science

The urge to find all the possible elements in nature increased after Marie Curie's discovery of radium. This element, by virtue of its long half-life and stability, was found very useful for applications in medicine and industry.

But the number of elements in the Periodic Table stopped at 92. It appeared that there could not be any more. "But Why?" the question was asked. It was then realized that all those beyond this number, being radioactive in nature, must have disintegrated in the span of the earth's age. So it was decided to build them up artificially from uranium. The idea was to add extra sub-atomic particles (neutron, proton, and/or alpha particle) into the nucleus of uranium and see if any new element could be re-created. Today 15 more new-elements have been discovered and studied.

However, in those early days of experimentation with uranium, no one knew exactly what to expect from the experiments, except that it was expected to be heavier than uranium. That was the natural outcome of addition!

So when Nodac, a professional chemist and scientist, proposed a new theory in 1934, it was immediately turned down. What she had done was to add neutrons into uranium atom. What she then found out from the experiment was that the atom broke down into smaller elements. This she revealed to her colleagues.

Yet, her discovery was shrugged off. Worse still, the great German scientist, Oto Han, mocked her, ridiculed her and caused her insults. Luckily, for the world, this line of research was thus abandoned in Germany.

In France, however, Irene Curie and company were engaged in investigating the phenomenon. She came to the same conclusion as Nodac did and said so. At last, the German scientist had to repeat the experiment himself. Alas! It was all true. What Nodac had declared four years previously was just the way things went. Now, as every one realizes, this is the theory on which the construction of the Atomic Bomb is based. The Germans had failed to realize this, and wasted four useful years of further research.

Oto Han then wrote a letter of apology to Lise Meitner. This lady, a scientist herself, had been working in Germany with him and had at the time, told him that his grounds for discrediting Nodac were not justifiable. Later, she, because of her Jewish race, was dismissed from her post and had to immigrate to Sweden. So, it was there that she received the letter of apology. Fully recognizing where this revelation would lead the Nazi government, she immediately alerted Albert Einstein and colleagues in America. Thus, started the neck-breaking race to be first with the bomb.

Had the Germans recognized the work of Nodac and had Lise Meitner not been dismissed from her post, the Germans would have had four years of advance development period to make the bomb. They could then have easily conquered or otherwise destroyed the world.

It was a spell of good fortune for the world that the Nazis did not respect or accept women's opinions. Male chauvinists are a threat only to themselves.



"We must not forget that when radium was discovered no one knew that it would prove useful in hospitals. The work was one of pure science. And this is a proof that scientific work must not be considered from the point of view of the direct usefulness of it. It must be done for itself, for the beauty of science, and then there is always the chance that a scientific discovery may become like the radium a benefit for humanity."

Marie Curie, *Lecture at Vassar College, May 14, 1921*

Chapter 7



Dmitry Mendeleyev

1834-1907

What is the composition of matter?

What is ordinary substance made of? This has been a topic of inquiry and discussion for a long time past. The Greek philosopher Aristotle taught that the basic constituents are fire, water, wind and earth.

Later studies gradually revealed that all substances are composed of elements. A pure element is a substance that does not contain different things but contains only one item – even if it is broken down into smaller and smaller parts. For example, air is composed of such gases as oxygen, nitrogen, argon etc. Water, if broken down by electric force (a phenomenon called electrolysis) is seen to be composed of hydrogen and oxygen gases. But each of these gases is not a mixture of other things and it is called an element. Metals like gold, silver, nickel and copper are also elements.

All substances are composed of such elements. Even our bodies, if we imagined them broken up into pieces, will end up in elements. But how many elements exist then? What are their individual and common characteristics?

We have seen in the previous chapter that Marie Curie, for example, has been able to extract a previously unknown element, which very soon found applications in hospitals and industries. Still other scientists continued to find new ones. But at times, the search appears to be random and dependent on chance. No one knew how to predict and where to look for any new element.

It was Mendeleyev, who tried and succeeded in devising a way to predict it. It may be suggested that the Italian Cannizzaro, when listing 60 elements in the order of their atomic weights, determined chemical repetition at regular intervals, but he stopped short of establishing a 'periodic table'.

Dmitry Mendeleyev was a Russian citizen born in the cold icy region called Siberia. He was the 17th child born to the family.

His father developed sight problem and turned blind. His mother in an attempt to support the family took a small firm on lease and ran it for a while. Unfortunately, the father died in 1847 and shortly after, the firm too burned down.

The mother, being helpless in the face of this crisis, left behind the grown up children and departed with Mendeleyev and his elder sister. She took the long track in the direction of Moscow, the capital city, with a firm determination to get work and to send her son to university. She managed to reach the city, but university officials made it clear that they did not expect any good to come out of Siberia: they declined to admit Mendeleyev into the university. Yet, the mother, aware that she was fatally ill and that she did not have long to live, headed towards Leningrad (now St. Petersburg) about a thousand kilometres away. There again she failed to enrol her son in the university. She tried medical school and was met with the same resistance. Finally, just two months before she died, she managed to enrol him at a certain college, and set him off on a good track.

Mendeleyev did not waste this opportunity. He studied hard and earned his degree. After teaching for a while, he went on to pursue his studies in Germany. It was there that he met and worked with prominent European scientists and this stood him in good stead in the years that followed.

Upon returning home, he taught chemistry and soon became a professor. But there were no suitable books available for teaching. So he decided to write one entitled, "principle of chemistry". That was when he began to ponder the problems of classifying the overwhelming jumble of isolated facts into a semblance of order.

He listed all the known elements of the time, and noted their characteristics. He put each element on a separate card and made a comparative analysis of the best possible arrangement.

Finally, and after a considerable effort, and re-arranging the cards several times, he was able to organize them in some order and classify them in a table. This is now known as Mendeleyev's Periodic Table. As every chemistry student knows, it is possible to place the elements in a specified slot in the table. Moreover it became possible to determine the characteristic (atomic weight, valency etc) of a yet unknown element that, when discovered, would fill the slot. From its position in the table, students can now simply tell if the element in question is acidic, radioactive, or inert gas, etc.

Mendeleyev, and other scientists, were thus able to predict the existence of the then unknown elements and went about looking for them.

Mendeleyev predicted and stated the properties for four elements. And when they were later discovered (one of them fifteen years later), they behaved exactly as he predicted.

We may pause here for a moment and give more details, in order to gain a better understanding of how things are arranged in nature. As will be discussed in the last chapter of this book, the universe around us is built mostly of hydrogen gas. It is this gas that is still found in abundance in any composition of the stars in the sky. The stars' light is the result of the heat generated from the fusion of their atoms.

A hydrogen atom has a small nucleus around which orbits an electron. When two hydrogen isotopes fuse together, the result is another element with two electrons in orbit. It is called helium. Further successive fusions produce elements with orbital electrons of 3, 4, 5, 6 etc. The last and heaviest naturally found element is uranium with 92 electrons in orbit.

But these electrons do not all rotate in one orbit. They fall into different orbits. The first orbit can hold one or two electrons but never more. The second orbit can hold up to eight (after the first orbit is filled); the third orbit again can hold eight and the fourth and fifth, eighteen each. Therefore, elements with 1, 9, 17 and 35 electrons are just short of one electron each to fill their orbits. These are hydrogen (H) fluorine (F) chlorine (Cl), and bromine (Br). In that respect, they are similar and fall in one column. They all have a tendency to fill their orbits by sharing an additional electron by combining with another

element.

On the other hand, elements with electron numbers 3, 11 and 19 hold a lonely electron beyond a filled orbit. These are lithium (Li) Sodium (Na) and potassium (K). These are similar in their tendency to share these extra electrons with others that need it. So elements with an electron available to share and another element short of an electron to fill its orbit have an attraction to each other and when possible unite to form a compound. That is how sodium and chlorine combine to make the common salt. An oxygen atom (lacking two electrons to fill its outer orbit) attaches two hydrogen atoms to itself thus getting us water.

In a similar manner, elements, which are missing two or three electrons to complete their outer orbits, or those having extra ones, have predictable behaviour in reacting with other substances. Those elements, with full orbital electrons (argon, krypton, neon) have no need to combine with others; they are classified as inert gases (these are also known as Noble Gases).

All these and others when grouped together in columns according to their behaviours and placed in sequence according to their atomic weights, form the Periodic Table.

This arrangement of elements is now a common knowledge. But in Mendeleyev's days, nothing made much sense and rhymed only with confusion. About 50 or 60 different elements were recognized and recorded. Their atomic weights were different (and not accurately known for that matter). Their heat capacity, gaseous nature, color, melting or boiling point etc., all appeared

haphazard. To compile all of these, try to arrange them into some order and finally succeed in the task must have required a lot of patience and perseverance. Mendeleyev must have tried many different ways before he hit on this arrangement.

This method of arranging things in some logical order (as in a telephone directory or archives files, or a dictionary for that matter) makes it possible to handle them easily and to search and locate any item in the collection.

Many of us encounter, in our daily lives, various occurrences that appear to us random and coincidental. But how many of us do really commit any of these events to memory? How many of us seek to discover their underlying cause and draw the right conclusions as a lesson for the future? We tend to treat everything as it occurs at the time and subject the event or discovery to our variable moods, so ending up in confusion and disappointment many a time.

However, Mendeleyev had a scientific training. He recorded on cards and analyzed the apparent varieties of elements that confronted him in his job. He attempted to discover the basic laws that governed these phenomena. He succeeded at last, and used his discovery to predict and help find yet more elements.

Mendeleyev is highly regarded in his country for more contributions he made in some other ways, too. For example, whenever he returned from visits abroad, he used to bring back new ideas and ways of doing things better. One occasion that is often mentioned concerns his trip to America where he visited an oil refinery. Upon returning home, he realized how, by comparison,

the oil refinery in his country was very backward and wasteful. So he took on the challenge, worked on it, and got the refinery renovated. That, it is said, saved the country a lot of capital.

How many of us have managed this sort of technology transfer? Despite several expensive foreign trips, trainings, workshops, factory visits etc., aren't there several cases where no tangible benefits have accrued to the country?

These are questions, which need to be asked. They have to be considered carefully, too. There are numerous technologies abroad, which could be put to good use here in the country. We do not have to rediscover the wheel all over again. We can adopt and improve them or modify them to our conditions.

Mendeleyev benefited from his visits abroad. He gained expertise, which he put to use at home. There is no shorter or simpler method than this.

Of course, there would be problems. The adoption and adaptation of various technologies is in the hands of private company owners. The benefits of these technologies will be made available only under license or if the owners invest in a country in need of development. Even then, unless there is "fertile ground", knowledge may not take root here, thus leaving the country in question, and its people empty-handed when the owners close up and pull out. This is known to have happened and it will again.

It requires trained manpower to understand and retain the know-how. This, in part, could depend on the policy and planning, which is the role of the government, but much depends on the rest of us to follow Mendeleyev's examples and

effect technology transfer with all due speed.

Corollary
Development of Metrology

Mendeleyev in the latter years of his life (i.e. 1892-1907) was engaged in developing metrology. He realized quite early that industries producing spare parts for instance, have to be able to measure with precision and to maintain the accuracy in all phases of production. Any significant variation in measurement and therefore in production will defeat the purpose for which the parts are intended.

There are measuring instruments in factories, in trade and in various service organizations, and unless these provide correct measurements, the results of planning, manufacturing etc., based on these erroneous measures, will of course, be in error themselves. This applies to all types of measuring instruments such as electrical, pressure, temperature and length measurements. For example, unless the weight-scales and blood pressure gauges in hospitals read correctly, the patient may suffer from the results of an erroneous diagnostic. The doctor, after all, bases his diagnosis on the measurements presented.

Measuring instruments are also liable to wear and tear, rust, loose connections, or being subject to ageing or mishandling. The resulting deviation from correct reading will incur damages to the institution and to the country as a whole.

Mendeleyev thus found it necessary to develop metrology and established an institute, which took on the responsibility of maintaining the accuracy of measuring instruments used in the

country. Today the millions of such instruments employed in various industries across the country are calibrated in a hierarchical order by this and similar other institutions.

Incidentally, there is one method of verifying measuring instruments, which Mendeleyev introduced and which remains in use even today. Suppose we use a mass of one kilogram to measure out a kilogram of coffee beans. Just because the arms of the instrument are in balance, does not necessarily mean that the weights on either side are equal. The pan carrying the one-kilogram mass could be lighter in weigh, yet it would be held in balance by friction due to rust; or the weighing balance itself may have been misaligned intentionally to indicate balance. So to countercheck the accuracy, one has to interchange the pans carrying the coffee beans and the mass of one kilogram. If the balance is maintained in both situations, then the coffee beans indeed weigh the equivalent of the mass of weight. This method of countercheck is known as Mendeleyev's method and is still used throughout the world.

The St. Petersburg metrology institute was named after Mendeleyev. It houses a permanent exhibition of his works, which is visited, by thousands of people every year. Mendeleyev's name has thus been immortalized.

Reihen	Gruppe I. - R^1O	Gruppe II. - RO	Gruppe III. - R^2O^1	Gruppe IV. RH^4 RO^3	Gruppe V. RH^3 R^2O^5	Gruppe VI. RH^2 RO^3	Gruppe VII RH R^2O^7	Gruppe VIII. - RO^4
1	H = 1							
2	Li = 7	Be = 9,4	B = 11	C = 12	N = 14	O = 16	F = 19	
3	Na = 23	Mg = 24	Al = 27,3	Si = 28	P = 31	S = 32	Cl = 35,5	
4	K = 39	Ca = 40	- = 44	Ti = 48	V = 51	Cr = 52	Mn = 55	Fe = 56, Co=59 Ni=59, Cu=63
5	(Cu = 63)	Zn = 65	- = 68	- = 72	As = 75	Se = 78	Br = 80	
6	Rb = 85	Sr = 87	?Yt = 88	Zr = 90	Nb = 94	Mo = 96	- = 100	Ru=104, Rh=104 Pd=106, Ag=108
7	Ag = 108	Cd = 112	In = 113	Sn = 118	Sb = 122	Te = 125	J = 127	
8	Cs = 133	Ba = 137	?Di = 138	?Ce = 140	-	-	-	- - - -
9	(-)	-	-	-	-	-	-	
10	-	-	?Er = 178	?La = 180	Ta = 182	W = 184	-	Os=195, Ir=197, Pt=198, Au=199
11	(Au = 199)	Hg = 200	Tl = 204	Pb = 207	Bi = 208	-	-	
12	-	-	-	Th = 231	-	U = 240	-	- - - -

ORIGINAL TABLE

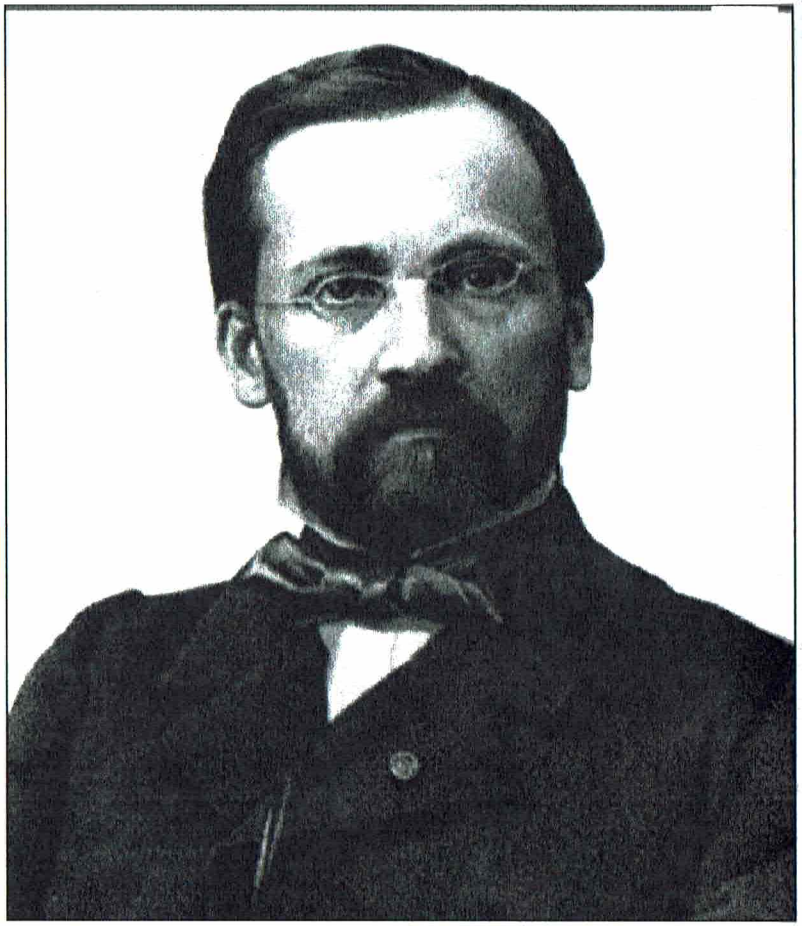
I	II	IIIb	IVb	Vb	VIb	VIIb	VIIIb			Ib	IIb	III	IV	V	VI	VII	0
1	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**	**11**	**12**	**13**	**14**	**15**	**16**	**17**	**18**
H																	He
Li	Be											B	C	N	O	F	Ne
Na	Mg											Al	Si	P	S	Cl	Ar
K	Ca	Sc	Ti	V	Cr	Mn	Fe	Co	Ni	Cu	Zn	Ga	Ge	As	Se	Br	Kr
Rb	Sr	Y	Zr	Nb	Mo	Tc	Ru	Rh	Pd	Ag	Cd	In	Sn	Sb	Te	I	Xe
Cs	Ba	La*	Hf	Ta	W	Re	Os	Ir	Pt	Au	Hg	Tl	Pb	Bi	Po	At	Rn
Fr	Ra	Ac**	Rf	Db	Sg	Bh	Hs	Mt	Uun	Uuu	Uub		Uuq		Uuh		

Lanthanides *	Ce	Pr	Nd	Pm	Sm	Eu	Gd	Tb	Dy	Ho	Er	Tm	Yb	Lu
Actinides **	Th	Pa	U	Np	Pu	Am	Cm	Bk	Cf	Es	Fm	Md	No	Lr

TODAY'S COMMONLY USED TABLE

Mendeleyev Periodic Table

Chapter 8



Louis Pasteur

1822-1895

The secret of Vaccination

"Let me tell you the secret that has led me to my goal. My strength lies solely in my tenacity."

Louis Pasteur[4] is a world-renowned biochemist who, not only advanced the frontiers of science, but also applied the knowledge to field work. His discoveries were applied in medical institutions, in agricultural farms and in industries.

Pasteur has many discoveries to his name. The first was patented in 1848. That was barely a year after he graduated from school. Previously he had managed to collect degrees in rapid succession: - a Bachelor's degree in literature in 1840, Bachelor's degree in science in 1842, a Master's degree in 1845 and a Doctorate's degree in 1847. This was a surprise even to his parents, because in his younger days, he did not have the slightest interest in learning; and passed his time drawing pictures and even switched to sculpting.

It was only much later that he appeared to wake up to science. Then he embraced it and was immersed and absorbed in it. Thus, he waded right through the academic courses and research and landed a new discovery in 1848. His reaction at his first discovery was immense. He jumped out of his seat, ran into the street and finding his assistant there embraced him, gasping, and shouting, "I have discovered"

[4] (3) No. 13; (1)

repeatedly. He told him that he was so happy and excited that his whole body trembled and his eyes could not focus on the instrument.

Such occasions of excitement are not uncommon. True, they may not appear as dramatic as a footballer scoring a goal, since the physical ability of the discoverer will, perforce; restrict his performance in that regard. But, sure enough, it is very pleasing when long-held riddles suddenly find solutions.

A certain physicist by the name of Dr. Feynman is on record as having sidestepped from a queue and danced frantically under the astonished looks of the people around him. They were queuing for their turn in a canteen at lunchtime when a colleague whispered to him the essences of what was reported in a seminar he had just attended. Realizing that this finding had just solved the riddle that had for so long racked his brains, Feynman could not restrain himself from expressing his emotions.



Dr. Feynman

We all remember the tale concerning the ancient Greek philosopher, by the name of Archimedes. The king suspected his goldsmith of not making his crown from pure gold. So he called Archimedes and ordered him to prove that it was pure gold; otherwise he would kill him!

The way to find out is to determine the density of the crown and compare it to that of gold. At the time, there was no known way to find the volume of that irregular shape. Worried of the prospect of death, he stepped into the bath. That was when

he got the idea of immersing the crown in a container full of bath water and collecting the overflow to measure its volume. It was at that revelation that he was excited, forgot to put on his clothes before he ran out to the street, and shouted Eureka! (I have found out.)

A person overtaken by emotions can express himself in quite dramatic manners. Pasteur was no exception to this.

Pasteur's attention was at one time drawn to micro-organisms. These are known to spoil food and drinks. Bread loaves grow mouldy, milk sours, beer and other drinks too, if kept long enough will spoil.

From ancient times, it was accepted that some organisms spontaneously grow from heaps of rotten material. Lice breed from dirty bodies; flies hatch straight out of cow-dung, meat when kept long enough can produce worms by itself, etc. Even mice were believed to be capable of just coming out of nowhere. This all meant that life could be created spontaneously. But as time passed, things began to become clearer. For instance, it was realized that we find worms in long-exposed meat not because they are created in there but because flies have the habit of laying and depositing their eggs in meat so that, on hatching, the young once may find food for their immediate need. In the same manner, meat gets smelly because of the bacteria in the air, which start to breed on it. If meat is boiled or cooked to kill off any micro-organism and is immediately sealed, it can then be indefinitely preserved.

Charles Darwin too, came along to explain that life begets life and further that, even large

organisms, such as humans evolved in stages through evolutionary processes from the simplest unicellular organisms. Therefore, not only life is not created spontaneously but also the original specimen of the species is traceable back to a unicellular organism for its starting point.

So what causes meat to rot or milk to sour? Pasteur studied this problem and was finally able to extract and culture the micro-organisms responsible for the damage. If, as Pasteur said, one could isolate these organisms from the air or apparatus, and prevent them from coming in contact with the meat, then it would remain free from contamination. One can even open a human body and stitch it up after an operation, without the fear of infection. Pasteur explained that if one could take the necessary precautions to keep the air and apparatus free from bacteria, the human body would then remain free from infection. If milk, too, could be boiled and sealed, or beer brewed with care and bottled, and food protected in the refrigerator, they could all be protected from bacteria and thus be safely preserved against spoilage.

As a result, the British and the French could at last dispatch beer safely by ship all the way to the far-flung corners of their colonies. Today European beer sells in our markets (and ours in America) by using Pasteur's method of preservation. "Pasteurized" milk is a daily sight everywhere and refrigerators have become an indispensable appliance. This is all because of Pasteur's scientific methods of preservation that were developed the world over. Pasteur did not stop there however.

He is perhaps best known for developing the process of vaccination. It is true though that several centuries ago, so-called "traditional heelers" in India and the Far East practiced vaccination. For instance, when a victim of smallpox provides pus, and this is mixed into the blood of a healthy man by simply scratching the pus into his skin, the healthy man will fall sick but then recover and thereafter will remain immune to the disease.

The Europeans came to learn of this tradition of treatment in the 18th century. However, there was no scientific explanation for it. It was left to Pasteur to explain that both the causes of infection and the preventive medicine against infection have the same origin; namely the bacteria. (Viruses were not known in those days).

However, people scoffed at Pasteur's claims. "How can a disease be a cure itself?" they sneered. Pasteur got mad at this. He decided to demonstrate in public that this is indeed so. He thus invited journalists, doctors, and other dignitaries to witness his experimentation. He brought out fifty sheep and injected 25 of them with the weakened germs. 12 days later, they were given another booster dose, and finally all the 50 sheep (including the vaccinated ones) were injected with a strong dose of anthrax. Two days later, the 25 vaccinated sheep where happily grazing the field whereas 22 of the others were already dead and the remaining three were dying. Pasteur was at last believed. He became famous.

Europe in those days was suffering from the heavy loss of cattle all due to anthrax. Pasteur then collected the germs from the infected cattle,

weakened them (by heat) and re-injected them into healthy cattle. The germs so treated, could not kill the cattle. On the other hand, they caused the cattle to develop immunity against them. Thereafter the cattle remained immune to any further attack by the disease.

The underlying principle, remains valid for vaccination of animals and people as well. It consists of weakening the bacteria sufficiently enough and then injecting it into a healthy animal (or human). The body will then develop an antigen, which will remain latent to fend off any future attack. The enormous economic and social benefits that accrued from Pasteur's contribution in this respect are obvious.

Another of Pasteur's contribution is his finding of a preventive method against the spread of rabies. This was in 1882. Rabies in those days caused terror in the hearts (or minds?) of people everywhere. It caused death in a horrifying manner. Pasteur therefore began seeking a solution to this problem too. He sought for rabid dogs and collected their saliva. He then filtered out the germs and after weakening them sufficiently, he re-injected them into healthy dogs. Further investigations on the disease revealed that the germs accumulated not so much in the saliva as in the backside of the brain. Again, he learnt that the best way to weaken these germs was to apply heat to them or simply store them for some time. He thus prepared the doses and vaccinated healthy dogs. Because of his continuous efforts, the horrifying disease was finally under control. Obviously, it was a great relief for every one. (For further information on

rabies, please see the corollary hereafter).

Pasteur thus made major contributions to his country and to the world at large. In honour of this great scientist, an institute was named after him, the Pasteur Institute, in Paris in 1888. Similarly, Pasteur institutes were established in various other countries (including Ethiopia) where scientists continue their research in bacteriology and treatments given for rabies etc.

Pasteur was able to register all these achievements for several reasons, among which were his natural curiosity for things around him, his urge to delve into unknown fields of research and his devotion for, and total commitment to his profession. It is true that not all of his research bore fruit. Some were just wasted. He had laboured on some projects long and hard, but nothing came out of them – often because he started on the wrong premise. Certain concepts and beliefs of the times were not based on scientific grounds and these led him astray. Yet, even this could be considered a finding in its own right. To show that certain concepts are wrong is a step forward in scientific research, which enables others to explore different paths.

Pasteur believed that fieldwork had to go hand in hand with lessons in the classroom, so he regularly took his students out for visits and experiments in factories and farm areas. It was also a lesson to others that, when farmers in the Deep South suffered severe loss of their silk harvest due to the spread of the silkworm disease, he left his Chair and his home, and went to work in the fields for three long years; and he did manage to solve the problem.

Such concern and dedication is not commonly found everywhere. He was so committed and devoted to his work that, as he wrote in a letter to a friend, he felt the nights too long and the daybreak too slow in coming to enable him to go back to work.

Pasteur's life and work should serve as a lesson for us all.



Louis Pasteur in his laboratory

Corollary
Rabies

People in Africa are terrified of rabies. As a result, more damage is caused by terror than actually is inflicted by the disease itself. The mere suspicion that a sick dog may have become rabid sends people scuttling to "Traditional medicine men" that prescribe a concoction of wild plant roots, leaves and barks for cure. The intake of this unhygienic, possibly poisonous, preparation sometimes causes vomiting and/or diarrhoea. Depending on the severity of the "dose", it could damage the stomach wall linings and remove parts of it, which is then claimed by the medicine man as evidence of the effectiveness of his medicine by driving out the small puppies that would have grown to dogs inside the stomach.

It is true of course, that the disease is fatal if untreated. However, unfounded fear and suspicion of its occurrence and the subsequent rush for local "Cure" is causing in the remote villages unnecessary and sometimes irreparable damage.

The cause of rabies is a virus. When a rabid dog bites a person, the virus passes on with the saliva into the body, and thereafter passes on to the nerves eventually ending up in the brain. There it develops and multiplies. The development time depends on the proximity of the bite to the brain and could vary from 10 days to 3 months. Sometimes it could even take one year; and recent publications now claim that it may

delay even as long as seven years.

Once the virus completed its development stage and is hatched out in the brain, then there is no remedy for the infected dog. The virus spreads through out the body concentrating more in the saliva gland. It is now easily transmitted through biting.

Yet, not only dogs are susceptible to rabies. Wild carnivores (fox, hyena, wolf, etc.) do also contract the disease. These in their turn transmit it by biting other animals, wild or domestic. As a result, domestic animals like cattle, sheep and horses can contract the disease from any such sources.

Drooling saliva is a clear indication of a dog suffering from Rabies. The dog unable to close its jaws (because it lost control of its muscles) freely salivates as it goes about. The virus actually proceeds to attack the body muscles starting from the hind. Thus, the tail of the dog dangling helplessly is the first sign of danger. This dangling, it should be noted, is different from tucking the tail between the legs that frightened dogs often do. As the numbing of the muscles progressed from the tail end forward to reach the brain, the dog dies. In the meantime, though, the dog may behave in different ways. It may turn out to be aggressive and bite at woods, stones, animals or anything that comes its way, thus causing a lot of harm before it finally collapses. Another type is the one that dazes the dog. The dog affected by this type of rabies simply roles up and lies down quietly. Even when disturbed, it is inclined to direct its bite to outsiders rather than to the family members. There is also a third type

of behaviour intermediate between the aggressive and passive types. At any rate, all rabid dogs eventually succumb to the disease and die.

A person afflicted with the disease, unless treated in time, begins to have headaches. He then becomes restless. His awareness is heightened. He is irritated or easily disturbed by loud noises, or by a breeze of air. He avoids glare of light and shuns even water. Because the muscles around his neck are immobilized, he can no longer swallow or drink water and so he avoids it.

As the disease progresses, he becomes more emotional. For example, he tends to embrace forcefully, kiss strongly or even bite his colleagues or acquaintances. When this stage is reached, the thing to do is simply to protect him from the disturbances he hates, and to lock him up in a darkened room and patiently wait for the end to come.

Regarding vaccination there are two approaches to it. The first is to immunize or vaccinate all dogs (and if possible even cats, cattle, horses, etc.) against the disease... In advanced countries, even wild life is treated and this type of treatment needs to be conducted every year[5]. However, once a person finds himself infected, the second approach should be pursued, and that demands immediate action. There is medicine available to be applied to areas of the body around the bite. This is followed by two weeks of daily injection around the belly part.

[5] In the Balie National Park (Ethiopia) more than half the population of rare and endemic wolves was wiped out by rabies in 1990-91.

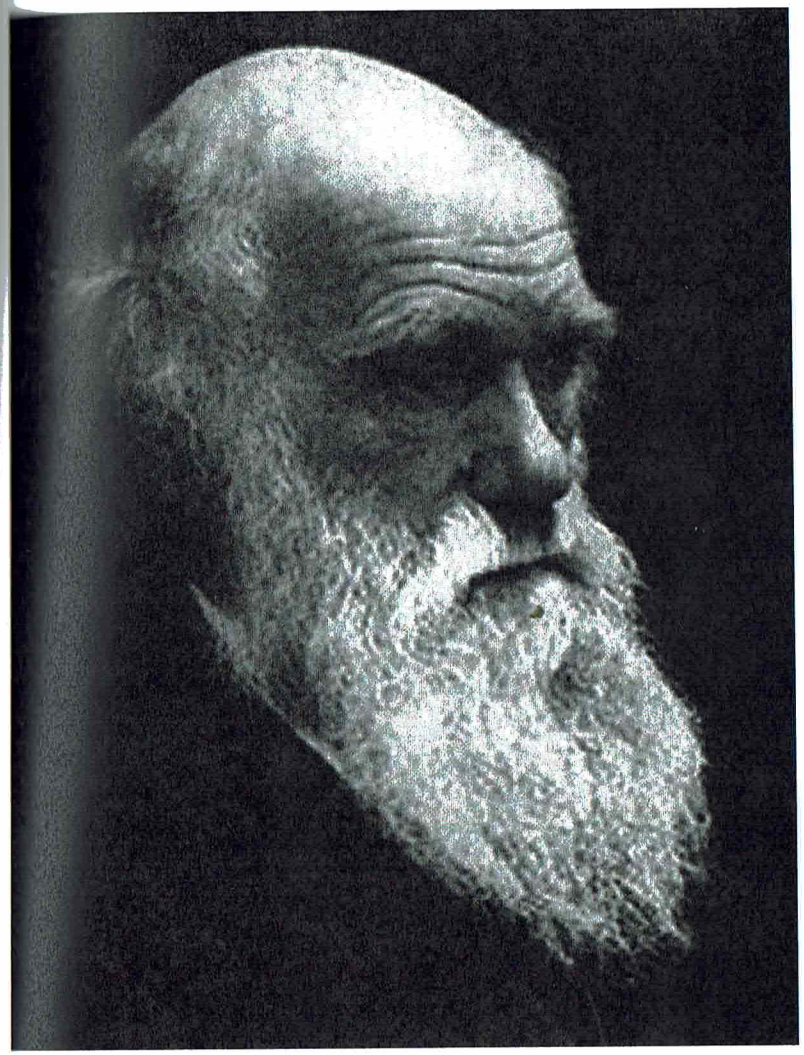
Finally, three booster injections are given 10 days apart. This is a safe and sure treatment.

Coming back to traditional medicines, I should say that they are unreliable. I should perhaps refrain from categorically declaring them ineffective, only because these claims (of their effectiveness to cure the disease) have not yet been subjected to vigorous scientific testing. Nevertheless, one should never take any chance with it, when scientifically tested cures are available.

Some chance events at times cause people to be misled. It is true that not all people bitten by rabid dogs are infected with the virus. For one thing, the virus may not have reached the salivary gland of the dog when it bit the person. For another, after several previous bites, the dog's saliva and teeth may be temporarily free of the virus. So if a few among the bitten victims, who received treatment from the traditional healer, are free of infection, the 'healer' cannot be credited with curing the patient.

Therefore, traditional medicines, serve no better purpose than to distract people from taking the appropriate treatment in time. Moreover, sadly enough, once a person has shown the symptoms of the disease, it is a mere waste of money and effort to take him to the hospital.

Chapter 9



Charles Darwin
1809-1882

The origin of Man

"We must, however, acknowledge as it seems to me, that a man with all his noble qualities...still bears in his bodily frame the indelible stamp of his lowly origin."

"If God allotted man his due punishment immediately after the committed sin, man-kind would have taken his lesson to heart", so say some people. Yet, in Darwin's case, many believed, that this had indeed happened.[6] Darwin had been a sick man for 40 years. Upon returning from his round-the-world journey, he postulated the theory of evolution and started to teach it, whereupon he fell sick and stayed that way for the rest of his life.

The theory he proposed was controversial. It created intense arguments and sometimes, serious quarrels among people. "How can man descend from monkeys?" demanded some. Well, Darwin did not say it quite that way either. He declared that living things, starting with the lowest and simplest of creatures, unicellular organisms, and developing systematically over millions of years and by evolutionary processes, managed to diversify and further develop into the variety of species we see today. On this basis, though apes and monkeys now took different paths of development, they probably had a common origin some millions of years ago. Yet, even this claim departs from the sayings in the scriptures. Even so, it is not clear if damnation

[6] (3) No. 5; (5)

from God, which brought down sickness upon Darwin, is a result of his own doing, the prize for his sin, as some believed.

Darwin had lost his mother when he was only eight years old and he was brought up under the care of his elder sister. His father was a huge man, (300 pounds) who ruled over his family sternly to say the least. Darwin always suffered under the strain of his father's imposition.

He did not do well at school either. Having been sent to university to study medicine, he was dismissed immediately. Then he went to Cambridge to study theology. He did not succeed there either. The man was more interested in horse riding. He spent the rest of his early days building up a collection of stones and fossils, mountain climbing and practising other sports. His father disapproved of all these 'lowly' inclinations and aspirations in very strong terms. He even reprimanded his son as being a disgrace and an insult to the family name. He threatened to prevent Darwin from embarking on the ship that was to take him on what turned out to be a historic journey.

This journey was a source of inspiration to Darwin. He collected fossils at every anchor port of the ship, and began comparing one with the other. He studied their differences and started to classify them accordingly. He then began asking himself how one species of animals can be found on different and vastly separated continents. Why is it that so many varieties of species could be seen in one locality? How was it possible and why was it necessary to create so many different types of animals, birds and plants? He racked his

brain for possible answers to such and many other questions. Finally, he arrived at a hypothesis. He reasoned that not all men are alike in every respect. Some are born runners. Others may be high jumpers. There are intelligent men. There are also fat and lean men. Other animals and plants revealed variations in many respects as well. Some have horns but others have poison. Some plants are thorny others are creepers etc.

Equally, the natural environment revealed variation. There are desert areas, snowy areas and others with different physical features. As a result, food supply cannot be uniformly available everywhere, so there is bound to be competition for it. Some will win while the others are bound to lose. Those that win the struggle will survive while the others are doomed to extinction. Therefore, one could conclude that creatures, which are endowed with the right features, talents etc that enable them to face the challenge and prevail over it, manage to survive while those that fail in the competition simply perish. This is the principle of "Survival of the fittest". This is how mother Nature makes its choice as to who should survive and who should perish. This variation of the environment and the subsequent competition of animals to remain fit and alive is a continuous process. In course of time, some changes are induced on the animals by temperature, by radiation or may be by other factors, and these changes will be retained if they help in the struggle for survival or will be eliminated if otherwise. Gradually, the useful traits, which help the creature to adapt to its environment and to

compete successfully, will prevail and develop further.

This explains why some creatures have become extinct while others have developed, gradually changed and adapted to their particular environment. This also explains how life can start from a simple organism such as a cell, and systematically grow, change, develop and learn to adapt. Darwin concluded that fauna and flora found on the earth today were not created individually, but evolved in the manner explained above.

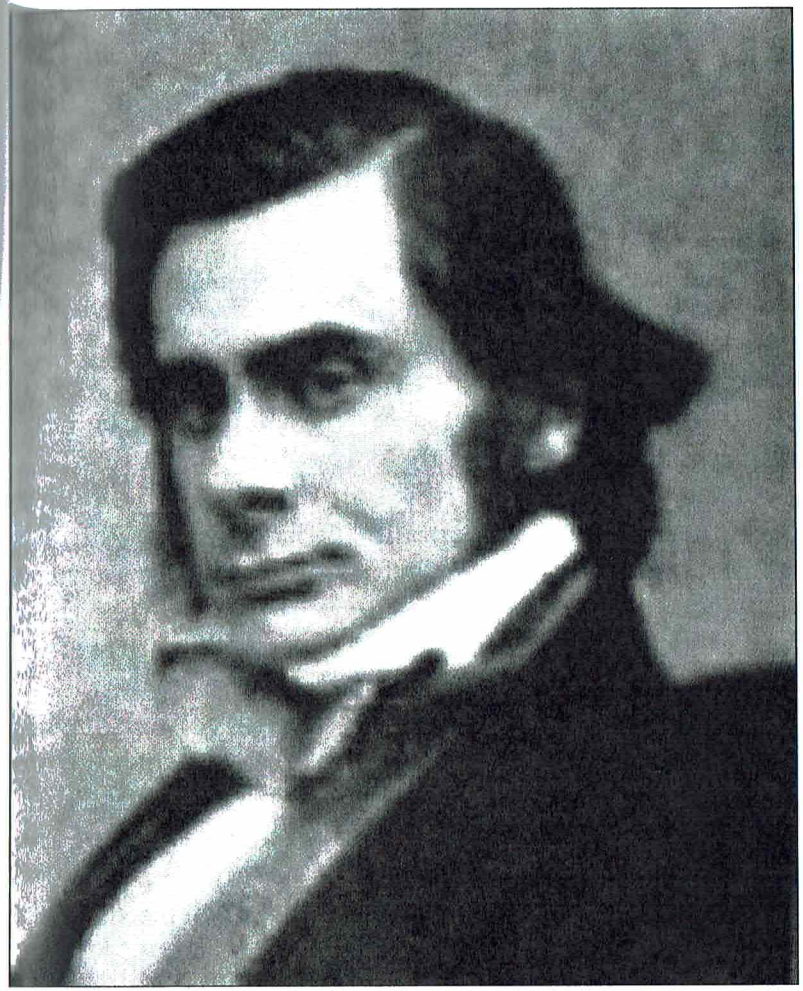
This theory caused huge conflicting opinions in the eyes of people. On the one hand, it simplified the means by which all these different species of creatures teaming in the oceans, on land and in the air came into existence. On the other hand, the Scriptures did teach that God created each type of animal separately and endowed it with life. Thereafter He watched over His creatures and on occasions (depending on prayers, fasts and appeals of intermediary officials) pardoned their sins, protected their welfare and assisted in various other ways.

Darwin's theory appeared to stand in direct contradiction to the teachings of the Scriptures. It all appeared irreconcilable. There were debates and quarrels sometimes resulting in bitter feuds. Students in those days found themselves caught in the crossfire. Their parents forced them to believe the Scriptures, but their teachers taught them otherwise. If they wanted to pass their examinations, they had to answer one way, but to keep peace with their parents they had to answer another way.

It was at this crucial moment that a direct confrontation between a scientist and a bishop took place. The year was 1860 and the stage was Oxford University in England. At a meeting of the "Association for the Advancement of Science", Bishop Wilberforce of Oxford, defended the Christian faith earnestly, and at one point mocked the scientist who as he said, was requesting the acceptance of ape as his grandfather. The scientist, Thomas H. Huxley, jumped to his feet and replied:

> *"If the question is put to me, would I rather have a miserable ape for a grandfather or a man highly endowed by nature and possessed of great means of influence, and yet who employs these faculties and that influence for the mere purpose of introducing ridicule into a grave scientific discussion, I unhesitatingly affirm my preference for the ape".*

At these words, the students exploded in roaring laughter and showed their assent in thunderous applause. Thereafter evolution stood on its own feet and science declared its independence of thought.



Thomas Huxley (Darwin's "Bulldog")

As time passed, new findings supporting the argument in favour of evolution accumulated and gradually objections against it subsided.

Darwin himself contributed a lot to this

accumulation of facts. He did research on flowering plants. It was he who explained that such plants have both male and female parts on the same plant for reasons that if cross-fertilization failed to succeed then, at least, self-pollination would ensure that the species did not die out. Cross-pollination results in healthier & stronger offshoots and is thus preferable. However, if the agents of pollination (insects such as bees) fail to visit the plant, or other causes prevent cross-pollination, it is wise to take precautions. The use of the flowers themselves to the plants that bear them is to attract the bees and/or other agents to come and visit for the nectars, whereupon they will carry off the pollen dust and possibly deposit it on another similar plant that they are likely to visit. Darwin pointed out that plants that use the wind to scatter their seeds, do not need to attract insects and therefore do not need to produce flowers.

Creepers (e.g. vines) have a relatively short life span (compared with trees) and do not have time to grow thick rigid stems for support. Thus, they are doomed to remain under the shadows of the dense forest, while deprived of essential sunlight. Yet, they adapted and soon grew tendrils to twist around other plants for support and to creep up to the tree-umbrella easily. That is struggle for existence, and they have found a way to win it, explained Darwin.

Darwin had his own reservations when it came to matters of religion. People accused him of disavowing God, but he wondered why God, who is benevolent, loving, kind and omnipotent, should permit a slave-owner to torture the poor

slave; or how indeed could He tolerate innocent children (especially of backward countries) suffering and dying in their thousands from disease and starvation? Darwin referred to some of his acquaintances, who were not believers but nevertheless were gentle and kindly people and asked why they should be damned and subjected to the tortures of Hell for all eternity.

Darwin was not an atheist, though. When Karl Marx offered to dedicate his book "Capital" to him, he declined the offer. Darwin was of a simple conviction that everything must surely be studied carefully but not to the exclusion of scientific findings.

Darwin however was not destined to lead the rest of his life in peace and good health.

Darwin's illness[7]

Darwin's misfortune in the last days of his life is in a way interesting and reminiscent of present-day experiences of many people.

Darwin fell ill immediately after returning from his five-year-long sea voyage and remained ill for the remaining 40 years of his life. It was not possible to pinpoint the complaints: - he had gastric and intestinal pains; and he suffered from palpitation, general weakness and lethargy. Sometimes his whole body shivered or he vomited. His heartbeat was irregular sometimes beating very fast. Therefore, the symptoms varied, and kept Darwin weak and confined to his home. He decided to leave London and so retired to his country home in Kent.

Darwin's problem, according to the diagnosis of the medical people was not physical but psychological. They could not ascribe his illness to any known disease, and so chose to explain it away as a mental worry of his own making, a result of his own disposition and mentality. A scholar, at one stage, declared that he had already studied the family history and discovered that along both the father's lineage and the mother's, there were cases of mental disorders recorded. He thus maintained that Darwin's troubles could be traced back to his ancestors. "It is a hereditary disease," he concluded.

Another professor pointed out that this illness

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[7] (5) pp 61-67

in an excuse of Darwin's own choosing. This professor said something to the effect that Darwin being a famous man in the world feigned the sickness to relieve himself of the burden of responsibilities weighing heavily on his shoulders. Darwin, of course, did not accept any of these suggestions and expressed his disagreement in anger; but that only made matters worse for him and caused him deep disappointment and grief.

Other doctors came up later still with yet more new diagnoses. One of them for instance declared that his (Darwin's) wife Emma was the cause of all the trouble. Emma, he said, was increasingly feeling strongly about Darwin's work, which had claimed that man descended from the apes and thus attempted to discredit God; she felt this to be un-Christian and so disapproved of it. It is this tension between the two of them that caused Darwin so much distress.

All this did nothing to help Darwin, but only to cause him more anger, disappointment and helplessness. It even worsened his condition, which in turn strengthened the doctors' arguments.

The irony of it all is that Darwin's illness had nothing to do whatever with these diagnoses, but was caused by an incident that occurred during his trip to Latin America. When staying the night in one of the villages in Argentina, Darwin had been attacked by bugs which today are known to be vectors (carriers) of the trypanosome disease. The victim of this disease expresses the common symptoms of heart problem, stomach disturbance, weakness and lethargy which Darwin then suffered.

The reason why the doctors of the times failed to diagnose the disease was simply that it was unknown at the time. It was identified only twenty-seven years after Darwin's death. Of course, it was not clinically established he suffered from the disease, but the symptoms matched exactly the complications caused by the chronic form of this infection.

Looking back now, one can imagine what distress and anguish the doctors had caused poor Darwin by their claims of his mental disturbance, hereditary disease, wife's disapproval etc., and causing the community to believe it.

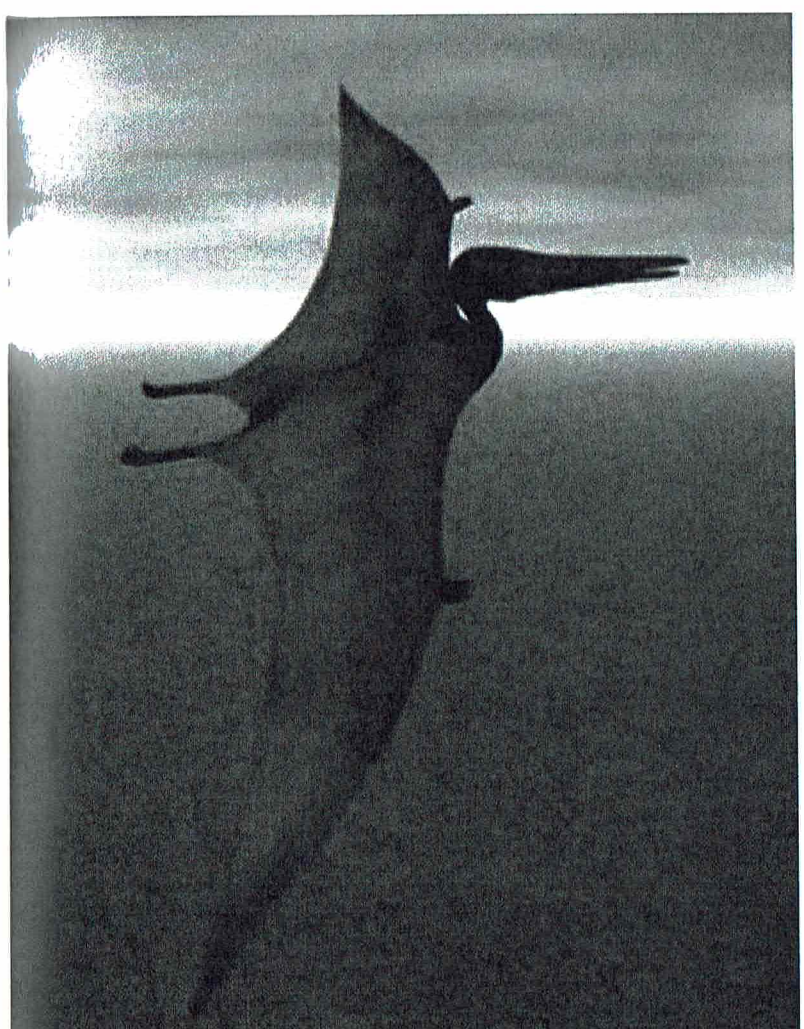
This occurrence is not just a thing of the past. In fact, this situation occurs even today. Some people upon falling ill are rushed to hospitals only to be told that they are normal. The fact is that their problems have not been, and could not be identified – therefore, they are not "sick"! Could it be of some comfort to recognize the fact that this situation has occurred in the past and still occurs in many countries as well? Anyway, Darwin suffered his long illness and died without any help available. However, his theory of evolution has greatly influenced our perception and has been considered as a landmark ever since. Despite initial apparent controversy with the Scriptures, it has now won broad acceptance by most people. In some respect, to learn of our antecedents has taught us humility, I suppose.

Corollary
Evolution

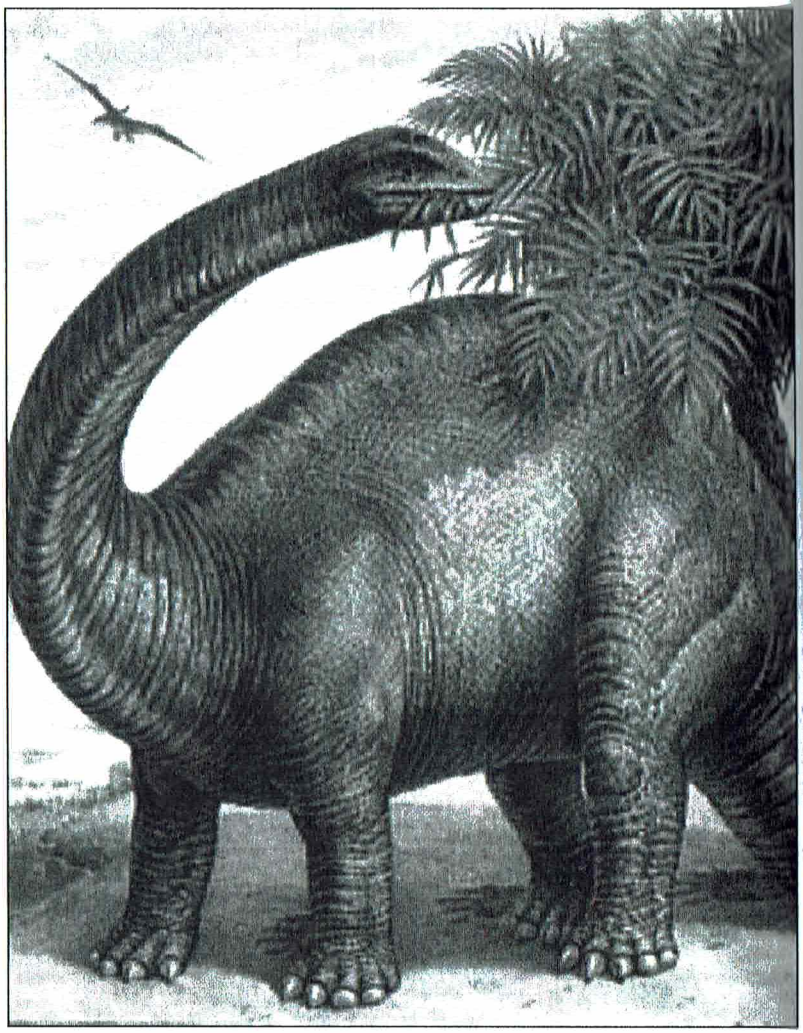
We have mentioned that Darwin's theory was then broadly accepted. To professionals who follow the details of developmental stage from lower to higher organisms, the argument for evolution is really convincing. The conviction now is that unicellular (single cell) organisms (at the level of the amoeba) evolved by a series of stages through millions of years to reach the stage where we are now. This process probably started some one thousand million years ago. At that time there was perhaps a cell composed of chlorophyll and of some other component characteristic of animal cell as well, which maybe underwent a series of mutation and evolved in two different lines, an animal cell and a plant cell. The animal cell, a type of amoeba, developed, specialized and developed again in a series of changes building up to a fish. That was achieved about 400 million years ago. Further development and specialization resulted in amphibians (the ancestors of frogs and crocodiles) about 275 million years back. Further evolution brought about the reptiles (e.g. dinosaurs) and later the mammals (dog, horse, etc.) then followed the birds.

This process was of course not a linear development; it did not follow a single line. It grew like a tree branching in every direction evolving and adapting to its immediate environment as it went further. For example, birds branched out of the main tree of evolution; but then different smaller branches (in the form

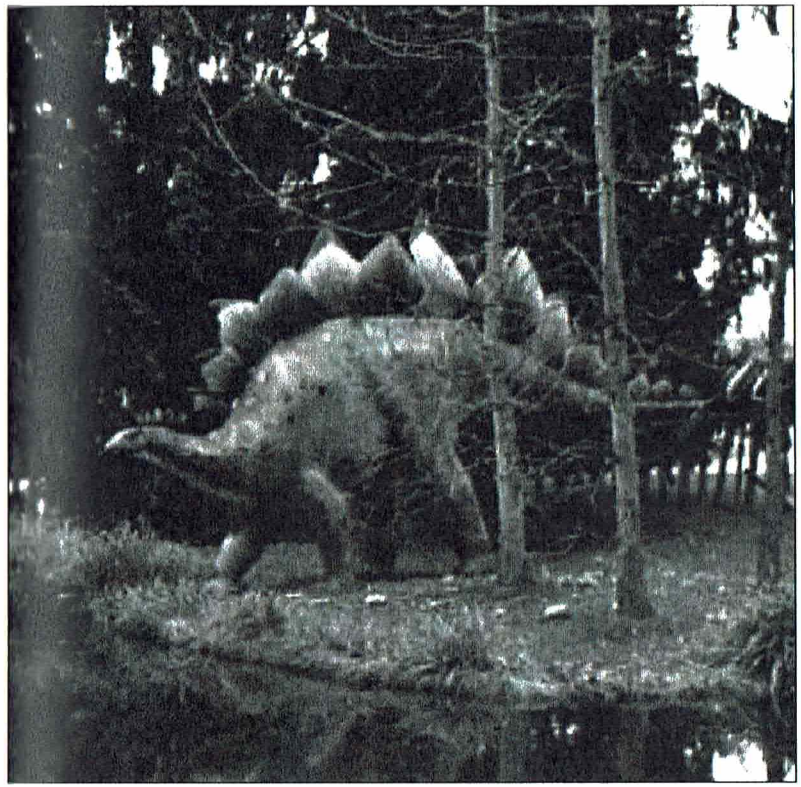
of different birds) sprouted and developed to repeat the process further on. Along the road, some became extinct as conditions of life changed and they lost the battle for survival. Among the extinct species, we could mention the tyrannosaurus and other huge reptiles as illustrated in the following pictures.



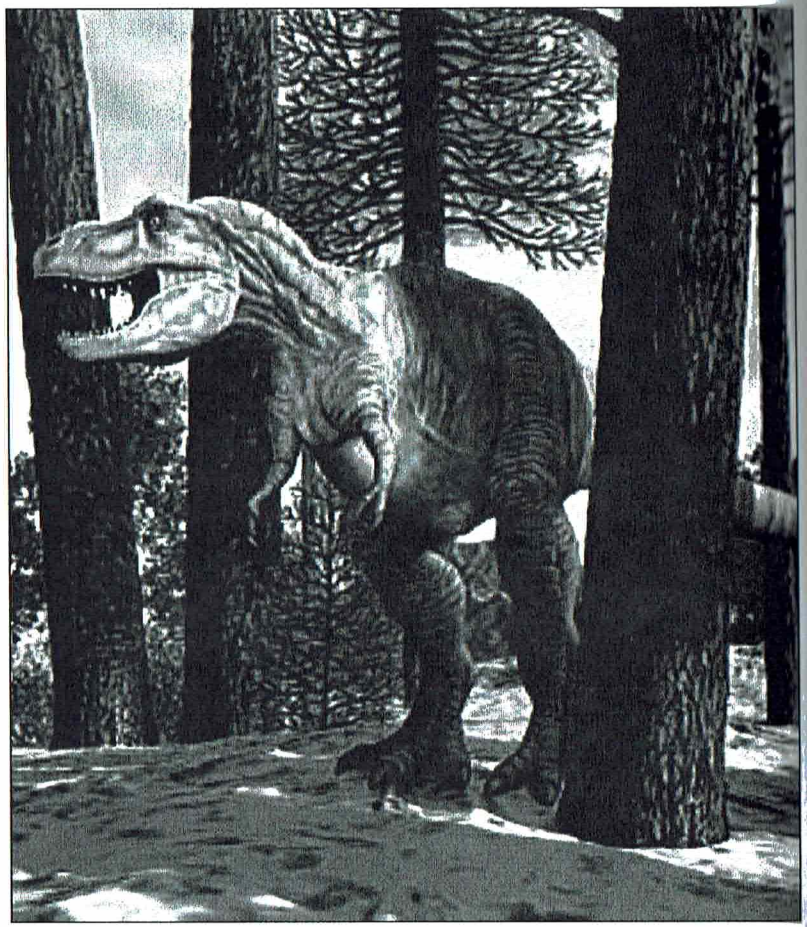
Pterodactyl – 8 meters wingspan



Brontosaurus – 20 meters in length

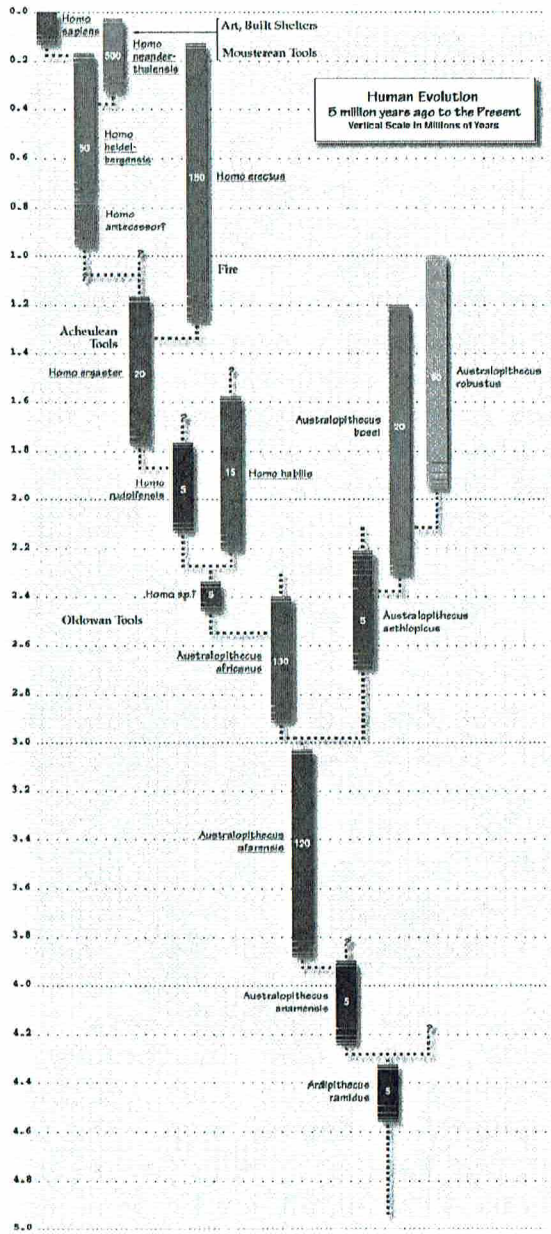


Stegosaurus (Herbivorous)
Supporting defensive armour spine along its back and tail



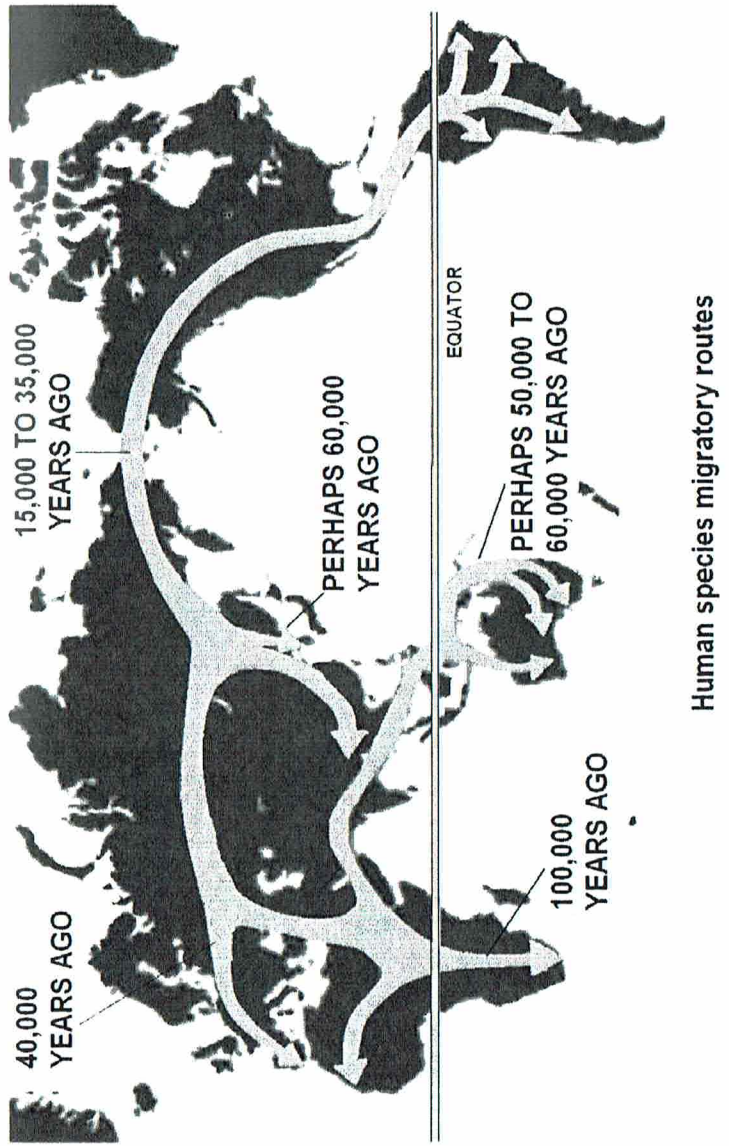
Tyrannosaurus Rex – 15 meters in length
Very dominant among all creatures

The next chart is a rough representation of the evolutionary tree.



Following up the tree, we see the species, called man, standing at the top of it. This creature admittedly stands at the top of the ladder of the evolutionary tree, but the way he got there may not have been worked out in the fullest detail. It is not possible that a four-legged monkey-type creature just decided to come down from the trees, started walking on two legs and began speaking English. There definitely were stages of development. Archaeologists have been busy searching for clues in fossils and rocks.

To date most of the findings are from Africa. The first find was from South Africa. Therefore, it is named Australopithecus. 'Australis' means "South" and Pithecus means 'monkey'. Later on, other species of monkeys were also found. Yet, they were different from each other and it was difficult to trace and determine the common parent to them all. Finally, Australopithecus Afarensis was discovered. That was the famous Lucy from Hadar in Ethiopia. It was a tremendous find. It showed just about where the tree of evolution branched. One branch of it became extinct, but the other led on to be Homo-ergaster, which further evolved into Homo-heidel. This in its turn, developed into Homo sapiens. Along the route, of course, many species have become extinct at different stages and times, e.g. Peking man (china); Java man (Indonesia), etc. The closest ancestor of ours that became extinct recently is the Neanderthal man. The fate of the still remaining species is not known yet, but our slender hope is that it will continue to manage.



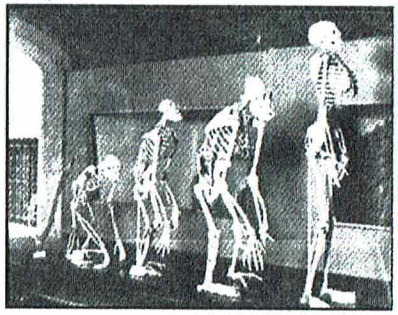
Possible human migration route from the cradle of Africa to the rest of the world.

ORIGINS OF HUMANKIND

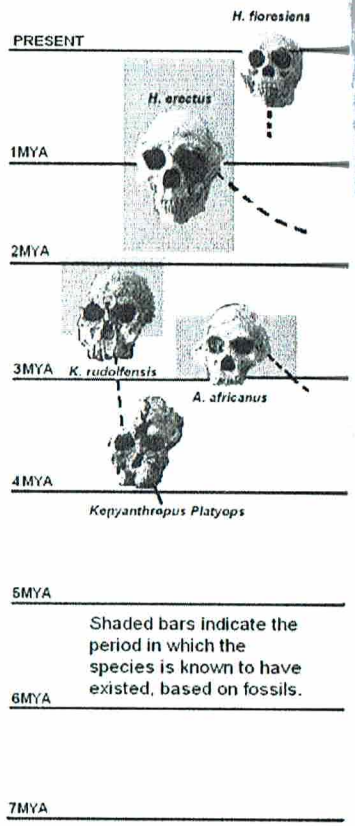
Modern humans are descended of bipedal primates called hominids, which evidence suggests, emerged in Africa 5 million to 7 million years ago.

An Evolving Theory

THE NEW VIEW: As fossil finds and DNA analysis have expanded our knowledge of our species' family tree, the old linear evolutionary model of monkey to man has been supplanted by one vastly more complex.



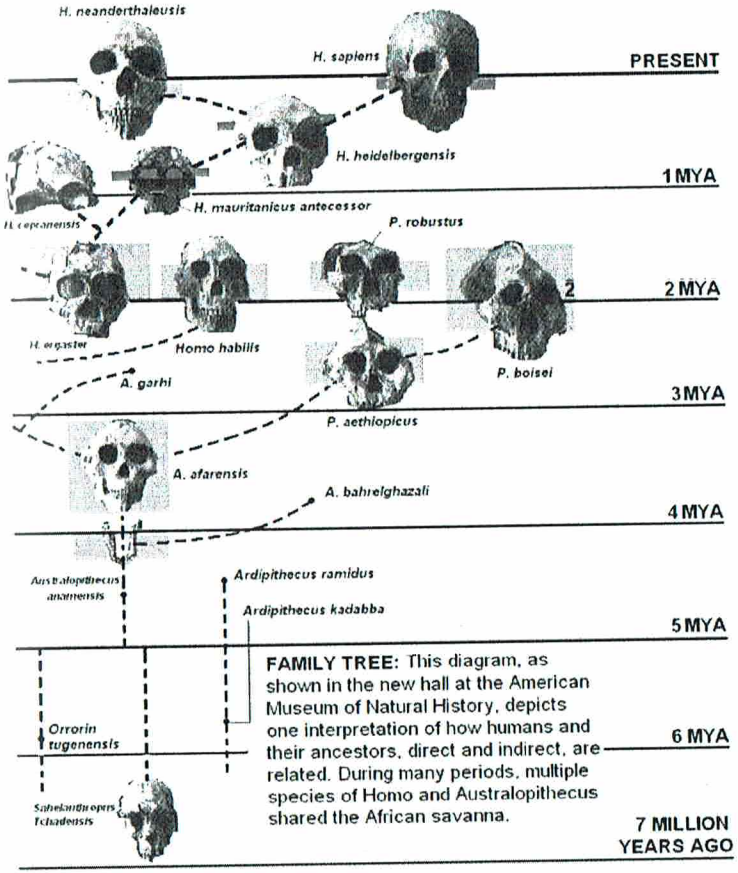
THE OLD VIEW: A 1935 museum display showing the evolution of humans.



Shaded bars indicate the period in which the species is known to have existed, based on fossils.

Various species became extinct as described above

The closest ancestor of ours that became extinct recently is the Neanderthal man. The fate of the still remaining species is not known yet, but our slender hope is that it will continue to manage.



FAMILY TREE: This diagram, as shown in the new hall at the American Museum of Natural History, depicts one interpretation of how humans and their ancestors, direct and indirect, are related. During many periods, multiple species of Homo and Australopithecus shared the African savanna.

Chapter 10



Gregor Mendel

1822-1884

What if the child is unlike the parent?

"The value and utility of any experiment are determined by the fitness of the material to the purpose for which it is used, and thus in the case before us it cannot be immaterial what plants are subjected to experiment and in what manner such experiment is conducted."

In the far distant past, it was not known if children had fathers at all. It was only known that they had mothers. Because of the nine long months, which elapse between conception and delivery, people did not comprehend the connection that exists between the two events. Therefore, it was thought that the wonderful blessing of being able to produce children was bestowed on woman-folk alone and as a result, man felt ashamed and inferior in respect of this capability.

Be that as it may, it is now known that both sexes have their own role to play in procreation. This arrangement is equally valid for animals and plants. Therefore, during Mendel's days it was known that one could pollinate plants to fertilize seeds and breed plants. What was not known then was, for example, how the parents' specific features, or any other traits, can be passed onto the offspring. Some men manage to father children looking exactly like themselves. Others may beget children looking not like them but like their father or uncle, etc. Others do not seem to bear any resemblance with the children at all. It is possible, for instance, that five or six children,

born to the same parents, can be totally unlike each other. Such dissimilarity among children born of the same womb has been a riddle for a long time; and might have caused the mother some problems too.

Mendel sought to solve this riddle and to find out any relationship between parents and their offspring's. He succeeded to throw light on it; and this achievement earned him fame posthumously.

Mendel, in his youth, showed great interest in sciences. Yet, because of poverty, he found himself unable to pursue his studies. As a result, he attended only a 2-year diploma course in philosophy and joined the monastery. There he studied theology for four years and was ordained priest in 1847.

Later, the abbot allowed Mendel to attend University to further his studies. He studied physics, mathematics, biology and chemistry for three years at Vienna University; and on successful completion of his studies returned to the monastery to serve as a science teacher in High School.

It was at this stage, that he started to do his own research. What inspired him to take up the line of research he chose was the observation he made of the fact that as plants bred, some of their seeds turned out to be black or dwarf and thus seemingly unrelated to the parent plant. He decided to cross-pollinate different plants and see what the offspring would look like.

His first choices of plants were peas and beans. Of these, he chose only one or two traits and decided to follow the changes through successive generations of breeding. For instance,

he chose to follow the variation in the height of peas – so he cross-pollinated the short and tall peas. When he collected the seeds of the hybrid and grew them, he found that all the new pea plants were tall. There were no short breeds in the lot. Mendel was surprised by the result. He had anticipated the hybrids to average in height between the tall and the short parents; or perhaps to be sorted out into two separate groups: - tall ones and short ones. Yet, his findings were different.

Therefore, Mendel reasoned correctly that even if the new generations of plants are all tall, they must be containing the traits for shortness hidden within them, i.e. they might contain 'short' genes.

Then, he took these tall plants and crossbred them. He collected the seeds and grew them. Alas! He noticed some change. He saw that for every three tall plants there was one short plant among the lot. So short plants can indeed be obtained from tall ones.

Mendel extended his experiments to include other traits or characteristics of the plants such as red and white flowered plants or round and wrinkled seeds etc. The results were all similar.

Mendel could not straightaway find the explanation for it. He puzzled and pondered the phenomena for eight long years. Nonetheless, during that period he managed to record 10,000 hereditary traits, which he had observed while breeding various plants. At last, he came forward with a new proposal, a hypothesis: - when male and female germs (sperm and egg) unite and fertilize, the trait of the developed offspring will

not be a mixture of two traits like mixing hot water and cold water to get warm water. Traits do not mix in that manner. Instead, the traits will remain separate. That must be why tall parents can produce short offspring. Therefore, we could deduce that when the offspring develops, only one of the two inherited traits expresses itself while the other one, being recessive, remains dormant. If the dominant gene is that for tallness, then the plant will grow tall. However, when this tall plant (which has a recessive gene for shortness within its seeds) is grown and cross-fertilized with a similar plant, the resulting offspring could be short. This time, the two traits for shortness combined and had the chance to express themselves.

That now explains why children may not look like any parent but look like their grandparent or uncle, etc. In a similar manner, intelligent couples can produce irrational children while their offspring in turn may be extremely intelligent (as their grandparents were). Another example – fair-skinned parents may bear albinos or dark skins infants.

Mendel's theory has helped explain away other cases as well. For instance, what determines the sex of an offspring? – was a question unanswered then. Today it is common knowledge that the egg from the female has just one type (say minus) whereas the sperm from the male has two types (say plus and minus). If the plus of the male reaches the egg first and fertilizes it, then the offspring will be male, whereas if it is the minus of the male, which fertilizes the egg, the offspring will be female. Normally there cannot be average

of the two types. Each one will remain an entity by itself. It is of course impossible to foretell which of the two types (+ or -) will manage to reach the egg first. It is purely a matter of chance. It may be noted here that the mother plays absolutely no role in determining the sex of her offspring. She merely receives what arrives first, and is therefore not to blame for any consequences. All this was made understandable on the basis of the theory laid down by Mendel.

Mendel presented his findings to a meeting of scientists and later published it in 1866. Yet, curiously enough, nobody paid attention to it. People were at the time preoccupied by Darwin's theory of evolution and overlooked this important work. Mendel was appointed administrator of the monastery a few years later. In the new position, he had the onerous responsibility of seeking ways to finance their monastic lives. He died in 1884 unknown and unrecognized as a scientist.

Fortunately, his publications had been distributed to other universities in Europe and America. Therefore, when in 1900 three scientists from three different countries, each thinking they had made a discovery in their laboratory in Germany, Holland and Austria, reviewed the literature, they discovered Mendel's works. It came as a surprise to them – the work had actually been done and published 34 years previously! Yet it had remained unnoticed until then. The poor monk has passed away unrecognized.

However, great deeds and achievements do not die with the person; instead, they find their place in history and shine into the future. Mendel is

long dead, but his fame shines on even today.

There is an interesting side-history to this progress of human development. It concerns the politics of the times. This is not altogether a new phenomenon. We have already mentioned it in the case where Einstein's Relativity theory was considered 'Jewish Science' as against 'good' German science. Mendel's Science appeared to be in contradiction with communism. The person who led the opposition to Mendel's theory was the Russian biologist Lysenko. Lysenko held the belief that human character is transmitted from generation to generation not by means of arbitrary combination of male and female reproductive cells but by the environment. If suitable conditions are created for up-bringing children, it is possible to induce permanent change in outlook. It is thus possible to cultivate human nature to bring about a bright future in the world.

Now this line of thinking was found compatible with the reasoning of the authorities in power in the former Soviet Union. Lysenko's theory was embraced and supported by the government. Therefore, he ruled that all scientific publications henceforth and all seminars in the country should be in line with his "correct" approach and that Mendelism was to be disavowed. It followed then that scientific works supporting or approving Mendel's theory were never entertained or made public in the country. Even schools were forbidden from teaching Mendel's theory.

According to the official tenets then prevailing in the country, historical materialism teaches that human social development progressed from

primitive communal life through the periods of slavery, feudalism and capitalism to communism. The conditions of communism dictate that "all people get according to their needs". For this to happen in a world where natural resources are limited, human selfishness and unrestricted greed for wealth should be eliminated by changing human nature and creating the "new man". This teaching of political science extended also to natural science. So famous scientists like Vavilov, who could not accept this line of reasoning were rounded up and sent to jail. Even Peasant Associations, which for years had been practicing crossbreeding their selected cattle to improve their stock, were discouraged and scoffed at by Lysenko.

Lysenko became famous and his name very popular. Communism too, came to be accepted as being scientific. Therefore, progress in genetic science was held back for twenty or so years in the Soviet Union. Fortunately, there was no such restriction in the West, so that now genetic engineering has reached such a high stage of development that it has opened a new vista.

The expectation among people was that the child of a scientist would itself grow up to be a scientist or something of that calibre. The fact is that it could be one, but then it could also turn out to be a simple labourer. A child born to a labourer could remain a labourer but it could also turn out to be a scientist. The environment and the standard of education provided could definitely modify the chance of success. Ultimately, however, it is the mental ability, which is the decisive factor. What a man can transmit to

his child and broadly speaking, what passes down the line of generations is not what is taught in life, but what is defined and coded in the genetic material only. This again is subject to chance when male and female parts join to form the embryo. That is why, as mentioned earlier, children born of the same mother can be so different in character and appearance.

The only factors that can change transmutable characteristics are called mutations, and these come about by radiation exposure, or chemical reactions or heat applied to the sensitive part of genetic glands. That is why one cannot just change human nature by training (or any such external factor) to create a new man.

I recall on this occasion one incident, which is a case in point. Charles Darwin was traveling in company of three foreigners on his historic journey across the Atlantic (and eventually round the world). These men were no different from the other crew in behaviour or in their habits of eating or clothing. They were civilized just the same.

However, these three people were returning to their native country and relatives. Three years back, the captain of the ship had brought them to England to civilize them and to teach them the Christian way of life. He hoped to change them from their cannibal-like behaviour and to teach them to live like Europeans. Meanwhile, they had also received some vocational training and could go back to their relatives to teach them in the Christian manner.

Yet, it took Darwin only a few weeks to realize that after some effort on the part of the three men

to influence their society, they failed and gave up on the idea. They soon mixed with their compatriots to return to the way of life they knew before they left. We all know of our colleagues who moved on to advanced Capitalist or Communist societies and adapted right away. The environment is very important in influencing a way of life, although it is not transmittable genetically.

The idea that environment can create 'a new man' should not be taken as a false notion unique to Communism's tenants. In the past, Scientists in the West have taken too much trouble trying to prove it.

The most famous quote of this attempt is an experiment that was carried on in Britain in 1833. A renowned scientist by the name of Weizman had taken mice and cut off their tails at birth. The mice would thus start their lives without tails and adapt to this condition throughout their existence. When they grew up and produced offspring's, Weizman would cut their tails also. He repeated this act through nineteen generations of mice. He stopped at the 20th and let it grow unaffected. Alas! It grew a long tail and used it exactly the same way its 20th of ancestors had done before. Inheritance of the genes for growing and using tails that long had been continuing through the generations of amputated mice. Weizman had been criticized for his poor observation in life. A Jew that he was, he must have noted that all Jewish children are circumcised by orders of the biblical Abraham; and yet despite some thousands of years since then, Jewish and Christian children are still born

the same ancient ways even if circumcision was practiced all these years. One cannot change genetic properties by external application of modifications or changes.

It is by mutation alone that permanent changes can be induced on progeny. By this method, pure tall races may beget short ones or white pea seeds yield black seeds etc. This too, of course, had to be tested to be believed. The first experiment conducted to test this theory was perhaps that of Dr. Muller in America. The year was 1927. He collected flies and exposed them to an intense dose of x-ray radiation. X-rays in penetrating through exposed bodies bombard cells, causing chemical reaction in them or just damaging some critical structures in them. This manipulation on the genetic organs will cause changes in the genes.

Dr. Muller bred the irradiated flies and examined the offspring. He found some flies with six legs (instead of four) and some others with four wings (instead of two). Others still, were without wings.

Different species come about, he learnt, only by mutation induced on the genetic constituents. The gene (now specifically identified as DNA) builds up the organism, and so any change in the gene alters the way it builds the body. This then creates a different type of organism. Dr Muller won the Nobel Prize for his work.

Today it is accepted that all these varieties of creatures populating the world came about as a result of changes induced by mutation. Now, if, as Darwin had taught, this change is advantageous to the creature, it is a welcome change. The owner

becomes more successful in life. If the change is disadvantageous then the owner becomes disadvantaged in this respect and is not welcome by the society. Therefore, it fails in life. But if the change does not affect the owner one way or another, it lives on normally.

Let us consider specific example: - if the mutation resulted in the birth of a child as limbless, say without the hands, then the child will find it hard to live a normal life, compete with fellow beings and find a mate to procreate in the future. If the change results in making the owner stronger or more intelligent, then the person will have a better chance to succeed in life, he will also have a better prospect to finding a mate and fathering several children as he wishes. Finally if the change due to mutation caused the person to have six toes on each of his feet, this can be covered up in shoes, and does not cause him any inconvenience in life. The hair of the African is curly and is thus different from both the monkey hair and the European hair. This mutational change is definitely not a liability and may even be considered as advantageous in particular situations.

So, as is often said, life is a struggle. Those who struggle successfully can survive, and those who do not will simply die out. When mutation comes into the picture, the resulting changes act to impede or to improve the chances of survival. As a result, several species of animals have become extinct, whereas the rest of us have managed to adapt better and even advance successfully.

The interesting point about mutation is that

not only has it caused to bring about different species of animals and plants, but even after human beings finally came on stage, it has continued to bring about minor changes in them as well.

One theory runs as follows: - the Eskimos (now properly called 'Inuits') are short and plumb in their physical build-up; their faces are roundish and fleshy. On the other hand, desert dwellers like the Arabs and Afars are lean and tall. This condition makes both races adaptable to their respective environments. The Eskimo has to preserve the little heat available. He cannot afford to lose much heat from his body. So the most advantaged individual will be that who has the smallest surface area exposed to the cold. That means that to be short and roundish is the best way to survive. The desert man has to manage to lose heat to keep cool. He needs to have the largest possible surface area exposed to the air. It means he needs to be lean and tall. Now, if the Eskimo is brought to the desert he may suffocate in the heat, and if the Afar is taken to the Arctic zone, he may succumb to the cold.

Another theory explains away the difference in the nose shape between the African and the European. The African nose needed to have large nostrils because he needs to expire enough to release the heat in his body. The North European will find it hard to keep out the cold with wide nostrils. Instead, he has a long and narrow nose. This serves to gain time to warm up the air as it is drawn in.

So when mutation brings about such changes, those found beneficial for the environment at

hand are welcome and survival is assured. The chance to multiply the race increases. If the change is detrimental to survival, it is defeated and eliminated in the struggle. Thus, the environment plays a decisive role in enabling or disabling the preservation of mutations.

Of course, there are people living in the same environment or locality and yet being different in make-up. One's diet does not necessarily agree with another. Some like spice, but others find it sickening. Some are allergic to some substances but a lot of others are not. Fast runners and heavy boxers rise to fame from among ordinary folks. This could be mutation come upon them or they may have inherited the right genes from their parents. Intelligence and special talents are inherited by lucky combinations or correct 'hits' like the right combination of numbers or the presence of 'jokers' in a game of cards.

Thus, bright children could be born of ordinary parents; and scholars could engender ordinary kids. That of course cannot be considered as the fault of the child. The best thing to do for a child is to provide it with a broad range of learning possibilities and entertaining activities, so that it can discover exactly where its interest and talent lie; and then to help it achieve its goal. This alone is the responsibility of parents and of the society at large. Schools have even a heavier responsibility than parents do in this regard.

At any rate, Mendel deserves the credit for having pioneered genetic engineering and research.



Gregor Mendel in the gardens

Corollary

A child born of just a single parent?

Farmers practised selective breeding long before Mendel gave it a scientific touch. Racing horses, strong bulls, high-yield cows and chicken were selected for breeding. Today such breeding is conducted with more precision. Different varieties of wheat and rice have already been obtained in this manner. Using this method, we can produce crops and fruits resistant to drought and pests, with better flavour or taste.

The key to all this is to find the appropriate gene (or DNA) responsible for the characteristic and to replace it with another one of the desirable trait.

But now, things have gone a stage further. Early in 1997, it was shown in Scotland that an individual can be reproduced exactly. So far, it needed both a male and a female to reproduce an offspring. However, it turns out that just one of them is enough for the task. The thing to do is simply to extract the genes from a normal cell of one of them, say the father, and transfer them into another normal cell from which all genes have been extracted. These genes (called recombinant genes) will proceed to build the offspring exactly the same way as they did the father in the first place.

The problem in the past was that only genetic cells multiplied themselves whereas normal (somatic) cells have this mechanism switched off and so just perform the job to which they have been assigned (e.g. muscle cells contract & brain

cells think).

Now a way has been found to induce these somatic cells into a dormant state (they stop their work) from where can be triggered the mechanism to multiply as genetic cells. The Scottish researchers took an ordinary cell from the udder of a ewe, then extracted the genes and made them recreate the original ewe. The newborn lamb (Dolly) became the exact genetic replica of the mother.

Lately, South Korea's researchers took a skin cell from a dog's ear and nurtured it to grow into a puppy (named Snuppy) which became an exact replica of its single parent. Other species cloned so far include mice, cows, pigs, rabbits, horses and cats. If this practice is extended to human beings, a man with enough money or political clout can order to duplicate himself in hundreds of copies and perhaps raise an army, all in his image. This clearly is unethical; and various countries are taking measures to forbid such trials on human beings. But then, who knows where the trend will lead in the future?

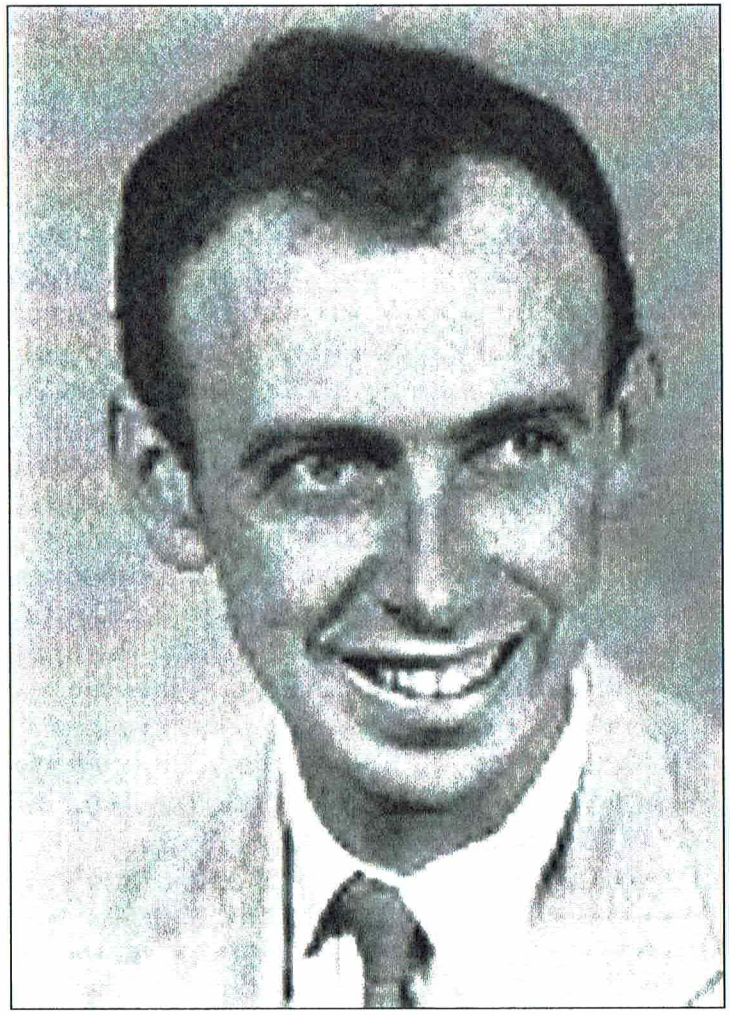


"Dolly"



"Snuppy"

Chapter 11



James Watson

1928 -

Solving the riddle of life[8]

"Biology has at least 50 more interesting years"

Civilization began in the caves of our primitive ancestors and developed to the stage where we are now exploring space and even landing on other heavenly bodies. This is made possible by the progress of science and the study of natural phenomena. The history of human progress is a history of step-by-step development; building patiently one on top of another over this long period between the cave life and now.

Of course, progress was not uniform and did not follow the same style. Some scientists are endowed with such power of mind that they see far beyond others and arrive at their discoveries easily. Some just stumble across it accidentally. Others still arrive at their discovery through a lucky combination of events, facilities or circumstances. There are even cases of discoveries arrived at in dreams. But nowadays most researches are conducted by teams or groups of people.

The problem, in this case, is personality conflict. Not all people pull together in one spirit. Jealousy, mistrust, envy and hatred come into play and spoil the team spirit. Personality conflicts observed in several research organizations are often the cause behind disruption or failure of major projects.

The case of the American James Watson doing

[8] (8)

research in England is not a bitter experience to regret, but what should be expected of a normal group of researchers co-operating but also competing with each other to 'strike the mine first'. I have chosen to present it in some detail to create awareness in our young researchers. It all started in 1951. The riddle of the times was "How does life regenerate itself?"

Mendel had already shown the way by which traits or characteristics are passed on through genes in the reproductive cells from generation to generation.

But what are these genes? How do they transmit such traits as color or intelligence? How is it that the characteristics of male and female do not add up when the sperm unites with the egg? This is like asking why a cell (of the father with two hands) uniting with a cell (of a mother who has two hands also) does not produce a person with four hands. What exactly is it that prevents this from happening? How actually do inert chemicals like the genes manage to build up a life? In short, what is the key to the secret of life? These were the type of questions being asked then, and the key, of course, lay in understanding exactly what genes themselves are.

The scientists had no doubts, even then, that genes were nothing other than proteins. Our bodies are built of proteins. There are of course thousands of types of proteins available. We employ different types in our muscles, nerves, cartilages, enzymes and vitamins. So a gene must be one of such types and cannot be very different.

Yet again, the gene must be different from all these. For one thing, a gene directs the building

of these proteins for all the different purposes required, and for another, it has the capacity to divide itself for fertilization purposes. This division too, must be an act of duplication, otherwise when a cell divides into two; the two off-springs will not look alike. If not, it means one will gain one part of the mother cell and the other another part (such as one will get the nose part and the other the mouth part). But this does not happen. So the gene must be dividing in some suitable way.

Therefore, the challenge was to understand the workings of the gene. To do this, one has first to determine its structure and composition. The chemicals making up the parts must be known and the way the bonds are arranged must be figured out.

"Who can do this job?" was the next question. Biologists refrained from tackling this problem because it requires a vast knowledge in chemistry; they were not quite up to the challenge in that regard. On the other hand, Chemists did not want to delve in the field of biology of which they do not know much. On top of that, this work required the use of mathematics, with which no one dared to tamper. So everyone hoped that somebody other than himself or herself will take up this task.

James Watson was just completing his doctorate dissertation in biology. His professor had long been aware that in order to understand genetics, one has to learn chemistry in addition to biology. He felt too old himself to come back to the classroom as a student and learn chemistry. So he decided to assign this promising graduate

to the task.

Looking for a suitable laboratory, he chose to send him to a professor in Denmark. He obtained a scholarship fund for him from Washington and packed him off to study the genes.

Upon arriving in Copenhagen, Denmark, Watson finds, on closer inspection that the situation is not as he desired it to be. The chemistry research went along a different route, and the biology research did not delve into chemistry deep enough to be of use to him. He was left half way between two streams of research. Besides, his grant permitted him only one year's stay. So he began to worry.

Looking for ways to save the situation, he learned that there was a seminar to be held in Italy. After securing the consent of his supervisor and that of Washington, he headed for Italy in the hope that he might meet other researchers and plan his activities a little more appropriately. Upon arrival in Italy, he found that the seminar participants were divided into two distinct groups. One spoke Italian fluently and was interested in the proceedings of the seminar. The other group spoke good English but not Italian, and having come away from the snowy winter of Northern Europe, the participants were more interested in basking under the Mediterranean sun than in taking part in the seminar. So open air tours and visits got more attention than anything else did.

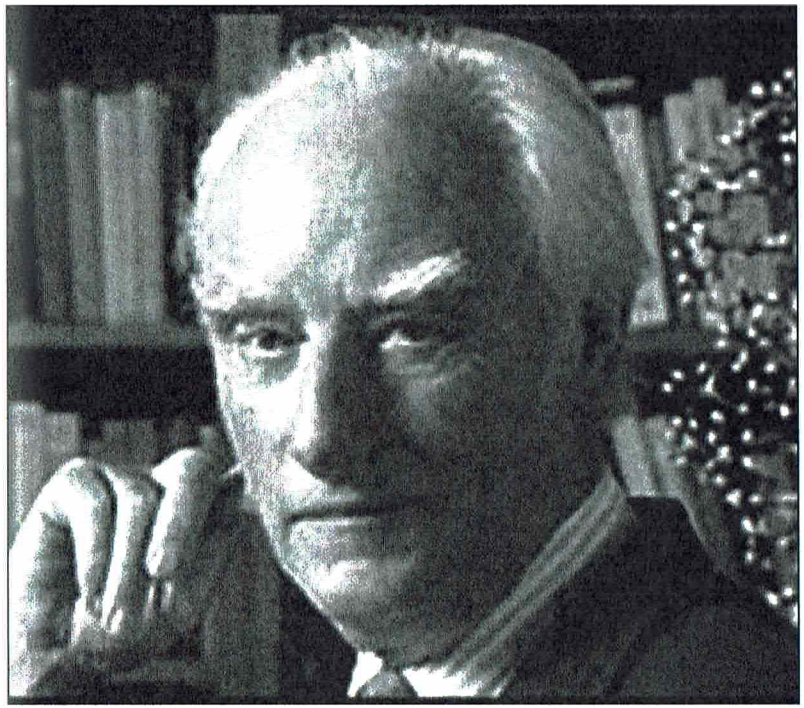
But there was one participant from England who had come on behalf of an anticipated eminent scientist who had failed to come himself. This junior researcher, by the name of Maurice Wilkins, took this opportunity to present his own

modest work. He had brought along some pictures to illustrate his point.

It was these pictures that excited Watson. The contention was that even if protein was the building block of life, there was DNA molecule in all living cells and perhaps this factor was responsible for transmitting traits down through generations. Some experiments made on viruses seemed to confirm this proposition. But nobody had any idea what this DNA actually was.

The picture Morris displayed during the seminar was a picture of DNA. Well, it was not a picture of one DNA because it is too small to be identified in a picture. What Morris had done was to collect a high concentration of the DNA solution and to let it crystallize. (A crystal is a visible form resulting from the regular alignment of the small entities.) Morris had prepared x-ray photographs of these DNA crystals, which he presented at the seminar. Watson was understandably excited by the presentation. Yet, Maurice soon made it clear to Watson that he intended to pursue his own research without any meddling or interference from him. Watson's hopes of joint work were dashed instantly. He returned to Denmark dejected and discouraged.

On arrival, he sent off a letter to Cambridge, England half-heartedly enquiring if he could transfer there. To his surprise, he received an immediate positive response. He packed up and left for Cambridge. The person who was assigned to work with him was a certain Francis Crick. He was a physicist by training but had switched to biology to unravel the secrets of proteins.



Francis Crick

Francis was no ordinary bloke. In fact, he was regarded with fear among his colleagues. His mind was so sharp that when an idea was suggested to him, he grasped it and jumped ahead to suggest an even better idea. That embarrassed many aspiring researchers. Besides, Francis had a habit of going round to the various laboratories and socializing with the workers, so that he knew everything about what was going on anywhere. Therefore, researchers were on their toes when he arrived for fear that Francis might

easily crack the problem upon which they had been labouring for so long, and get the credit for it. As a result, they shunned him as much as they could.

The authorities too, did not like him. Francis, when he laughed, just roared. His laughter was so loud that it was heard all around. The University's Chairs avoided him because they felt Crick showed disrespect for their authority once too often.

Yet, everybody realized the power of his brains and so, in their own interest, did not distance him too far.

Francis, as always, had the feeling that the secret of life lay not in the proteins but in the DNA, but he was stuck with a problem: - A close friend of Crick's, a Maurice Wilkins was handling the work in London.

It is not courteous to interfere in other people's work, good English manner does not allow for such behaviour. But Francis did not expect Maurice to show any progress in the field, because he knew there was a conflict between Maurice and his workmate Miss Rosalind Franklin.

It was at this stage that Watson came into the picture. Watson made it clear on arrival that his concern is DNA, and so the two were glad to find each other and both looked forward to a fruitful endeavour.

As they settled down to work, they decided to try their hand at replicating the work of Linus Pauling. This eminent American scientist had just published the model of protein. This publication had of course, reached them immediately as it did

everywhere else and they wanted to repeat the work. This is a common practice in the scientific field; everyone puts the new findings to the test to confirm or disprove the claim. This is how science builds on a firm basis as it advances forward.

However, Watson and company had other reasons for pursuing this avenue of research. They sought to know if this method could be applicable to DNA as well. They were certain that Pauling, having known the components of protein (carbon, hydrogen, oxygen... etc.) would surely proceed to arrange the models of these components in different forms and x-ray them until he would hit on the form that yielded the same pictures as the films of the DNA crystals.

Watson (and company) built the models, but they had no pictures of the crystals with which to compare their results. The pictures were in the hands of Maurice. They thought of making their own films, but then assembling the equipment and mastering the technique, itself would take about a year, and Watson just did not have the time. They approached Maurice about it. He told them that in an attempt to smooth down relations between him and Rosalind, he had handed over all of the pictures to her. Rosalind, for her part, did not see the point of these people meddling in her affairs.

So the only choice left to them was to wait patiently for Rosy (Rosalind) to present her papers at a seminar the following month. They hoped to see the pictures and learn the details.

The day came and they attended the meeting. Rosy presented her papers and her pictures. What came out of that meeting was that the

woman was a very highly trained person and that she sure did apply her knowledge well to the task at hand. The pictures themselves were of high quality; nevertheless, they were not divulging the details of the DNA structure. This, Rosy announced, had to wait until she had improved the technology in the near future. She regarded this presentation merely as a beginning.

They then proposed to her to build models using known components and comparing them to see if they tallied with the DNA crystal pictures; but she regarded this crude form of research as child's play (or a monkey's game).

Watson felt fenced in. To make matters worse, Francis lost all interest in this work, because he ran into another problem of his own making-- he fell out with the authorities again. The trouble started when he noticed a scientific magazine about a research finding that his immediate boss and the director of the institution, Sir Lawrence Bragg, had published jointly. They had left his name out, and did not acknowledge his contribution. Francis said that it was he, who brought up the idea in the first place. After exchanging harsh words with his boss, he decided to take up with the director to expose this 'theft'. Sir Bragg took a stand saying that he had never heard that Francis had contributed anything to the findings. Francis was equally adamant. He did not believe that Sir Bragg could have failed to hear of his participation when he, Francis, had been going round announcing it to everybody around him.

Sir Bragg was already at the end of his tether with Francis and now the lid blew off. He told him

that he was terminating his contract and threw him out of the office.

By then, Francis was in deep trouble. Watson was in a jam also. The work was stranded.

Later, some arbitrators came round and explained, on behalf of Francis, that he was the one who hit upon the solution published in the journal, and that he deserved some acknowledgement. Sir Bragg was persuaded to pardon him, considering the fact that Francis had tremendous potential to contribute to the benefit of Science. The pardon was granted, and the atmosphere was cleared again.

A few days later, another colleague of Francis, called Max, received a letter from a friend, the contents of which he showed to Francis. The friend, being a mathematician, had formulated an expression defining a pattern of exposure of x-ray diffracted from helical molecules like protein structures. Francis, pondering this method, trying to understand it, sensed that some thing was fishy in the procedure. He could not lay his finger on it, but felt that a conclusion based on this, might be faulty. So he took it to another colleague and showed him the work. They agreed that there must be something wrong in the treatment.

So, Francis went home and stayed up all night thinking about it, and by morning, he had figured out what was wrong. He hurried to do the correction and to write it out in the form acceptable for publication. He feared lest Max's friend realized his mistake and amended it before sending it for publication. Having prepared it so, Francis ran to show it to his friend who, he

found, was equally intrigued and been working on it all night. They compared their findings and having agreed that essentially it was all the same, they submitted it jointly for publication.

Francis was thus on top of his spirits again; and the work with Watson proceeded in earnest.

But the structure of DNA became too illusive. They knew that Pauling in America has established that a protein molecule is helical in shape. X-ray pictures confirmed the fact. Therefore, it was reasonable, Watson thought, that DNA could also be helical in shape. They searched for all literature published on this subject and reviewed it. They knew what sort of atoms or elements went into the making of a molecule. Analytical chemistry has enabled scientists to use acids and other chemicals to dissolve and crystallize or isolate, in various ways, the different components that make up the giant molecule. Even the ratio of their composition has been worked out to some extent. The problem was just how all these parts joined to one another. This was the riddle.

After exploring various approaches, Watson decided to build a three-chain model. So he got the workshop to make him an imitation of the various kinds of atoms, and started joining them up. The bonds and the angles of the joints had of course to be according to the rules dictated by chemistry laws. Gradually a structure began to emerge. Watson hoped that if there were a few chemically unbalanced forces in the bonding, these could be sorted and rectified by comparing its picture with the x-ray pictures of DNA crystals. The structure took up a helical shape.

Now that created a sensation and a sense of anticipation – they were on to something. The only question was where to get the x-ray pictures with which to compare their newly developed model. They had an idea and extended an invitation to Maurice and Rosy to come up to Cambridge to survey this new 'creature' of theirs.

By then, the news had made the rounds that some progress was in the pipeline and even Sir Bragg waited in anticipation of some announcement. He had, in the past been stung, when the American, Pauling, beat him to the discovery of the structure of protein molecule, and now Sir Bragg was anxious to get even with him by the discovery of DNA in his laboratory.

Rosy and company agreed to come over from London, and so careful preparation was made to receive the group. Francis, of course, would be the 'master of ceremony' since he could talk and double-talk to manoeuvre his way through a maze of trouble. At any rate, no one else could dominate a talk when he is around. When Rosy arrived, she made it clear that she was not interested in any dilly-dally and demanded to see the model. After some introductory remarks, the model was presented and uncovered. Rosy blew up! "Is that what you called me for?" she fumed. She did not need any further explanations. She knew that DNA could never be of this model. Queries after queries followed. In a minute, the whole theory collapsed. She left everything in tatters and took the train back home.

When this news reached Sir Bragg, he too felt ashamed. He believed this mess was the making of that talkative Francis who could have done

better had he babbled less. The issue again unsettled the calm that had been restored a while ago by the arbitrators. The director felt that the DNA project should be left to Rosy's group and Francis had better be dismissed. He could stay only until he wound up his Ph.D. Work. The situation was made worse when Pauling from America got wind of this impending discovery and announced that he would come over to look at the model. It was going to be utterly embarrassing to be humiliated by this presentation. Sir Bragg could not be expected to bear with all this.

Fortunately, though, Pauling was prevented from coming to England. His application to obtain an exit visa from America had been refused. The man had apparently been running science and politics side by side at all lecterns he mounted and his "peaceful co-existence with Soviet Union" campaign being covered from his scientific research (and hence government) funds, had caused discomfort to the Administration. This announcement was a relief for Watson and Francis.

On the heels of this development followed another piece of bad news for Watson. A letter from Washington reminded him that the grant originally awarded to him was for a scholarship to pursue his studies in Denmark. Since he had chosen to go to Cambridge of his own accord, the scholarship was to be terminated shortly. Watson was in trouble again. He had wasted much time going around Europe, and he was now to return home empty handed. To save the situation, he tried to investigate the simple tobacco-virus in the hope that he may get one publication out of it.

However, these viruses are built on DNA anyway, and so the problem boiled down to the same issue. So Watson decided to give the three-chain model another try.

He instructed the workshop to prepare large numbers of atom models of different colors to use in building the DNA structure – that would take a whole two weeks. What would he do in the meantime? He decided to use the small number of atoms at hand to build a two-chain model. This helped him to pass the time. At any rate, come to think of it, why shouldn't a two chain model work? Nature in fact prefers two rather than three. Two feet, two hands, two eyes... etc are all in pairs. So he went ahead and built a two-chain model.

The principles of logic dictate that to reach the right conclusion one has to be able to start from the right premise. But sometimes as it so happens, false premises have led to the right conclusions, as in the parables. Watson's argument in favour of binary arrangements may not 'hold water', but the fact is that he arrived at the right conclusions. He discovered the secret or replication of the genes and hence of life.

It did not happen immediately. He fiddled with the model for sometime trying to bind one atom to another in a way that could make sense. He always started by placing the main strands in the middle and building the other small components around it. The main ones are, of course, the sugar and phosphate chains. The other remaining ones were adenine, thiamine, guanine and Cytosine. He was trying to fit them around the main strands but he could not. Then an idea occurred

to him. He thought of interchanging their positions. He placed the main strands on the outside and placed the others on the inside. And lo and behold, 'The Heavens opened'. Every thing became crystal clear. The riddle was solved and the replication method became obvious.

The four radicals have different lengths of bonds. Yet, when adenine is coupled with thiamine (with hydrogen bonds between them); it is exactly symmetrical with Cytosine coupled with guanine. This symmetry allowed the exchange of positions without affecting the external shape of the sugar phosphate strands. This is true, of course, only as long as adenine remained with thiamine and the other two are together. See diagram below.

Now this turned out a beautiful structure. The sugar phosphate strands twist about on the outside with the base pairs connecting like rungs of a ladder in the middle. The whole thing looked like a spiral staircase. But that was not all! The way it replicates itself (or regenerates) during cell division for multiplication was now clear. The DNA spiral can easily separate into two halves, simply by separating right down the middle. In that situation, each strand will serve as a base for the synthesis of another new strand to match it. That is because if, say a sugar chain has adenine as its base, it is only thiamine that can bond to it; none of the others can connect to it. Once thiamine is pulled in and bonded, then a phosphate molecule is locked on to it. The same situation applies to guanine and cytosine. Thus, if there are enough ingredients of molecules in the

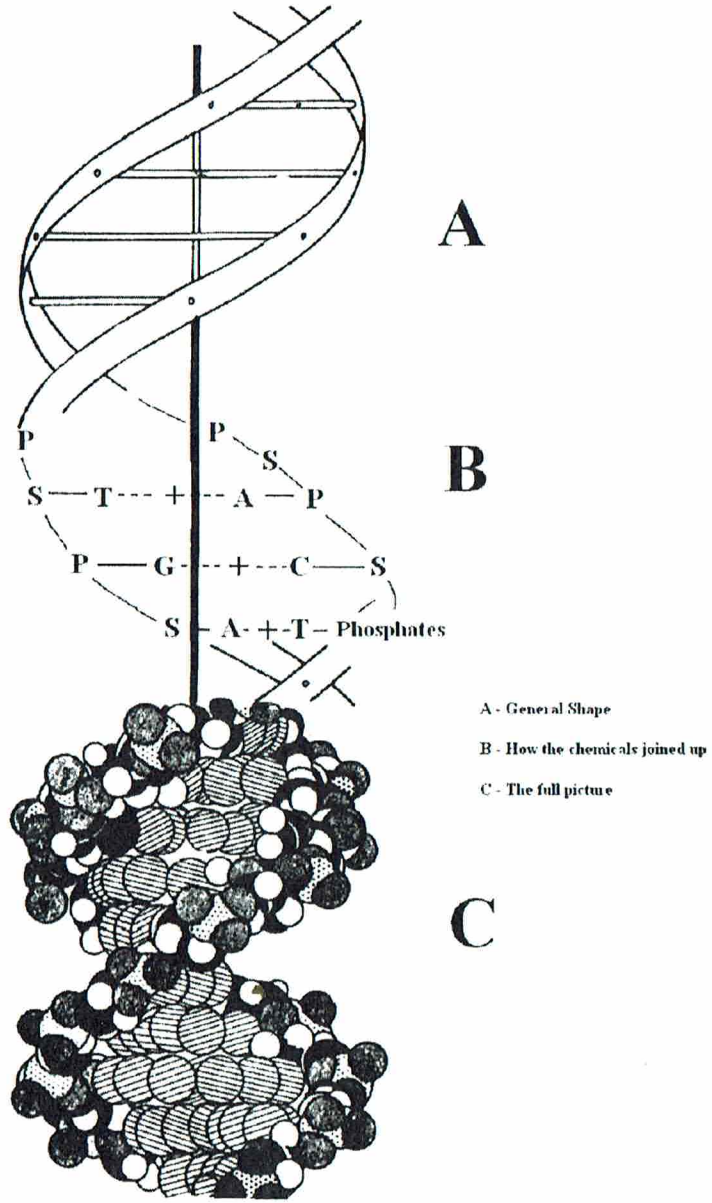
soup, DNA can easily split and form two DNA molecules exactly identical to the original one. This was a revelation. That was how the DNA or the gene was able to replicate itself exactly!

A living cell can, and does synthesize its food only by the guideline issued from the DNA. It is clear, therefore, that the DNA directs the cell to prepare these molecules. Once that is done, then the DNA begins to split into two-strands and each strand completes itself from the prepared material in the cell body. It then directs the cell to divide into two parts with the DNA's going to each of the parts. The cell has thus duplicated itself. That was the essential trick used by cells. The amoeba divides into two, and so do our cells. Each one is exactly like the other and that is how life begets life!

When this revelation downed upon Watson, one can imagine his sense of satisfaction. Well, he was not as expressive as his mate was. But he needed not bother. Francis turned the world over. He announced the discovery loudly to everybody in hearing distance. He went around the campus breaking the news. Letters were dispatched in every direction and the world learned of the discovery in no time. Of course, they deserved the credit. The two together and with Maurice were awarded the 1962 Nobel Prize.

In retrospect, we realize the contributions made by Rosalind Franklin. It was she who first compiled the evidence and made the x- ray films of the structure of DNA. She expressed her displeasure at Watson's demonstration of the three-chain model because she already knew that the sugar phosphate strands lay on the outside

and not on the inside of the helics as was confirmed later. Unfortunately, it was not to be her name that became famous in the world. Worse still, the lady became a victim of the radiation emitted from the x-ray in her laboratory. In those days, the effect of intense radiation exposure on the body was not understood enough, so that the necessary precautions were not taken. She lost her youthful life to cancer in 1958. She had kept to her workstation even after she knew of her terminal illness, and had worked to the last few weeks of her death. It is on the strength and sacrifice of such people that science is built.



DNA – Three forms presentation

Corollary
The progress of genetics

The discovery of DNA structure has brought about a big advancement in genetic engineering. We had learnt from Mendel's days that genes are responsible for transmitting traits from one generation down to the next. Now Watson and company have shown that a gene is just three or more segments of the DNA structure. DNA is, relatively speaking, a very long strand made up of a number of genes connected in series. Therefore, if one of the genes is the responsible factor for, say, shortness, then one can cut it out and replace it by another gene that is a factor for tallness. Then on, the generations that follow, will have this factor for tallness. In a similar manner, other traits for color, shape or mental power can be improved by genetic manipulation.

As a result, genetic engineering is now opening frontiers in different fields. Suddenly conventional ways of improving stocks are becoming out-dated. One used to crossbreed animals and plants to improve their quality. Strong bulls or race horses used to be selected for breeding purposes. This method has worked all right, but it was not foolproof. There was always an element of chance in it.

Now, precision work is becoming the order of the day. Once the gene for the trait of speed has been determined, one just removes it and replaces the required gene for better speed. This is only a matter of engineering. Then the living cell will be allowed to develop and grow, and presto! We have

a super-racing horse.

In this manner, Japan and India have achieved improved types of rice and wheat. Experiments have been conducted in Europe too; pigs, sheep, goats and chicken have produced better quality offspring.

This suggests that developing countries can increase their crop-yield using this technology. For example, the traditional food crop for Ethiopia is Teff. This crop has such a short stalk that it has not been possible to use modern harvesters to reap the crop (as for barley and wheat). The grain also tastes sour when fermented and baked so that stomach-aches and ulcer, common afflictions in the highlands, are ascribed to the bread of Teff. These situations could now be improved to make healthy and nourishing crops for the people living in this area.

To date major advances have been registered in several other countries. Scientists have been able to isolate useful genes and synthesize them. These are then built into another organism, say bacterium, which then start to produce the required item. For example, we are already producing medicine useful for human beings. Insulin has already been produced in this manner. Enzymes and different kinds of proteins essential for human beings have also been produced.

In farming and animal husbandry, plants and domestic animals can be bred, which are resistant to pests and diseases. This avoids the need to use insecticides and herbicides, which have their own side- effects. Such treatment for coffee, cotton and tea will be a highly welcome

benefit. Advanced countries are working on an even higher level than this.

Considering the research, in which Watson was engaged since his Nobel award, we see that he started to determine the role of each gene in the organism. We have seen that DNA is a chain of genes slung together in a row, and these genes determine the traits of the individual.

Sometimes a single gene determines the trait, say for height. But sometimes it takes a number of genes to define a trait like intelligence etc. Yet again, a gene may be responsible for more than one trait. Now all this has to be sorted out and tabulated. The difference in the structure of each gene (the number and arrangements of the base pairs of the segment) has to be determined. Well, this is not an easy task. The relatively long strand of DNA itself is not visible to the eye or easily detected by microscope. The engineering task of cutting, splicing, and analyzing the gene is thus no easy job. That is why one country alone cannot provide enough qualified manpower to deal with the hundred thousand genes present in the cell. On top of that, the cost estimate for such a project (known as Human Genome Project) runs into billions of dollars. That is why Watson has been trying to finance and carry out the project with the help and participation of Japan, Britain, France, Germany and other countries. Although Watson has now resigned for other reasons; the project is in progress and is estimated to be completed in 10 years or so.

Once that has been accomplished, it may be possible for us to build life itself ! DNA, as we know, is made up of a pair of sugar & phosphate

molecules with two pairs of chemicals forming the rungs of the ladder. These molecules are now known and can be synthesized. So if they are connected properly, it means that DNA is constructed. Now DNA can replicate itself. DNA is also responsible for engendering proteins and these are the ones essential for life.

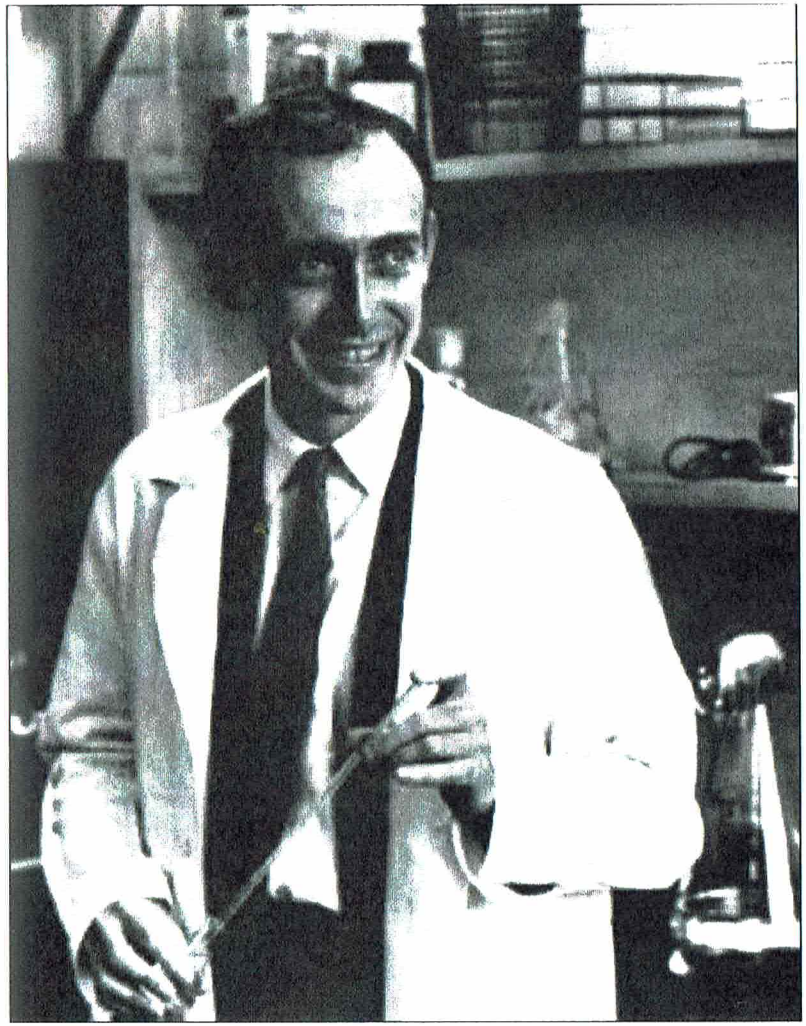
True, there are thousands of protein types. Each type is responsible for a certain activity and we need several types even for just seeing, smelling or tasting functions. However, all of these types are made up of amino acids and there are only twenty-four of them – these combine in different arrangements to form the proteins required. (Note that only twenty-six alphabet letters are required to make sentences that make books and encyclopaedias.)

These amino acids are built under the instruction of DNA. This instruction is coded in the combination of the base – pairs of the four molecules (adenine etc.). A gene, we have seen, consists of three of more segments (or rungs of ladder). Each rung (or row) has four different possibilities of building from the four available base molecules. Three rungs therefore have 4x4x4=64 different possible arrangements together. Four or five segments have correspondingly more choices. So a gene can be coded or arranged to produce any of the amino acids, hence proteins.

It follows that since organisms are composed of different types of proteins, which in turn can be built by the DNA; it is possible to construct the required set of DNA to start the process of life *in the laboratory*. Architects design a building in

every minute detail of it and put up the picture long before the excavation work is started. In the same manner, one may design the sort of creature wanted and then go about building the DNA to manufacture it.

Where this technology will lead us to is not yet certain, but, sure enough, it raises many grave ethical issues.



James Watson

Chapter 12



Aklilu Lemma

1933-1997

Observation versus seeing

The riddle that gnaws at the heart of every honest citizen is why backward countries remained backward. A few hundred years back, all countries were more or less at the same level of development. Going back in time to the period before Christ, the Middle East appeared the center of civilization. Queen Sheba is mentioned in the Bible and admired in Ethiopian history for her travels to Jerusalem to witness the progress achieved by King Solomon and his people.

Later in time and up to the eve of the Industrial Revolution, it was China (where Marco Polo went) and the other Far East countries that led the way to civilization. In those days, the continent of Europe was in the "Dark Ages". America was not even discovered by Columbus.

In short, revolutionary changes started only recently. All the technological wizardry that we witness today is the product of the last few hundred years. It used to surprise me when I met famous scientists, whose works and discoveries I had learnt in school, attending conferences. I had thought that such people would not still be alive. I see from biographies that many of the prominent scientists in history were still alive after I was born. So I get the feeling that discoveries were a recent phenomenon.

Why was it that the African continent was left so far behind in civilization? If civilization is such a recent phenomenon, why were we still dozing when others woke up and ran?

Various explanations can be proposed. I think

the major reasons are the physical features and the climatic conditions of the continent. It is a rugged mountainous region deeply dissected by gorges and valleys resulting in isolate areas where people cannot meet and mix freely. If people do not come together, they cannot learn from each other and there is no stimulation for improvement. There is no trade and there is no progress.

Tropical diseases are another factor. These sap the energy – both physical and mental – of the inhabitants and make animal husbandry very difficult. Tsetse flies, for example, cover almost half the continent and afflict both humans and animals. Malaria is another tropical disease that still plays havoc with people. The remedy for it was to spray DDT in every house of every village in an attempt to break the development cycle by wiping out the parasite. But now that DDT has been discovered to have undesirable side-effects and since the mosquito has developed resistance to it, the campaign, which already cost the continent hundreds of millions of dollars, is in limbo.

Bilharziasis or schistosomiasis is another debilitating disease for which a cure was not available until recently. The parasites responsible for this disease harbour in the liver, pancreas, spleen and intestines of human beings, and upon breeding in millions, impede the normal functions of the organs thereby causing pain and even death to the victim.

These are some of the factors, which scourged millions of Africans over the centuries. It took a long time to bring the problem under control,

partly because these tropical diseases are unknown in the temperate zones of Europe and therefore, did not interest the scientists. Besides, there has always been the problem of funding such research by governments whose first allegiance is naturally to their respective countries. We are reminded of Darwin having suffered for forty years, because the disease was totally unknown in Britain then.

But eventually, when the "Scramble for Africa" began, the extent of the problem in Africa was recognized. In fact, "White settlement" was impeded for several years due to the lack of protection against these parasites. The fact that the African race was able to survive at all is a major achievement in itself. However, it remains a fact, the features and environs are major factors, which hinder progress.

A situation of one such scourge occurred in a region called Adwa in Ethiopia in 1964. The Ministry of Health in Addis Ababa received a report of the tragedy in the area and a request was thus submitted to the national university to send qualified staff to investigate the case. The university assigned a team of biologists with Aklilu Lemma as the team leader to tour the region and to report on its findings.

Dr. Aklilu Lemma was a fresh graduate who had just completed his doctorate works in pathobiology and had joined the biology faculty of the university. He was born in Jijiga (then a part of Harar province) on September 18, 1933. He attended elementary school in Harar and completed his secondary education in General Wingate School in Addis Ababa. He pursued his

college studies in Addis Ababa University and graduated in 1955. He then went on to John Hopkins University in the United States where he earned his D.Sc. in 1964. He was employed as a lecturer at Addis Ababa University when he received his assignment to Adwa.

Aklilu was surveying the afflicted area when he came across a small pool of water where villagers were washing clothes. In those areas, as in other remote areas, it was hard to find soap so people were using Endod for washing clothes. The word Endod is a vernacular name given to what is known in scientific jargon as phytolacca dodecandra. It is a tree that produces small-size berries, which can be collected, dried, powdered and mixed with water to produce a foaming detergent. Thus, it has similar effects as soap when used for washing clothes.

Aklilu was passing by the pool when he paused for a while and noticed some dead snails floating in the stream where the villagers were washing. Walking up the stream, he observed some other snails in the water, but these were alive. This observation marked the beginning of what was to result in a fruitful research and international recognition for Aklilu. He wondered what must have caused the death of the snails down stream – in the pool. He asked for some suds from the washers and put some of the live snails in it. In a few minutes, they let off small air bubbles, then bled and shrivelled to death. So Endod was the cause of their death. Therefore, Endod can serve as a Molluscicidal agent to control Bilharziasis, since the disease is transmitted by small parasites, which use snails

as their host for breeding. Now then, if snails could be killed readily by Endod, the disease can easily come under control. This is of benefit not only for Adwa or even Ethiopia, but for most other developing countries as well.

But does Endod attack only snails? Or does it adversely affect other marine creatures too? If it kills other water-born creatures, then its utility is very restricted. Hence, it became necessary to determine just how little is enough to kill the snails without affecting the other creatures. This is where Aklilu's research began. But very soon, it started to diversify.

Senior students from the Biology Department were mobilized to collect snails from ponds and lakes around the city. Then Endod mixed in water at various concentrations was laid out in glass beakers and the snails placed inside. After 24 hours, they were removed, washed in fresh water, given a recovery period of another 24 hours and the number of dead snails was then counted. This gave a promising result. Further experiments on the effects of temperature, light, storage, age of snail etc., on the Molluscicidal activity of Endod were conducted. Field trials around irrigation canals and lake shores were carried out. After that, Aklilu launched the program by announcing the pursuit of his laboratory research and field-observations through seminars and symposia to local and international interest groups. The response was immediate and the interest was high.

Aklilu expanded the work. He established an institution and diversified the activity. To begin to understand the phenomena, snail breeding was

started up, the cause of death brought on by Endod was investigated and which component of the Endod was the active ingredient was also studied. For example, the berry, bark, stem, leaves and roots of the Endod plant were all analyzed. Cultivation of Endod, extraction of the active component, preparation of detergents from Endod and other side-effects, if any, were all surveyed.

The actual mechanism of infection causing the sickness and the need to fight the snails in order to interrupt the life cycle of the parasite became clear. The parasites responsible for human infection are the larvae (cercariae) that are released from the snail into the water. These enter the body through the skin of the legs, hands or body as people wade in the water. They then enter the blood circulatory system and find their way to the liver, intestine or bladder. There they grow to become adult worms and mate. Thousands of eggs are produced, half of which find their way out through urine and faeces into water. The larvae upon hatching swim around looking for snails to enter and continue the cycle.

To break this cycle of development, the measure taken in the past was aimed at treating all infected people to rid them of the disease. But this had not been possible. One reason for this is that the victims are, for the most part, people of Developing Countries who do not have the necessary toilet facilities in the fields. Another reason that could be cited may be the high cost of synthetic chemicals that need to be imported. Spraying these chemicals in the rivers, ponds and lakes of a wide region is very costly.

This is the reason why Aklilu's announcement of the Molluscicidal effect of Endod was received with enthusiasm and high hopes. On the strength of this encouragement, Aklilu established the Pathobiology Institute under the umbrella of the University of Addis Ababa. He sought for funds and obtained some from foreign donors. He proposed to enlarge the activities to include other related tropical diseases, which tended to be ignored by scientists in temperate climates. Leishmaniasis was one of these diseases that were transmitted by mice and moles. It attacked the skin and invaded the tissues causing pain. The diagnosis was elusive in local hospitals and the treatment was not easy. Field studies were conducted and surveys made in the country.

Trypanosomiasis was another problem. This disease attacked cattle in their thousands and is transmitted by blood-sucking insects. The people, whose mainstay in the rural areas is cattle, are economically affected when their scraggy cattle become unable to provide traction or milk, and even die. Again, research and field surveys were undertaken. Samples were collected and the distribution of the disease in the country was mapped. Other branches of research on flies and insects that act as vectors for diseases were also investigated. At this point, scientists in other countries interested in one or other of these activities came to join the research. Some brought along their own equipments and funds; others sought international sponsors to support them, but all were provided with laboratory space and manpower to train.

The Pathobiology Institute soon gathered

strength and flourished. The facilities were expanding and up-to-date. One of the more conspicuous instruments at the time was a nuclear energy source given as a grant. It was a cobalt-60 gamma radiation source that was housed in a separate little block away from the laboratories.

The source emitted powerful radiation. Now this radiation is of the nature of x-rays and can penetrate even deeper into tissues and other objects. It can thus easily cause damage to life, but if used in a controlled environment, can help sterilize or weaken micro-organisms.

Louis Pasteur had already shown that some micro-organisms, if sufficiently weakened and then injected into the body, can stimulate the body to produce antigens that will thereafter defend the body against further infection – which is the principle of vaccination. While using this powerful radiation in a controlled environment, it was attempted to irradiate the germs suitably and inject them into cattle, sheep and dogs to investigate the effect. Seed crops and fruits were also exposed in samples to see if new mutations could occur.

This burst of activity in radiation works demanded protection measures for the workers. Marie curie, and Rosalind Franklin, we have seen, lost their lives due to high exposure to radiation. Hence, there was the need to establish a radiation protection service. But it became at once clear that x-ray technicians in hospitals around the country needed the service as well. X-rays were used for diagnosis (e.g. bone fracture) for therapy (e.g. Cancer) and for radiography in industries

and workshops. All the workers engaged in these fields had to be included in the service planned.

A radium source was secured from abroad. With this as a standard source of radiation for calibration purposes, film badges were used to monitor exposure. Thus, a new laboratory for radiation protection was established in 1975 and it extended its services to all x-ray technicians in the country.

This is one illustration of how one concern leads to another, and activities grow and expand in many directions. What initially started as a study of the effects of Endod on snails grew into an institute whose activities branched out into several new but related research and development activities.

Development is dynamic in the sense that once started and handled properly it can awaken and stimulate related activities thus diversifying and multiplying itself at an increasing pace. The Pathobiology Institute became the center for information dissemination on these diseases, a training ground for research students while providing services to other people wanting to use, say the radiation source, for their own researches.

As regards Endod itself, research is still going on both at the national and international levels. So far, sixty-seven brands or types of Endod have been identified in Ethiopia alone. Of these types, number 44 is said to be highly resistant to pests, easily cultivable in different regions and with a high yield of berries to the tree. Several countries, Kenya, Tanzania, Zambia, Brazil and the Philippines among them, have now received samples of this variety for cultivation and for

continued research.

There are indications that Endod has other uses besides killing snails. Obviously, it is used as a substitute for soap to wash clothing. This has been in practice in Ethiopia for generations past. Aklilu had intended to combine these two benefits. Instead of preparing Endod as a Molluscicide and going around to spray it over lakes and ponds, he suggested to prepare it in the form of soap, so that people can buy it and go about using it in rivers and ponds thereby serving the double purpose of washing as well as killing the infectious snails. This practice will reduce costs enormously and ensure continued application even in remote areas.

One should mention that Endod could as well kill fish and leeches. People used to apply Endod to rivers and ponds to float out the fish en mass. This makes fishing easier than hooking fish one by one. But this adverse effect of Endod on aquatic creatures can be avoided by careful application. Snails stay near the banks of running water and in shallow areas of ponds, whereas fish swim in running water and deeper parts of the water, so that application of Endod intended for snails may not cause serious harm to fish and the like.

Further uses of Endod might include abortion, dandruff, malaria eradication and lightweight cement blocks (due to its foaming effect). Other possible uses have been indicated in other countries. Researchers in the United States, Canada, Denmark, Finland, and Japan have been looking into these possibilities. International organizations like UNIDO, UNICEF, and WHO,

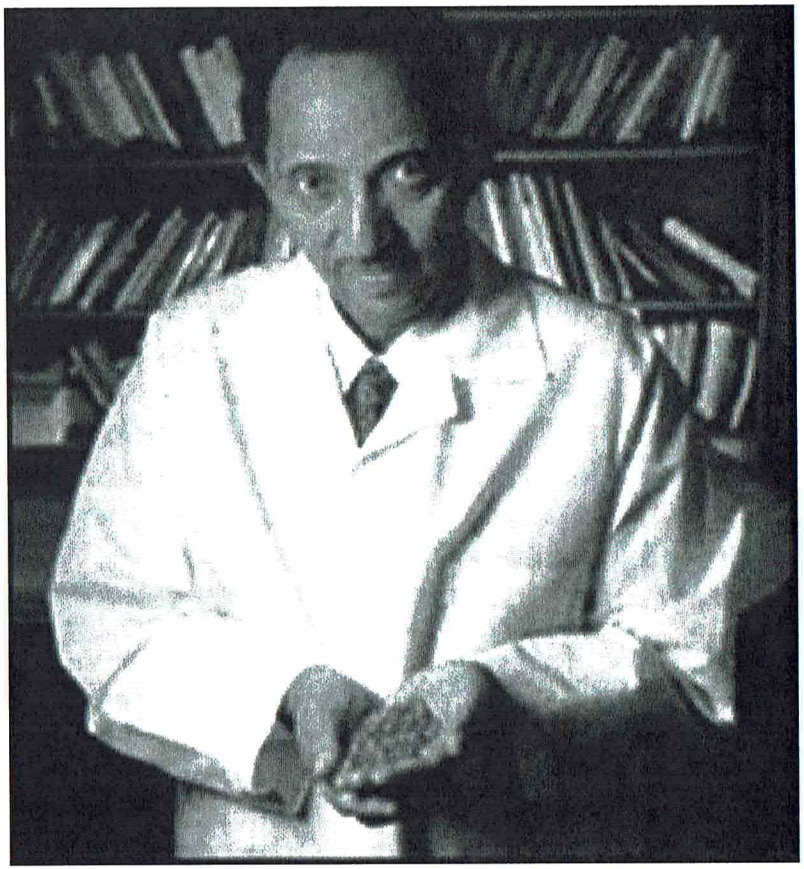
have also shown interest in the hope that these findings may address some of the problems of Developing Countries.

Dr. Legesse Woldeyohannes is now leading the Endod project in Ethiopia. He replaces the late Dr Aklilu Lemma with whom he had been cooperating for several years. In fact, it was Legesse who identified Endod variety No 44 and introduced it to the world. He is currently heading the Ethiopian Endod Foundation and coordinating other related activities.

As a result of their joint effort to pioneer the Endod project to help alleviate the poor man's problems, the two have been jointly awarded in 1989 the Right Livelihood Award prize. This recognition by such organization was very gratifying to them and indeed helped in further promoting the research effort. The 3rd international workshop on Endod was held in Addis Ababa in 1990 and it hosted about 40 eminent scientists from 12 different countries. This is evidence of the fact that Endod is winning worldwide attention and recognition.

This, of course, is a source of joy to us. But Endod cannot be the only plant worthy of further investigation. There are several different kinds of plants growing everywhere. In Ethiopia, for example, there are 7000 kinds of plants as reported by scientists. Of these plants, about 1500 of them are endemic to Ethiopia. Perhaps some, if not many, of these plants can provide a cure for some of our afflictions. Perhaps still, some may hold the key even to the losing battle we are waging against the ravaging diseases of the world. This of course is for scientists to

explore and investigate. Scientists of Developing Countries have the duty to face up to this challenge and contribute their mite for the well-being of their people.



Aklilu Lemma with grains of Endod

Corollary
Bilharziasis and Endod

Bilharziasis (or schistosomiasis) is a disease, which is caused by a worm called schistosoma that infects the liver, intestine or bladder to cause swelling and pain. It is spread by infected people contaminating the water with the eggs of the worm in their urine and faeces. The eggs, once in the water, hatch and release larvae (miracidia); these then swim about in search of snails, and upon finding one, enter the body and continue their development. After a couple of weeks, hundreds of Larvae (cercariae) are released daily from a snail, and these swim about looking for human beings. As peasants wade about washing, drinking, bathing, or irrigating the fields, these cercariae dig their way through the skin, enter the body, and settle in the liver, intestine or bladder. Here they complete their development and in turn, produce eggs in their thousands. Half of the eggs may then be evacuated through the urine or faeces while the rest remain in the body to cause pain and weakness.

Depending on the type of Bilharziasis (urinary or intestinal) they cause damage to the bladder and kidneys (thus causing blood-release into the urine) or they cause swelling of the liver and spleen, which results in fever and diarrhoea. The stools may also be stained with blood.

Therefore, to break the lifecycle of the worm, the one easy way is to eradicate the snails. Now this can be achieved by applying Endod to the waters. So cultivating Endod on a large scale and

spraying the waters with it appropriately, (thereby killing the snails) will rid the people of the disease.

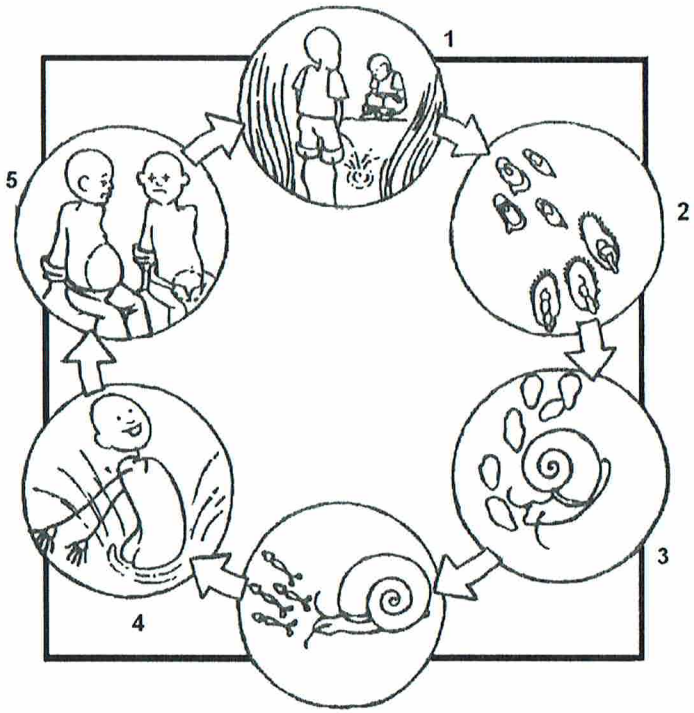
Cultivation of Endod is now a well-established procedure. There are male and female types of Endod – the male produces only flowers. It is the female that grows the berries. So to cultivate the plant, branches are cut from the female tree and stuck obliquely into the ground. The cuttings may be about 30 centimetres long and with two or three nodes each. When the plant grows and produces fruit, the berries are collected green (i.e. before they mature to redness) and then dried (to prevent rot or loss of potency). This is then powdered, dissolved in water and sprayed on rivers etc. If used as soap for washing purposes it obviously yields double benefit.

The amount of Endod required to kill almost all snails in the stationery body of water is sixteen grams per one cubic meter of water. For running water, it is recommended to be up to twenty grams per cubic meter. Working out the measures all in volumes turns out to be one litre of Endod powder in thirty-eight cubic meters of water.

Application of Endod to a large body of water (e.g. lake) requires attention. It will not be necessary to spray the whole surface area. Instead, it is enough to limit the spray to the banks where aquatic vegetation shelters the snails and where people come in contact with water. Three meters around the lake or pond is a good rule-of-thumb to spray Endod powders. The frequency of application may be once every three months (to catch newly – hatched eggs that may have been left behind after the snails were

eliminated). To maximize effectiveness, spraying should be done in summer or dry season when snail populations are concentrated in reduced water volumes

Bilharziasis is a disease widely spread mostly in East, West, and Central Africa and also in Brazil, and in South East Asian countries.



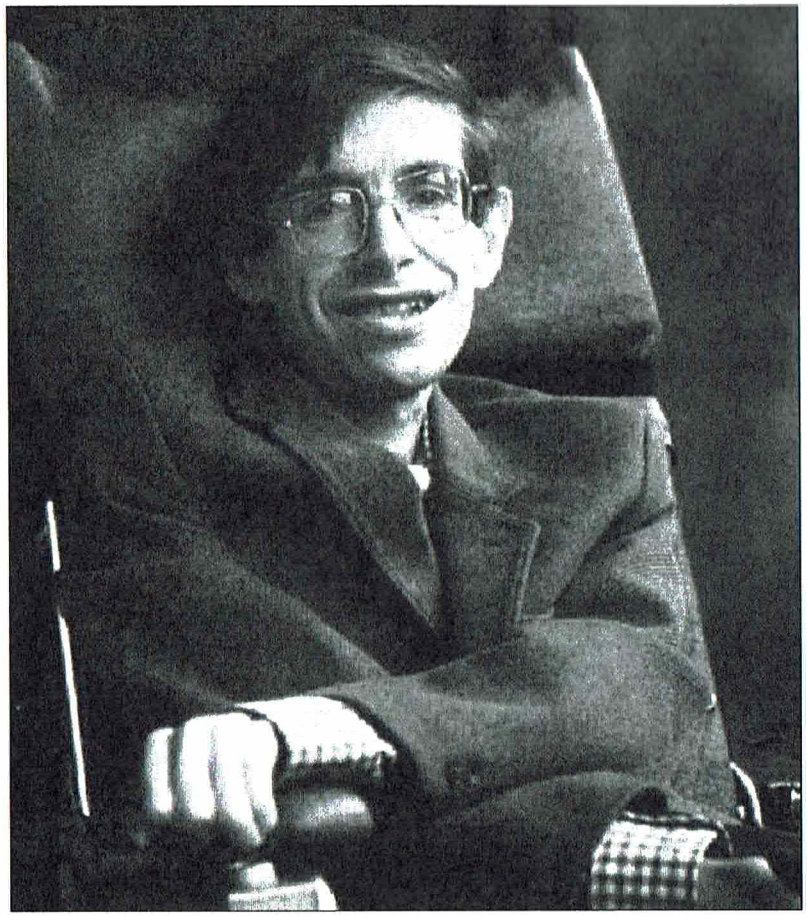
Bilharzias Lifecycle

Legend:

1. When an infected person relieves into the water
2. the eggs hatch and
3. enter the snail
4. the cercariae finds a host
5. multiply in the intestine and bladder

...the cycle continues.

Chapter 13



Stephen Hawking

1942-

How may it all have come about?

"I think computer viruses should count as life. I think it says something about human nature that the only form of life we have created so far is purely destructive. We've created life in our own image."

It is a long time now since Stephen Hawking has been expected to die. A year after graduation from Oxford University, Hawking fell victim to an illness. The year was 1962. The doctors were puzzled at first, but soon learned that this was a fatal disease and Hawking had no more than two years to live.

Hawking's condition soon began to deteriorate. He felt a loss of dexterity and paralysis that made it difficult for him to lace his shoes and later even to talk. Gradually he began to lose control of his voluntary muscles.

Then he reached the stage where he could no longer walk. He became confined to the wheel-chair. Then he lost his speech; he could no longer talk. Thus, he had to suspend his studies for the PHD degree. Broken-hearted by his son's misfortune, Hawking's father approached the teacher to help him get the degree before his death. The teacher, sympathetic though he was to the boy, declined the request. Hawking was very depressed when he learnt of his eminent death. He spent the next two years listening to classical music and reading science fiction books. Occasionally he drank to help himself forget his fate.

Finally, all body movement ceased. He could

move none of his limbs. This is a motor neuron disease. There are two types of muscles in our body: The voluntary and involuntary muscles. The voluntary muscles are those we use to move our body parts (hands, feet, neck, etc.) at will. The involuntary muscles control heartbeat, brain activity and all those others over which we do not have voluntary control. Hawking's disease was the type that paralyses the nerves controlling the voluntary muscles.

Hawking finally lost control of all his voluntary muscles. He could not move any of his body parts. But strangely enough, his condition started to stabilize at this point. Death itself was no longer imminent. His spirits rose again. Today Hawking is still alive. True, he needs close attention from helpers. He will remain helpless, for instance, if his head dropped onto his shoulders or forward, he needs someone to raise it back to the head support of the armchair.

But what does this man do for a living now? He is a professor in Cambridge University. He is a physics teacher and a researcher in theoretical physics. He is regarded by some as the foremost scientist alive today.

Einstein had been grappling for the last thirty years of his life trying to formulate the grand unification theory that encompassed all the forces of nature i.e. gravity, electro-magnetic forces, and Strong-and Weak-nuclear forces. He did not succeed and the struggle continued after him. Scientists armed with the most powerful computers at hand are still labouring at the task. It is now over forty years of ceaseless work to solve the problem and no one has succeeded yet.

It is the conviction of many scientists that it will have to be Hawking who can 'crack the nut' at last.

Hawking's brainpower is stupendous. He can work out several pages of complicated equations without the need of paper. His power of memory too, is immense. He is known to have remembered even the page number of a minor mistake in an equation he read in a book some years ago. Other examples of his feat in remembering past events could be quoted. This talent is perhaps unique among present day scientists.

Now, what exactly is the riddle that is bothering Hawking? The question put simply reads, "How is the universe created?" [9] Of course, religion can provide an answer to that but Hawking wants tangible facts, which can be understood clearly, tested experimentally and thus scientifically proven to be acceptable.

Asking this question did not start with Hawking. Scientists have been asking it and attempting to find answers to it even from the days of Einstein. To grasp the essence of the question, we may go a few steps back and review the background information. To begin with, what is the universe?

We know from the elementary schools that our earth is a planet that revolves around the sun. There are eight other planets too that revolve the same way. The sun itself, though it looks big, is quite an ordinary star that appears big only due to its closeness to us. There are 400 thousand-

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[9] (2)

million other stars in our neighbourhood. These are collectively known as the Milky Way. This is a galaxy, and there are other 125 thousand-million galaxies in Space! This is only as far as we could see today, and there could well be more of them beyond our vision. The totality of these stars including the space and gas in between forms the universe.

All of these stars are in motion. They move at different speeds but they all move in such a manner that they appear to have started out from a certain central point. The scientists of today believe that some fifteen thousand million years ago, a Big Bang occurred and matter and energy whirled out throughout the universe. Apparently, the effect of this gigantic explosion still affects the stars and galaxies flying out in all directions today.

So going back in time and asking ourselves "where were we a million years ago?" 10 million years ago?' etc., we work out the equations defining the situation then.

This work made a significant headway during Einstein's period. Einstein, having introduced the subject of Relativity, turned his attention to this task. He was convinced that the laws of nature in their totality can, and should be, expressible in the form of an all-encompassing equation or set of equations. We know for instance, that if a car is traveling at a fixed speed along a road, we can calculate its position an hour ahead. If a stone is thrown vertically up at a known speed, we can determine how far it can climb and when it will fall back to strike the ground. In almost the same manner, we should be able to calculate from the

known speeds of stars flying out from the center of the Big Bang, where they would be after a given period of time. We could also determine where they were and how hot they were in the thousands of years past.

Einstein had put some equations in place, which went a long way to define the state of the universe. There are, of course, some difficulties in defining the equations precisely. One of them is that the law that governed and defined the universe then is not the type that we are experiencing today. Today the dominating force governing the stars is gravity. It is gravity that spins the earth round the sun, that propels the sun and the other stars in our galaxy in their own orbits, and finally, even the whole galaxy together with other galaxies in their respective directions. We are held to earth by gravity and our satellites revolve around due to gravity.

But going back in time, we learn that it was not gravity but the so called 'weak-nuclear force' that played the major role during the time when matter was close together and the temperature was very high (this is the force that governs radio-activity for instance). Before that period, the electromagnetic force played the dominant role. It still spins the electrons around the atom and is the cause for light waves and radio waves so useful to us now.

The strong force, which was called into play in the early seconds of the birth of the universe, is the strongest force. It still holds the protons and neutrons of the atom together. Incidentally, had one or another of these forces not existed, the stars would not have formed, the sun and planets

would not have been the way they are, and, we would not have been here!

Scientists generally accept that initially all of these forces, being inherent to matter, were all combined and united into one force at the birth of the universe. It is that single all-embracing force, which is required to be understood. In other words, the aim is to unify the four known forces into a single mathematical representation. This is the problem. It is the issue that has engaged Hawking's mighty brainpower to this day. The Grand Unified Theory! What would result from solving this equation? Would it reveal the fundamental nature of the universe? Hawking's hope is the "complete understanding of the universe; why it is as it is and why it exists at all".

If the search leads to that revelation, it will be very gratifying. It is true that there are many yet unsolved problems in life. For example, we do not even know the mechanism of thought, i.e. we do not know how we think. So we may not be sure if the problem at hand, when solved, will settle all our questions. Of course, past experience shows that when a scientific problem is solved, many other related phenomena become clear. Even, apparently unrelated ones come into focus and get explanation from such unsuspected sources.

At any rate, the riddle is there to be solved, and although we cannot foretell which riddles will be then clarified – we are all anxious to get to the end of this matter.

But what is the theory of the history of the universe today? We may review it shortly as follows:-

Mendeleyev's Periodic Table has shown that

there are 92 elements and perhaps more in the universe. All these must have emerged from fusion of the basic element hydrogen. Even today, three-quarters of visible matter is constituted of this gas. It was perhaps about 13 thousand million years ago that these elements began to be formed by the fusion of the hydrogen atoms under heavy pressure and temperature. Quasars, now mostly seen on the edge of the universe, are believed to have been formed then. That period is about a thousand-million years from the Big Bang (creation of the universe).

Hydrogen atoms took their present shape about 500,000 years after the Big Bang. The fast electrons must have cooled down enough to fall into orbit of the atom.

Tracing our steps back in time, we reach within three minutes of the beginning. It was at this point that protons and neutrons united to form the bare atom. This scenario can be recreated in the laboratory using accelerators, so that scientists are fairly confident of the validity of their equations.

We are now getting closer to the beginning. At about 10^{-2} second, the universe was so hot – about $2x10^{11}$ degrees Celsius – that matter was created and annihilated continuously in energetic collisions. Matter and energy, so close and compact then, was spreading out fast.

At 10^{-10} second, the entire universe was about the size of our solar system. It was at this stage that the four types of forces mentioned above were together for the last time. Modern laboratories equipped with powerful accelerators can, we are told, reproduce this condition exactly.

Gravity, as a force, was separated from the others just before this event point. The other three had separated even earlier in time.

Going a little further back, we reach the point 10^{-43} second after the beginning. This is the critical edge up to which scientists are fairly certain of the validity of their equations. But beyond that point, nobody is yet sure of what went on.

We have seen, in the first chapter of this book, that time and speed of motion are inter-related (i.e. the faster the speed, the slower the time). Now speed itself is length or distance covered per unit time. So time and space are connected. In fact, time and space are so related that one cannot think of one in isolation of the other. This, by the way, supplies the answer to the question that we as children used to ask i.e. "what remains after the end of the universe?" And what was there before Creation?" As we cannot imagine time without space, then if there wasn't space, there wasn't time either, and when space is no longer there, then there is time no more. So the question of "before space was created," or "after the end of space," cannot be asked because time did not exist then. The two appeared together.

Today it is generally accepted that time and space came into existence together. The question remains though how they started at all. There is no answer as yet. Scientists are racking their brains to crack the mystery, and everybody else is curious to know the answer. There is no success so far.

Hawking has taken on the challenge and with

his head reclined on his wheel chair, he is wrestling with the problem as the other scientists around him wait patiently and hope that he may bring them the answer.

True, the body of knowledge accumulated so far is immense. We know exactly what was going on when the universe was a million years old. We can reconstruct the conditions when it was a hundred years old or even less-say a year or alas, even a week. Theoretical physics has taken us back to the time when the universe was one second old and even fractions of it!

But even a fraction of a second is a time counted after the creation of the universe. What is required is to know how it was created first (i.e. at zero time).

Whether this is possible or not, is not yet known. So far, science has not been able to provide the answer. It is here, naturally, that philosophy and religion are sought to supply the answer. When people fail to explain away certain phenomena, they do not rest until they have found some explanation and so they tend to resort to religion. We always had explanation, say for lightning, even if science had not come up with its explanation of electric discharge.

The creation of the Universe (i.e. at zero time) still seeks explanation from religion. To recap the teachings of the Bible, God created the Heavens and the Earth. That was the beginning. Other creatures came on stage later in time. Science tells the same story. The universe was created. Then followed everything else. Of course, not all this process of creation and development took place in just eight thousand years. It has taken

thousands of millions of years to evolve to this present stage. But this is a matter of reckoning the time lapse and this is not a grave contradiction.

On the other hand, science itself teaches that entropy goes in one direction. Things tend to disorganize, disintegrate and disperse with the passage of time. People die; and the body disintegrates with the passing of time. Buildings crumble and fall into rubble. Metals rust and wear out, etc. Everything tends towards disintegration. We do not see the reverse happening. Stones do not gather of their own accord to form themselves into a three-storey building nor do small pieces of gears and levers assemble themselves into a watch. This requires an external force to do it. In the same manner, it appears that it requires an external factor to build natural elements to form living organisms like ourselves. It is our existence that gives meaning to the existence of the universe. This is the position adopted by most people nowadays.

Some scientists have opted to go back to studying and exploring the holy books of various religions. Perhaps the secret of life in general, lurks somewhere in the bosom or shadows of some past and forgotten teachings. Perhaps we have over-looked some details somewhere. So we have to look at every nook and cranny, dig up and explore the earth and scan the sky, study sciences, philosophies and religions and do everything else possible in search of the ultimate truth. It is human nature to struggle to know, and this impulse will inevitably surge ahead.

In lieu of Conclusion

Now we have covered some of the aspects of the lives of scientists. We have scanned their childhood experiences, their ordeals and exiles, their financial, political and social problems and finally the effect of their works on society all in the manner the size of this book permits. What remains perhaps is to mention that we need not put all scientists on a pedestal and idolize them but consider them just as ordinary humans as we are. "What does a scientist look like?" asked a teacher of his pupils. His intention was to stimulate the children to aspire to be scientists themselves. The responses he got shocked him. The children replied something as follows;-

"He is an absent-minded person always decanting flasks and beakers."

"He wonders about wearing white overalls."

"He is one with uncombed messy hair and can't see without eye glasses," etc.

The children's concept of a scientist was not encouraging at all.

True, a lot has been said and written about the wisdom and intellect of scientists. But this may tend to make them remote from the rest of us. So let us mention some of their weaknesses to show they are only ordinary humans subject to frailties.

Competition among colleagues is one major force that drives research. "Publish or perish" is a common saying in their circles. Publishing is the key to recognition and in the long shot to the possible chance of winning a Nobel Prize and being placed in the annals of history. Serious

scientists draw their strength from such springs of hope or at least from the desire to contribute their mite to society.

As a result of such intense competitions between colleagues, there is a tendency to cover up one's on-going work until after publication and to shield projects against leaks or theft in the meantime. There have indeed been cases where quarrels have erupted and claims made against theft of one's research findings. A case in point is the claim made by French and American scientists to have discovered the "Aids" disease. The issue was settled by a special committee convened to investigate the matter. Similar conflicts arise between individual scientists quite often.

Some cautious researchers devise their own methods to protect themselves until the time is due. For example, a certain scientist, having discovered a substance that turns into a superconductor at-180^{0}C sent his findings to the publishers and intentionally changed the name of the substance. Only after he was certain that the publication was to be issued, did he go and rectify the 'error'.

But there are others who raised a lot of dust. A fairly recent example is that of Stanley Pons and Martin Fleishman. These scientists jointly announced that they had discovered a method of fusing light elements to release energy for use. Of course, this will be a milestone in human history. The reason is as follows:-

We have known for a long time that our sun pours forth so much energy by the mechanism of fusing light elements and releasing the energy

therein. The element is hydrogen gas. Our scientists too, were able to build the Hydrogen Bomb based on that principle. Yet we were unable to utilize this fusion energy for peaceful purposes because we did not know how to control the process systematically. It was possible to get the elements together to explode, but not to control the explosion to supply a steady flow of electricity. This possible source of energy is so enticing that everybody is anxious to get at it. The reason is that the fuel, hydrogen, is available from water, and water is affordable by every one including Developing Countries. So to unlock this energy is regarded as something similar to 'bringing heaven down to earth.'

So now, when Stanley Pons and company claimed they had made it to this discovery, it was naturally a tremendous achievement. This was a historic achievement, perhaps the best in the century. But then how to protect this secret from theft or false claim until they made it public? Sending it for publication, they feared, would take time and something might go wrong in the meantime. The best and simplest way was to convene a group of newsmen and announce it to them. So they did just that. The news was broadcasted immediately and the world came to learn of it in no time. Aware of the fruits of the discovery, everybody was delighted. Excitement, hope and ambition rose in every corner and every one talked about it. The two scientists, needless to say, became famous overnight. This all took place in March 1989.

But on closer examination later, the finding was not valid. The conclusion they had drawn

from the phenomenon they witnessed was wrong. It was for reasons other than fusion that the energy was released in the process. So the claim, it turned out, was false.

The interesting point is what took place between the time of their announcement and the time of disproof. Various laboratories in different countries claimed to have performed the experiments themselves and confirmed the findings. There was a race to be among the first (if not the first) to perform the experiment and thus to share in the glory. Even Developing Countries like North Korea announced the confirmation of the finding in their laboratories.

Other scientists came up to claim their rights to the discovery. They vowed that it was they who had done the experiment before and were therefore the rightful owners of the benefit. Courts were designated to examine the case, and lawyers were appointed by the litigants.

In the meantime, the State allocated a large sum of money, no less than 4.5 million dollars, to develop the required technology within six months and be able to tap the economic benefits before other countries (like Japan) snatched it and ran away with it. Other States and countries too were known to have taken their own steps, though the amount of money involved was not announced. But one can be sure that the total sum allotted is no small amount.

This shows how fierce the competition is between scientists and laboratories to get ahead and register discoveries. Examples abound in all different branches of science (as is also illustrated in this book) how intense the struggle is to get

results.

Since first-hand experience is a better illustration than reading about it in reports, I should lay down my own experience to show such weaknesses. The urge to announce new things or events is so compulsive as to make one intolerably impatient to withhold, especially during close competitions. I had the good fortune once to work in an astronomical observatory tracking satellites. One night, as I was surveying the skies with a camera, I caught a bright object, which I could not find on the star chart. "Where has this object come from which is not marked on the map?" I asked myself. I had known that comets coming towards the sun from the depths of space suddenly appear visible as they approach us. I had also known that the name assigned to a newly discovered comet would be that of the person who saw it and reported it first. So I took an immediate decision. I decided to report this new finding before others did. I measured its magnitude and position in the sky and dispatched a telex message to headquarters.

Having done that, I sighed in relief and satisfaction. It was pleasure. I needed neither food nor sleep – it was just sheer bliss. But it was later revealed that it was only a planet I had seen. Planets, because of their revolution around the sun, do not appear on star charts as they do not have a fixed place. Now this wandering planet had just crept into view at that unfortunate moment and had misled me. That planet still angers me, but I well understand the situation Stanley Pons and company were in, when they took that measure to announce their findings to

newsmen.

The types of people that do not deserve any apology are those who seek fame using fraudulent methods. I remember a case of a certain biologist based in Australia who became world-famous by his ability to perform experiments that confirmed certain theoretical analyses. Many scientists were grateful for his having confirmed their claims, and he was even proposed for a Nobel Prize. But on closer scrutiny, it was found that he did not get the results from experimental data but merely by "cooking" results, that is, by arranging figures so as to fit the theoretical predictions.

This is a wicked attempt to earn fame or glory by fraudulent methods. This is a disservice to science and a drawback to progress and should be condemned. The person's name is now associated with this treachery, and I am not sure if he likes it the way it has turned out.

But that is science. The virtue of it is that it is not subject to manipulation using fraudulent methods. It is the recognition or study of the laws of nature irrespective of people's wishes and desires. It cannot be taken for granted or accepted by majority wish but has to be able to be subjected to experimental verification by anybody who cares to check. That is why science is able to develop steadily on ever more firm and unshakeable grounds. The evolution of science is also the reason why our way of life is much better today then it was in the days of our ancestors.

Of course, one can argue that science has two faces in the sense that it has both advantages and disadvantages.

On the positive side, one can cite recent

achievements in space science, the satellites that travel in space and explore other heavenly bodies. Nearer at home, the telephones, televisions and other gadgets that amuse and entertain us can be mentioned. Being able to watch and enjoy football championship matches being played thousands of kilometres away on another continent, from the comfort of one's lounges at home is undeniably a major achievement. Health, transport, and industry can draw up a long list of impressive major advances made in science.

On the debit side, one can point out the 'progress' made in the conduct of wars. For example, in ancient times when people quarrelled they beat each other or perhaps even bit each other. Later when bows and arrows arrived, it became possible to attack from afar. This was 'a major advance' of sorts. In due time, the gunpowder arrived. This was a devastating weapon. It is said that soldiers, under order of their commander, fired this terror weapon at their enemies. But then, of course, the smoke belching out filled the air and hampered their vision to the extent that the soldiers could not see even their commander or indeed even each other. So the battle stopped until the wind 'benevolently' swept away the smoke.

Other inventions followed in the form of poison gas and nuclear bombs. It is now possible to wipe out the entire human race in a world war. This, in its own way, may be termed 'progress'.

To date over 1500 major wars have been fought. There are, of course, thousands of smaller ones that history has not recorded. All these have

been the cause for the ensuing human suffering, blood-baths and horrific deaths. This is the dark side of science, or to put it properly, it is the application of science to the detriment of man.

Looking at the benefits of science, we have mentioned how it helped raise us from the state of savagery to the present age of computers and satellites. How was it possible to achieve all this? Well, it was step by step, patiently but steadily. It is by the untiring effort and selfless devotion of researchers dedicated to their work that all this wealth of knowledge is accumulated.

These individuals called scientists are not of any unique brand. True they are the **Pillars of Creation**, but they did not have a common background nor were they afforded some special privileges. Some among them, like Mendeleyev for instance, were poor orphans; others like Von Braun were born to government ministers. There were bright and not so bright students among them. Louis Pasteur, Stephen Hawking and James Watson were bright from the start. But then there were so-called stupid and vain pupils like Charles Darwin, and even dropouts like Albert Einstein. There are, even if small in number, those lucky ones who stumbled into famous discoveries and thus changed the thinking of the world; some even solved riddles in their dreams. But there are those who by dint of hard work and persistence managed to score results, and these are the majority in number.

It is the sum of all these findings consolidated by engineering that made certain countries advanced, and transformed a couple of them into superpowers.

But the pity is that the benefits of this body of knowledge have not seeped enough into the rest of the world. As a result, the difference in the standard of living between the developed and under-developed countries is sky-high. Of these two groups of countries, one has members who suffer from malnutrition and disease to such an extent that some die of hunger; while the other group has members who, failing in their attempt to control their diet and to keep their over-weight in check, succumb to death. Of course, we are all mortals but to die from lack of food is very sad and tragic.

This situation came about because of the failure to benefit from existing science and technology applications. The problem with Developing Countries is that we have not been able to partake of the advantages of using modern technologies. It is of course a waste of time and effort to try to 'discover the wheel' all over again; instead, it is wise to transfer existing modern technology and use it where appropriate.

Equally important though, is the need to develop one's own science and technology-base and to train work force. It certainly requires trained personnel to be able to use advanced technologies. However, it is not possible to send people abroad to train in all the fields of activity required for the country. It is indispensable that a country should develop the capacity and the infrastructure to train its own work force to guarantee sustained growth.

Therefore, it is vital to strengthen the base of science and technology in all the necessary branches. Science popularization should be

carried out among the masses and especially in the schools. When vocational technical schools as well as advanced development centers can produce enough qualified manpower, this can attract entrepreneurs to the country and also enable to retain their know-how.

Of course, the need for lead scientists should be obvious. To start with, to import appropriate technology (transfer of technology) requires careful analysis by the elites. Again, to plan, device and conduct research to develop local technology requires high calibre professionals. Research findings that led to discoveries in coffee bean quality, in Endod Molluscicidal effects, in false banana nutritional value and in other fields as well were the result of the dedicated work on the part of our scientists. The main concern of scientists in advanced countries today is mostly in the fields of space exploration, atomic energy, computer technology, Defence and other related matters not quite urgently required for Developing Countries. They cannot be expected, of course, to set aside their own interests and to work on ours instead, so it befalls us to fend for ourselves.

Finally, it is essential to provide leadership. People like to have idols to imitate. To lead by force of example, by dedicating oneself to work is thus the way to stimulate people. It will promote participation in the necessary campaign to develop broad scientific culture among the people. Investing in the people is important since ultimately, it is the citizens of the country that are the wealth of the nation, and it rests on their shoulders to solve their own problems.

There is a saying that 'two heads are better

than one'. Three, four or more are, by deduction, still better than one. That is true, of course. But then leadership is important too; and this is embodied in individuals. Discoveries emerge from individual heads. Even organizations are headed by individuals. This is not to undermine teamwork, yet it is equally true that individuals make up the team and that wise leadership is essential. This all goes to show that we have to look for talent in youngsters, then cultivate and nurture them and then be able to benefit from their good leadership even in science.

We have seen enough examples in this book of how it is individuals, possessed of strong will, perseverance and tolerance in the face of misery, who were finally crowned with success and reached the pinnacles of fame.

To recapitulate a few cases:-

Marie Curie became a double Nobel Laureate by working her way through colleges, studying day and night, some times putting her feet in ice-cold water in order to overcome sleep. She had even fainted of hunger.

Louis Pasteur too, left behind the comforts of his home and stayed out in the farms for three years studying the disease that killed the silk worms. We know he did manage to solve the problem. That is what is meant by dedication to work.

Even today, there are scientists who work tirelessly from dusk to dawn. Some I know work straight up to eight or nine o'clock in the evening. All this is mostly to contribute their knowledge for the good of society.

Coming back to our own situation, there is

indeed a lot to be desired from our scientists.

Questions beg to be asked: - How to transfer appropriate foreign technologies into the country? How to adapt them for local use? What relevant issues appear in publications and technical documents that could be used in our situation? Etc.

It is now possible to surf the Internet. It is possible to contact professionals almost anywhere to help solve problems and to get useful suggestions. These could be substantiated by carefully designed research. There is simply ample opportunity for scientists to contribute to this society of ours.

People in authority may be expected to help them by putting in place the right policies to facilitate transfer of technology, to train manpower to promulgate appropriate laws and regulations to reward technological renovations, all to enhance development. Political, cultural or administrative obstacles, if any, could be eliminated. This will promote freedom of thought and action, transparency of management, creativity and fair competition, all of which will clear the air for speedy progress in science and technology as in others.

The precondition for all this is of course a fierce determination and complete dedication to work to the maximum capacity and capability. Nothing less is expected of professionals in science and technology as of any other responsible citizen.

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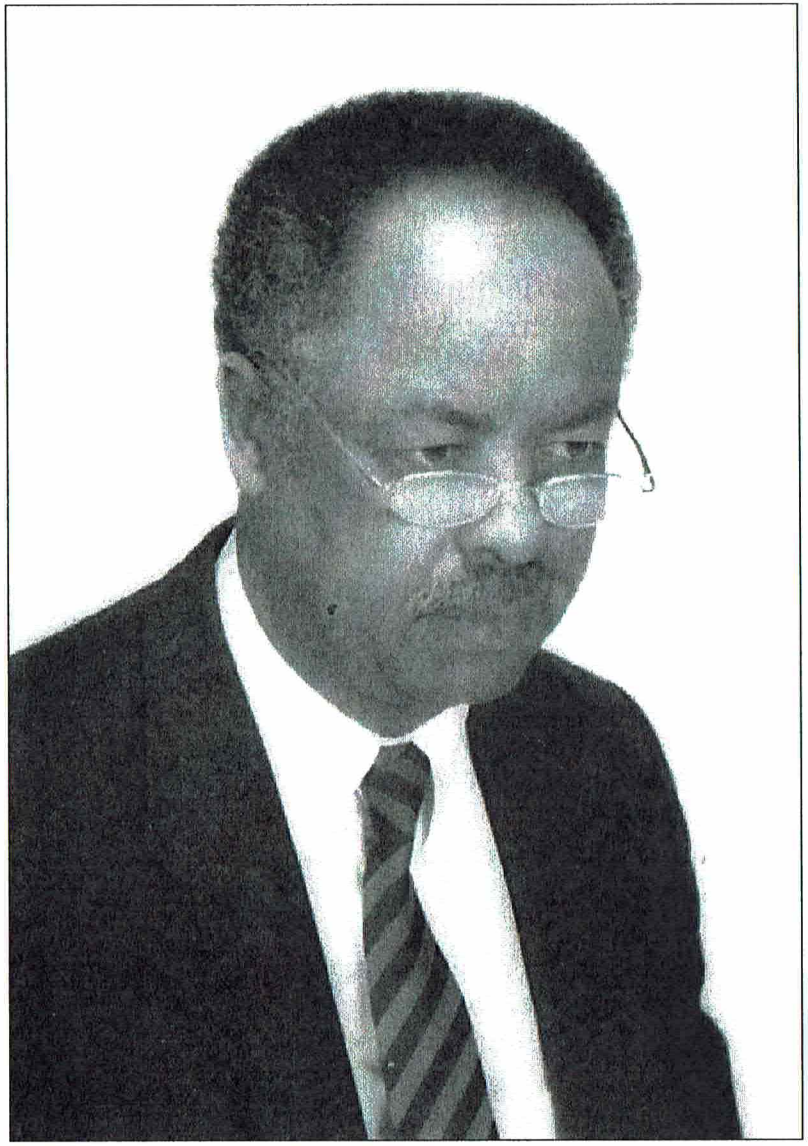
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About the Author



Tafesse Muluneh

Tafesse Muluneh was born in Holeta, Ethiopia to a district lawyer. He attended school, graduated with B.Sc. from Addis Ababa University, Ethiopia (1966), and obtained M.Sc. from University of Surrey, England (1970).

He worked for two years at the Smithsonian astrophysical observing station in Debrezeit Ethiopia (1966-68); and later at Addis Ababa University part lecturing and part running the Radiation Protection Service mostly for hospital X-ray personnel.

He then joined the Ethiopian Standards Institute (later upgraded to Authority) in 1976 and served as General Standards Engineer, Head of Engineering Standards Division, Head of Metrology Department, and finally as General Manager of the Authority until he retired in1996.

He dedicated his life to advancing Science and Technology in Ethiopia. With the firm conviction that progress comes through the application and utilization of modern technology, he worked to disseminate technical knowledge among the populace.

Towards that end, he wrote and published the following books:

HOW IT WORKS – explaining the workings of 15 utility gadgets commonly seen in public bars (coffee machines, refrigerators, clocks, TV, radios, etc.)

NUCLEAR ENERGY – its historical development, the mechanism of producing it, and importantly, the uses and abuses of it all.

THE OTHER WORLDS – a lesson in astronomy and the concept of evolution.

SCIENTISTS – describing the works and discoveries of 13 scientists

In an attempt to fight bigotry and dogmatism and to promote mutual understanding and tolerance in the community, he laid out a comparative analysis of 15 religious denominations in Ethiopia (Orthodox Christianity, Islam, Jehovah's Witnesses, and Catholics, etc.).

Finally, as President of Ethiopian Chess Federation, he wrote and published a chess book that comprised of three parts – for beginners, for regular players and for tournament players – all in an effort to encourage the youth to exercise in deep concentration and analytical thinking.

Of these works, the present book is the one we have in the English version.

Pillars of Creation

Darwin says that we descended from the monkeys.
He looks like a monkey himself; that is why!

Nobel kept tinkering with dynamite; the result--he got his house blown up, his father maimed and his brother killed.
Serves him right. The crank.

Einstein says that with appropriate speed of travel one can slow down time, implying that the father, if he traveled fast enough, will end up younger than his son.
That is Jewish science for you.

Von Braun tried to send a rocket into orbit; but the thing fizzled on the launching pad.
All that money up in smokes. Isn't he German?

Pasteur says to prevent disease, you have to inject the disease into the person.
Oh! The French.

Watson and Crick played with models of molecules and now say that they know the mechanism of cell replication, and hence the secret of life.
Get the English and American to work together, and that is what they come up with. Pooh!

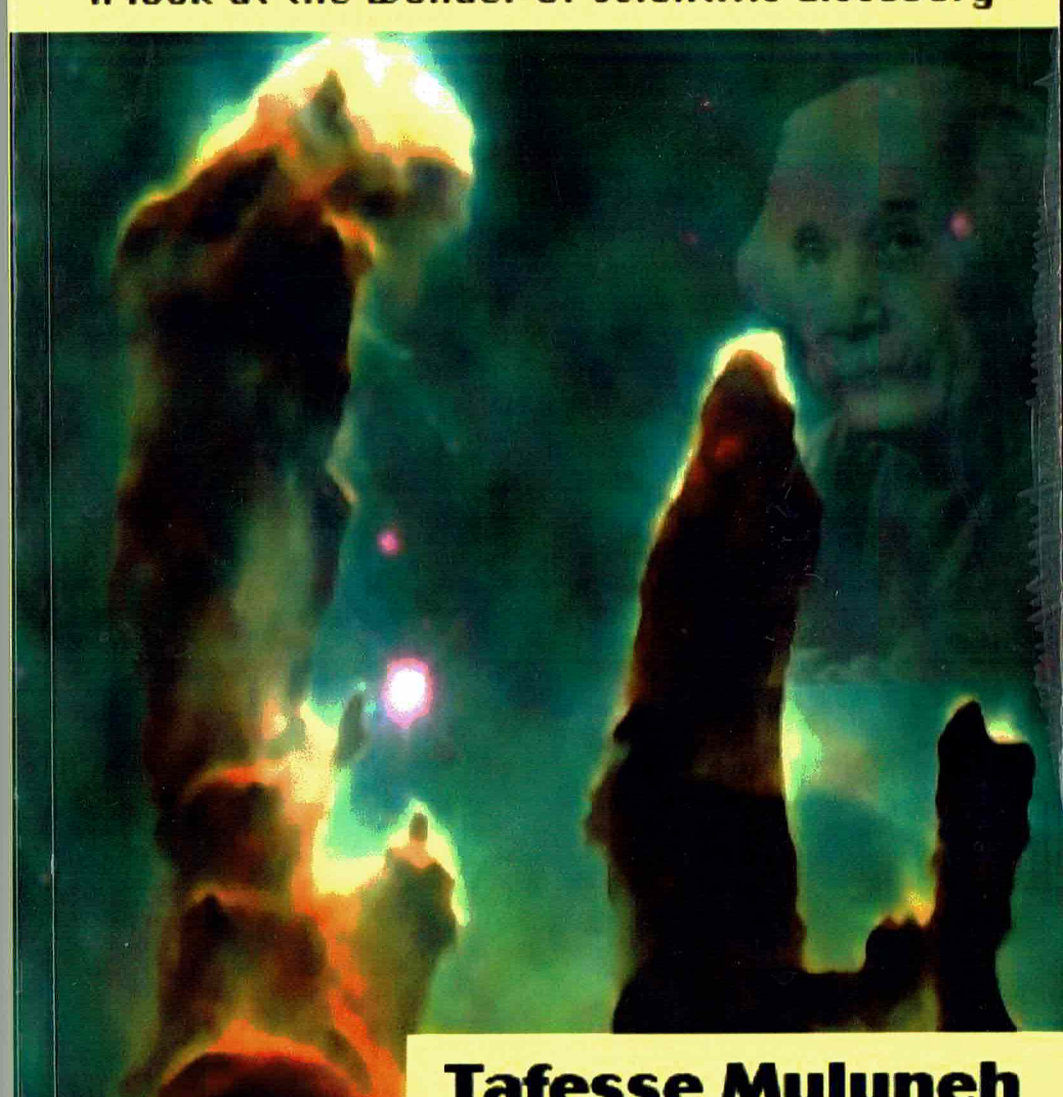
Initial reactions are thus not all positive. But then Science keeps marching on; and as we reap the benefits, our lives get richer, fuller and more enlightened.
This is an interesting compilation of the history of major discoveries chosen from major fields of Science; and the corollary to each chapter updates the status of the ensuing science.
A boon to teachers, students and the public at large.

Tafesse Muluneh.

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PILLARS of CREATION

A look at the wonder of scientific discovery



Tafesse Muluneh

PILLARS OF CREATION

Cover Picture

"Pillars of Creation", as this group of stars is known, is 7000 light-years distant from us; and is seen shrouded in thick cloud and dust. Inside it, a lot is going on by way of stars forming, erupting, exploding, etc., and perhaps forming planets and even life.

As it is, we cannot see the specific details inside, but only wonder "What in Heavens is going on?" as we stare at the glow of activity depicted at the top of the picture.

In like manner, looking out at us from that side should puzzle the observer there (if any). Various wave signals (radar, television, radio) emanating from here and streaming out, and the various construction/destruction activities here may make one wonder "What on earth is going on?"

All activities, that got us from the Stone Age through the Industrial Revolution to the Computer Age, were ushered in by the creative endeavors of our scientists - our Pillars of Creation - the face of one of them is also depicted at the top of the picture.

By
Tafesse Muluneh

Pillars of Creation

Originally prepared in Amharic under the title:
Scientists:
The challenges of their times
And
The fruits of their labours

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PREFACE

Of course, we all labour to earn a living. We sweat at it from dawn to dusk. But in spite of it all, our standard of living is far below that of developed countries. Why?

The answer is simple: - they make better use of science and technology. It takes one of their farmers just a few hours to till a field. Our farmers would take the whole day to plough it.

One loader operator hauls a pile of building blocks easily in a few minutes. The same load would take 30 of our labourers an entire day to transport it. It is even harder to compare air freight with horse-pack or computer operators with the abacus.

But why has science not found a fertile "field" in our place? Some answers are suggested in this book; but the main study is how other people in those times and under those circumstances happened to develop the sciences – what helped them? And what occasions prompted development? Of course, no claim is made to have traced the history of the development of science in this small book, yet I believe that case studies of some scientists and their experiences can serve us a good lesson. To cite a few examples: Gregor Mendel was a monk; he was also engaged in a teaching profession to subsidize his living. In his spare time, he did some research on growing plants and their cross-breeding. Today it is considered that his work marked the beginning of genetic engineering, and Mendel's name became

famous. Louis Pasteur too, began his investigations when confronted with the problem of cattle and sheep being wiped out by anthrax, and even people perishing of various contagious infections. As a result of his effort, children today are protected by vaccinations, and the menacing rabies is under control.

Other examples have been cited in this book. The point is to encourage the youth to ponder riddles and investigate things on their own. Obviously, schools are the source of trained manpower for the country: and student-teacher relationship influences enormously the proper development of the student. Hence, the teacher has to consider carefully his approach to, and the handling of his students. For example, say, the subject matter at hand is chemistry and the teacher is discussing the intricacies of the Periodic Table. Now the students may simply get bored and drowsy. However, if the clever teacher related to the class how Dmitry Ivanovich Mendeleyev managed to be accepted at the St. Petersburg College, thanks to his mother's unrelenting efforts to get her son from Siberia to the heart Russia while dying of a terminal illness, then the story becomes quite interesting and everyone in class will stay awake.

Such stories will alert students of the difficulties one may often encounter when striving towards finding answers, which could promote progress while making better use of science and technology. These tales may also help the distracted student to follow the subject matter with more understanding of the men behind the studies. This book helps in such respects.

The teacher can also help students in some other ways. For example, remembering that the great scientist, Albert Einstein, had, at one time in his younger days, failed school examinations in language and history courses, and had been dismissed from the school, he will realize the fact that not all students should be gifted in all the subjects taught in their class.

Once other readers learn, how the scientists-to-be surmounted adversities early in their lives and finally made it to the peak of their careers, they can actually *create* their future and make a success of it. They will realize, by nurturing their talents, or pursuing their hobbies or studying the environment and considering what they can do on their own or in association with others, they can achieve untold successes.

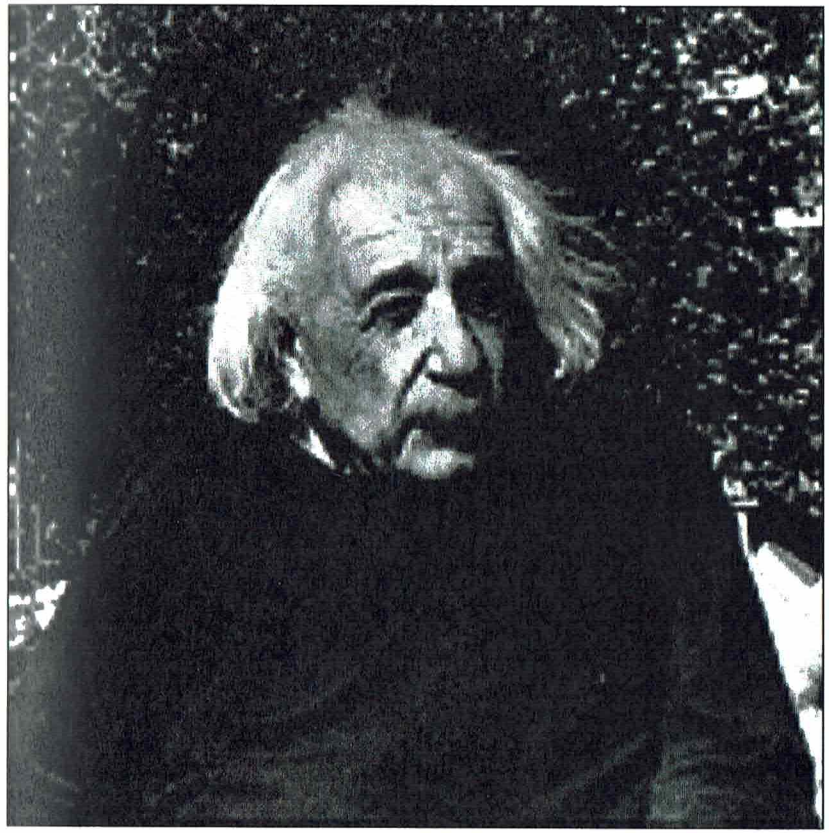
Science research has its own ups and downs. It has its own stock of frustrations and it demands a lot of patience. Most of the time, it turns out that the result of all the research is a mere waste of effort. Authorities must make allowance for this possibility. Yet the researcher too has to be careful in choosing the line of research that is most likely to bear fruit.

Finally, to keep the balance between the main three branches of science (physics, chemistry and biology) roughly equal number of scientists have been chosen and presented in this book. Thus, the impact their contributions made in the fields of health, education, defence, religion, or philosophy on the public, and their consequences have been outlined. The starting point of some of the most famous technologies (e.g. Atomic energy,

missile technology, genetic engineering) and their ensuing results has also been discussed to some extent herein.

Considering the short development period (less than 150 years) in which the Western World achieved such enormous progress, we realize that countries under development could catch up with the developed countries – if they seriously tried. Otherwise, they will quickly fall farther and farther behind, hence the grave responsibility that rests upon the shoulders of this and the coming generations.

Chapter One



Albert Einstein

1879-1955

The worth of education

"There comes a time when the mind takes a higher plane of knowledge but can never prove how it got there. All great discoveries have involved such a leap. The important thing is not to stop questioning."

When scientists are mentioned, the name that leaps to my mind is Einstein. Other names come only later. This name is not only famous for me or for those of us engaged in the study of physics, but for all scholars of science. Most scientists gain prominence only after several years of hard work, and later reviews of scientific progresses due to this work; so that the scientists concerned may not get the recognition in their lifetime. Einstein however, was able to get this chance early in his life. How could this happen? Well, before we deal with this, let us go back in time to see what the man had to go through.

Einstein was a Jew born in Ulm, Germany.[1] Born in 1879, he grew up and went to school in Munich. At the age of 15, he was reported weak in history, geography and Latin and so was dismissed from school. (His teacher had remarked, "He will never amount to anything.") Einstein indeed was slow; even in learning to speak – he stammered a little.

Later he went to school in Switzerland and somehow managed to enrol in college. He graduated in 1900 (reportedly with the help of a student friend) and became a mathematics

[1] (3) No.6; (6)

teacher. Shortly afterwards he joined the Swiss Patent Office. It was here that he had the opportunity to pursue his studies in his beloved subject – physics. He published his works in 1905, which provoked a sensation overnight. Hesitation, doubts and confusion reigned among the scholars of the time; but all chose to remain quiet until the theory was proved or disproved. Einstein's brain-power however, and his theory proved indisputable.

He began to receive requests from universities to lecture in their classes and thus moved around for a time to settle later as a fellow of the Science Academy in the University of Berlin.



Albert and Mileva

Einstein's life met a curious turn when his Yugoslav wife and close collaborator in his research, Mileva Maritsch, who was also a physicist, took their two sons on a holiday to Switzerland whereupon the First World War broke out and prevented her from coming back to Germany. The marriage had to be dissolved after several years of forced separation.

Einstein later married Elsa, while he pursued his research. In 1916, he published his works on the general theory of relativity. This again was another milestone.

But there was no peace in Germany then. Einstein felt the hatred expressed against his Jewish race. He felt that the political climate in the country was leading to inevitable war. So he began to give addresses at every platform he found and aired his views in an attempt to bring about understanding and tolerance. Yet, he was met with more hatred and hostility.

"The big political doings of our time are so disheartening that in our generation one feels quite alone. It is as if people had lost the passion for justice and dignity and no longer treasure what better generations have won by extraordinary sacrifices."

By this time, Einstein had become a world renowned figure. Einstein's fame encouraged a group from the British Science Academy to undertake a mission to the island of Principe to verify his theory. There was a solar eclipse downing on the island and the group decided to check if light rays really bend around the sun on

their way from the stars beyond. Alas! Einstein's prediction was correct!

Overnight Einstein became a celebrity. His name became a household word. Soon jokes about him started to circulate. Of course, the theory he propounded was not easily understood by most people and certainly not by the uneducated one. One of the jokes run as follows:

"One dignitary was told that there were only three who understood Einstein's theory, whereupon he asked in surprise, who the third was! The two he knew were Einstein and God."

Meanwhile the Nazi hostile attitude toward the Jewish population throughout Europe, and Germany in particular, became worse by the day. All the while Einstein made his position clear that he was against war; and he urged others to take a similar stand. As a result, the Authorities despised him. His close friend, the Foreign Minister, who was also a Jew, was assassinated by anarchists and it was rumoured that Einstein was next on the list.

It seems Einstein himself had foreseen what was likely to come when he had commented about his situation even 11 years before Hitler came to power:

"These days the Germans consider me a German, but the French consider me a Jew. But if my theory proved wrong, the Germans are going to consider me a Jew and the French are going to consider me a German."

Einstein once went on a mission to the United

States, and he learnt that during his absence, the police had been to his home to conduct a search. Actually, he was campaigning in the States for all Jews to return to their homeland-Israel – and build it up. He urged them to establish a university at home and teach their children in their own language and culture. Incidentally, when Israel was finally established, he was offered the presidency but he declined on the grounds that politics was not his profession.

Back in Germany, the attitude towards him got harder. At one point, even his physics theory was barred from being taught in schools. The German politicians of the time began to draw a line between German Science and Jewish Science. It was this attitude, which the Swedish Nobel committee foresaw as early as 1922 when it awarded him the prize. The committee concerned lest they be charged with political alignment against German Government inscribed the citation to the effect that the award was given not for the Relativity work that gained him world-wide fame, but for a previous rather insignificant work (Photoelectric effect) and merely generalized the rest as theoretical physics.

Einstein was finally publicly accused by the German authorities for *"having failed to promote the good name of his country in the course of visits abroad as it was his duty, as a citizen to do so."* However, Einstein remained steadfast and responded that by no means would he ever be supportive of the Nazi regime and cruelty towards other people and decided to give up his citizenship and to settle in the United States.

"My political ideal is democracy.
Let every man be respected as an individual and no man idealized."

When Hitler finally started the war and set Europe ablaze, Einstein could no longer stay aloof. He reminded everyone he met during public speaking engagements and in private circles that it was their duty to stand up firm against Hitler's inhuman and vicious attack against peace-abiding people.

History records that it was Einstein who wrote a letter to President Roosevelt in 1939, which persuaded him to allocate funds for the development and construction of the Atomic bomb to settle the conflict. The bomb was actually constructed on the basis of the theory he had formulated years earlier. The formula related mass to its energy equivalence as $E=mc^2$.

Earlier, however, Einstein had put forth various other postulates as well. Now what were these postulates that brought him fame in the first place? It is hard to present and explain these theories in such a small book; but then it will not help to popularize science if we completely leave out the subject and confine ourselves merely to exhort Einstein's fame. So we will attempt to discuss at least one of his postulates – Relativity.

Before Einstein came on stage, it was the belief that Quantities simply added up in the conventional manner. For example, 2+3=5. This is a formula. Speeds too can be added up in the same manner. So if a train travels along a straight track at a speed of 50 kilometres per hour and if a passenger on board runs in the

direction at a speed of 15 kilometres per hour, the total speed of the man with respect to the ground is 50+15=65 km/hr.

Again, if a man riding a horse threw a javelin in the same direction, and if a man standing stationary on the ground also threw a javelin, the two javelins won't achieve the same speed; that of the riding horse will gain the speed of the horse on top of the rider's throw. Now that was all clear.

But Einstein came forward and declared that this was not valid in every circumstance. He was not concerned about people's feelings; he just boldly announced "that is not correct!" and that was that! He explained that when dealing with speeds of travel, one cannot keep on adding numbers one on top of another. What's more, one cannot attain speed faster than that of light. Therefore, one cannot add speed on top of that.

He further explained that measurement of the speed of light remains unaltered regardless whether it was measured from a speeding carriage or from a stationary place. Therefore, speed of light is invariable in every condition of travel. This is one of his starting points.

The other one is that natural laws are the same under all conditions of constant motion. For example, a man standing on the side of the road can read a book calmly or pass a thread through the eye of a needle. Also, a man aboard an airplane or a train passenger riding along a straight track can read a book or stick a thread through the eye of a needle. As long as there is no change or variation in speed of travel, the passenger can throw dice or jump a rope as easily as a man on the side of the road does. Indeed the

passenger may not even be aware of his travel unless he looks out of the window.

Starting from these two hypotheses and using them in his calculations, Einstein stated the following three postulates;

1) When an object moves at high speed, its length shortens,

2) When an object moves at high speed, its mass increases,

3) For any one moving at high speed, time lapses slowly i.e., time slows down.

These conclusions are easily deduced from his two hypotheses and basic transfer equations. Now the question arises: what are the practical implications of these postulates? And can they be verified by actual experiments?

The first postulate did not appear to worry anybody. If, say, a car is traveling at a speed of 100 kilometres per hour and one has to cover this distance by measuring only five times, then one's measure (ruler) has to be 20 kilometres long. Now if the car's speed is to be measured by an observer from another car traveling a bit slower than the first car, then this car does not, relatively speaking, run fast. It appears to move slowly with respect to the train. Therefore, to measure this shorter distance by again measuring only five times, then the length of the measure (ruler) will be shorter than 20 kilometres. If say the car were moving at a speed of 10 kilometres with respect to the observer on the second car, then for the observer to cover this distance by measuring five times, his ruler has to be 2 kilometres instead of twenty. Only that way can the measure of the speed of the car remain the

same regardless of the speed of the observer.

In this argument, Einstein was not in conflict with any system of faith or belief; so people just let him have it his own way.

The second postulate was easy to verify. In previous times it was noted that electrons could be pushed by electric forces to attain high speeds; but then once they got to a certain level of speed, it was harder and harder to get them moving faster with the same force application. This, at the time, was a puzzle. However, once Einstein made it clear that as the speed increased, the mass of the electron also increased, the puzzle was solved. Even the increase of mass was calculated according to the suggested formula, and it tallied with the experiment.

The third postulate is the one that created the most controversy. How does the passing of time depend on the speed of persons, i.e. slowing down for one, and speeding up for an other? It should pass on independently of the observer's state of motion!

Yet, according to Einstein's equation, if the speed of light is 100, and a person travels away from the earth at a speed of 86, his life-span interval will be reduced by half. Therefore, if the person returns 10 years later (according to his count) he will find his twin brother on earth to have aged by 20 years since he left him.

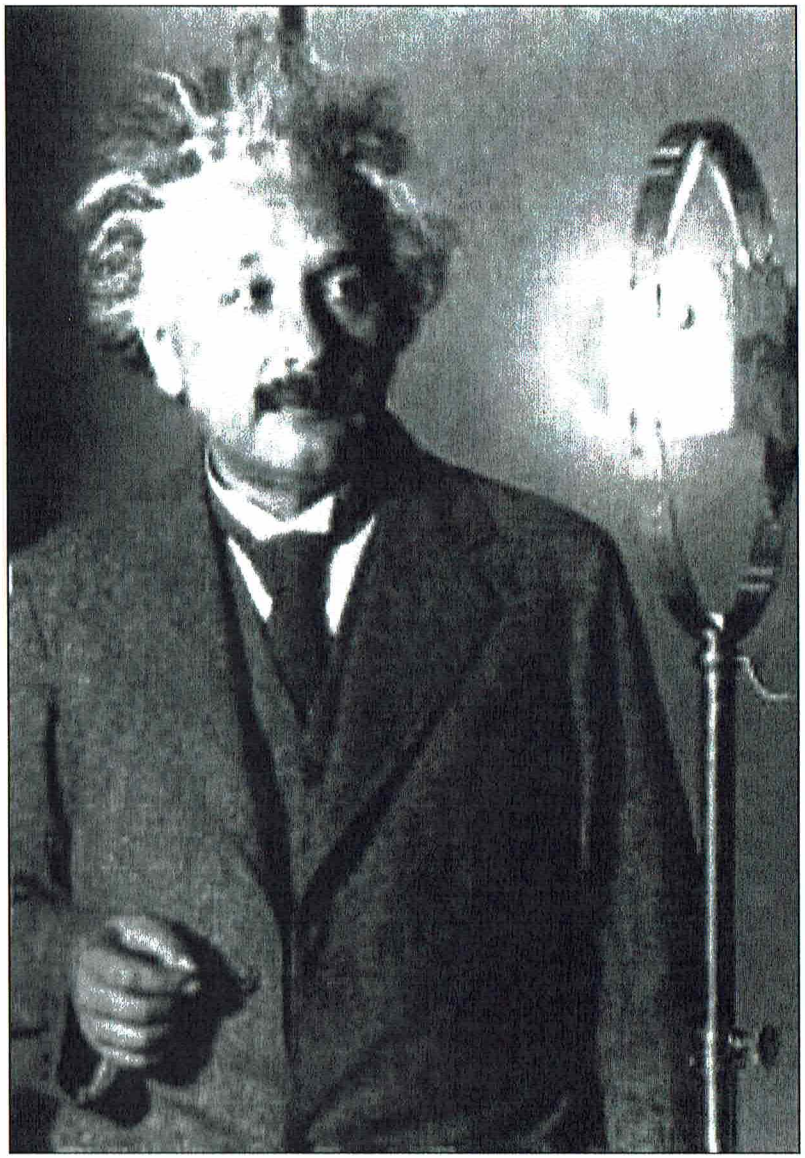
Again, if the observer traveled at a speed of 99% of that of the speed of light, a period of one year according to his reckoning will be equivalent to 50 years on earth. Therefore, a 30-year-old traveler leaving his newborn baby behind, after a one-year journey, will find his baby to be a fifty-

year-old man. This means the returning father is now 31 years old and the son is 50 years old.

That conclusion was incredible! Every one was puzzled and amazed. "How," they retorted, "could time pass at different rate for different people?" People talked and wondered. Einstein began to be regarded as a wonder. Jokes continued to circulate. He became popular everywhere.

The wonder of it all is that nobody to date has been able to disprove his postulates. In fact, some of the earlier theories now got explanations and became clear. Let us mention one such case: mesons are physical sub-particles that have a life-time of less than one second – they disintegrate. But mesons reach us here from the skies. How could they manage it if their life time is that short? This was a puzzler. Yet, now according to Einstein's theory, because they travel fast, time passes slowly for them. In fact, the time lapse for the magnitude of their speed was calculated using Einstein's equations, and it was found that indeed the time according to the traveling mesons themselves is less than one second! This was a convincing experimental result in favour of Einstein's argument and it also followed that if one were able to travel at the speed of light, time would come to a stand-still. This was a revolutionary thought that opened an entirely new vista.

Einstein remains to this day a towering genius.



A towering genius

Corollary
Space-travel

"Would Einstein's postulates help us in space travel?" is the question drawing attention these days.

The theory has been shown to be valid for elementary particles-electrons and other small particles, which are indeed governed by these rules. So as their speed of travel increases, so does their mass, etc. Now if the theory applies equally to large bodies, such as ourselves, that will bring us a step closer to the possibility of space travel. Consider the following:

Mankind has been exploring space for quite some time now. What are we? What is the basic natural law that governs everything? Where does it all end? These are some of the questions yet to be answered. The search continues in every direction. Man has set foot on the moon. He has also brought back stones and soil. But he failed to detect any life or for that matter even any sign of water there.

Now just as the Earth and its moon revolve around the sun, so there are other eight planets (most of them with their moons) that revolve in the same way we do. They have their own days and nights, seasons and years. But there is apparently no life on them, and the atmospheres do not seem able to support our type of life.

But what is there beyond our solar system? Other stars have their own planets. What is it like over there? We have been using telescopes and radio wave dishes to study the nature of these

far-off places, but now we find that space travel could also be a possibility. But "how and when do we get anywhere?" is the big question. Space is so vast that even light rays take years to get from one star to another.

One set of trials conducted this last quarter of century appears very discouraging. For example, a satellite (Pioneer 10) was launched on March 2, 1972 to explore the neighbouring planets. It was forecast that eventually it will travel out of the solar system. In the event of that happening, it may travel into deep space where it may ultimately be picked up by civilized societies. In that event, a gold plaque depicting the figure of man and woman and the location of our earth and sun were placed in the satellite.

True enough, Pioneer 10 managed to move beyond the solar system. Today it is 10 billion kilometres away and continues to travel at a speed of a million kilometres a day. It is the first manmade object to go beyond the solar system, and will also manage to pass beyond the Milky Way – our galaxy – that contains the sun and millions of other stars besides. It is heading towards the neighbouring galaxy, Andromeda, and it is expected to reach a star, named Rose 248, in that galaxy after 33 thousand years.

Another satellite on a similar long journey is Voyager 2, and it is heading in the direction of Sirius, the brightest star we see in the sky. To fly past this star, it would take Voyager 358,000 years. To get to the next star on its path, Lambda Aquila, it would need a travel period of four million years. The question is: if these satellites had human passengers on board, how many

generations would it require getting there? And would we ever manage?

But Einstein seemed to weather the problem a bit. If space travelers can move fast enough, time will be shorter and they would not age that quickly. Therefore, barring any problem of acceleration/deceleration, man's dream of traveling to other worlds is not to be set aside entirely.

This opens up new horizons for mankind. Today experiments are being conducted by simulating biosphere in space and in enclosed isolated conditions on Earth to enable man to produce his own food from the plants and animals around him as he travels boldly into outer space. Thus, perhaps one day, he may reach somewhere beyond the horizon.

It is a common belief (and it seems in instances to be a fact) that there are indeed planets around other stars. But still there is no sign of life anywhere. If that is so and we are the only intelligent life in the universe then may be it is our destiny to go forth, inhabit other planets, and multiply.

Lucy and her group that lived 2½ millions years ago in the plains of Afar-Ethiopia gathering fruits and digging up roots to sustain their lives may have thought that was their destiny and that their descendents would be confined to that way of life forever. Today we ask ourselves if, though we have to toil for our daily bread, this is to be our fate forever. Would the planetary systems of the other stars be doomed to lifeless barren existence and God's miraculous creation of life remain confined in this world of ours? Or does

our existence have a meaning transcending the trivialities of our common life? We the descendents of Lucy have managed to get thus far today; and then who knows what the future may still hold in store for us?

Chapter 2



Wernher von Braun

1912-1977

Research and the moral question

"Research is what I'm doing when I don't know what I'm doing."

The misery and suffering that World War II brought upon mankind is immense. The former Soviet Union alone lost 20 million people. England, France and several other countries have been subjected to the horrors of the Nazi Regime prior, during and for many years after WWII. All in all no less than fifty million people have perished. About 100 million have been maimed.

The extermination of the Jews was especially horrendous. Under the pretence of giving them work, they were rounded up from various cities and towns and were then gassed. About six million of them have perished in this war. Now it is obvious that the German Nazi leader Adolf Hitler was responsible for all this devastation and crime. Of course, Japan's monarch Hiro Hito and Italy's Fascist leader Benito Mussolini were his collaborators in organized genocide. Ethiopia, it will be remembered, was one of the early victims of this world war as well.

But these three were merely the political leaders. The people who actually provided the force and muscle to the war effort, who provided the necessary ammunition and other equipment to the fighting forces were the technologists and engineers. One of these engineers and scientists who played a very decisive role on the side of Hitler was Wernher von Braun.

It was the rockets designed and constructed by

this man and his subordinates that brought destruction to several English and other European cities and towns. It was these that spilled the blood of children and other innocent victims in their own homes. What did von Braun think of it all in retrospect? Did he express any regret? Did he spend any sleepless nights? The answer happens to be in the negative.

Wernher von Braun was caught by the Allied Forces and carried off to the United States. There again he applied his talent to develop the same weapons for the US Military. However, the war was won, peace was established and America turned its attention to space exploration. At this point, it was the former Soviet Union (later engaged in Cold-War with the West) that started the race rather dramatically by launching the first man-made satellite to earth orbit and von Braun became indispensable. He built various rockets, improving them at every stage, and it was finally his rocket – the huge Saturn rocket, that carried man to the moon.

Now considering the sum total of his activities, is this man, von Braun, to be praised? Incriminated? Or, is a scientist responsible for the consequences, which his inventions and developments have brought upon people whether they are good or bad? This is a moral question.

But let us return to von Braun's history for a moment. Wernher von Braun was the son of a minister of State. His father had wished for him to become a diplomat like himself and was sad when he learnt that the boy had decided to study engineering. "A Noble man should choose to be a lawyer, a judge or an administrator but not a

mechanic," grumbled the disgruntled father.

Von Braun was rather a weak student in his early days. He did not do well in physics and mathematics, which was cause for concern regarding his future. But, as destiny would have it[2], he was presented with a gift, which was a book, entitled: "rockets and space travel". He was excited about it, but could not follow the calculations to understand the mechanisms introduced to him throughout the book. So he settled down to serious studying on the subject. It has been reported that he became a leading student in his class ever since.

At the age of 18, he joined a voluntary organization called the Amateur German Rocket Society. This is a normal practice in Europe and other countries: Volunteers gather together, raise some money and organize themselves to pursue some project or any other activity that maybe worthy of interest. This could take the form of swimming club, flying club, rocket club, motoring club, astronomical society etc. Thus, some fields of activity in which the government is not interested or inclined to spend money, can be pursued by volunteer groups even by employing experts and building laboratories. This helps advancing research, in promoting vocational training, and sometimes even in developing some unique processes to enable the group to establish enterprises and factories. Ultimately, this is a contribution to the country's development itself.

Von Braun's Rocket Society was actually able to fly some rockets. Mixing alcohol and oxygen

[2] (3) No.18; (6)

and igniting it produces large quantities of gas, which if ejected through a narrow hole at high speed, pushes the rocket in the opposite direction. This is still the general principle of rocket propulsion.

Von Braun co-operated with the other scientists in the group to develop the rocket. Still a student, he managed to learn how to pilot an aircraft and accumulated various other experiences with the group. He graduated from the university in 1932 with an engineering degree whereupon he was invited to continue his research on rocketry for a Ph.D. degree. But this was not accidental or a chance affair.

Germany, which had initiated and lost the First World War, was under the obligation, according to the Treaty of Versailles, of not producing or storing any form of armament or weaponry for fear that it would yet spark another world war. Germany, which was now looking for a loop-hole in the treaty, found that rocketry – a new field of science – was not included in the list of forbidden exercises. So an engineer soldier by the name of Dornbeger was assigned by the government to develop this weapon secretly. Now Colonel Dornbeger (later General) was searching everywhere for talent and found Wernher von Braun. He approached him, persuaded him and provided him with the funds necessary to work on his doctorate in rocket research. This he did, and in 1934, Wernher von Braun was finally awarded his long coveted Ph.D. He was then assigned to continue the same work in the military.

Von Braun took on the task and immersed himself into it. He reportedly worked day and

night to develop efficient rockets; he launched them to the sky and measured the height they attained, the load they could carry and the way to guide them. By this time and since the rocket-power and von Braun's research was progressing in leaps and bounds; it became difficult to keep the project under cover.

So von Braun went about searching for a safer place to test his rockets. After a while, he spotted a protected area near a lake and surrounded by thick forests. He figured that if he shot the rockets along the length of the lake, it could travel 400 kilometres without the risk of being detected beyond the lake. So he arranged it with the government's assistance and obtained funds to build a secret military base in the area. Laboratories were constructed. Runways, oil depots and other necessary facilities were also built. This is the famous 'Peenemünde' where rockets were designed, built and launched. Needless to say, scientists and engineers worked on the project day and night, and they managed to produce results. One such experimental rocket fired along the lake traveled over 300 kilometres at a fantastic speed of over 500 kilometres per hour. It was the first man-made object that traveled faster than the speed of sound.

Von Braun now wanted to impress Hitler with his achievements. He filmed the launching site, the huge engines and the launching scene. Hitler was indeed impressed. He boasted that *"Europe and the world will be too small from now on to contain a war. With such weapons, humanity will be unable to endure it."* Von-Brawn was duly awarded his professorship.

This took place some time in July 1943. But unbeknownst to the Germans, the English had learnt of the existence of this military base, from secret reconnaissance flights and suddenly arrived in August to destroy it. It was a complete devastation.

Yet von Braun did not give up. He gathered up the remaining staff and started building an even more powerful rocket. They named it "Revenge" and worked on it to perfection. They were thus able to use it to rain bombs on Europe's cities. London was showered with 2000 explosives at various times of day and night. The English found it practically impossible to defend themselves against this rocket attack, mainly because it was built in a secret underground base and then moved about on mobile trucks, and also because these rockets traveled faster than sound, they arrived at the scene before they were detected. Each rocket weighed about 12,000 kilograms and carried *one thousand kilograms* (one metric ton) of explosives. Such a huge rocket flying to the enemy camp with such speed was really very scary.

As planned, the rockets brought terror and destruction to ordinary peaceful citizens. But did von Braun regret his actions and the role he played in the war? He wrote:

> *"With the tight press censorship imposed, the abuses of Hitler's regime were not known there. I never realized the depth of the abyss until very late and particularly after the war. I felt that while Hitler was unquestionably an aggressor and a conqueror, this put him more in a class with Napoleon than with the*

devil incarnate. However I felt that, like it or not, it was my duty to work for my country at war:" [6]

After the defeat of Germany, von Braun gave himself up to the American Forces. He and 127 rocket scientists under him traveled to the United States and again continued to work under the armed forces there.

This was of enormous benefit to the Americans. They gained the knowledge painfully accumulated over several years in Nazi Germany. Even some rockets were collected and shipped to the states. There von Braun dismantled them and explained the details of the work to the new 'ballistic scientists' of the era. Further improvements were made to these rockets and it is now commonly accepted that the late Pershing Missiles that were installed in Europe were near replica of these rockets.

Von Braun's engagement has admittedly been put to good use as well. It is understood that a rocket group under the wings of the army and navy attempted back in 1954 to launch a spy satellite to orbit, but was unable to do so because of lack of funds. When, however, the former Soviet Union launched a satellite on October 4, 1957 (Sputnik), the Western World was shocked; and the United States immediately allocated funds for von Braun to speed up his work.

Later the famous NASA (North American Space Agency) was established and von Braun duly transferred to their headquarters. There he began building huge rockets like Jupiter. Finally, he built the famous Saturn Rockets, one of which carried man to the moon. The early Saturn

Rockets weighed as much as 500,000 kilograms and were three or four storey high. He used just eight motors in tandem to lift such heavy load to earth orbit, and when he first achieved that on January 4th, 1962, it was considered a near-miracle. He was simply adored. The United States felt confident that it could make space-travel possible and the people were exhilarated beyond expression.

A few years later (in 1969), the United States managed the first moon-landing by man. It was unanimous; this was all made possible due to von Braun's talents and toils. In recognition of his achievements, he was bestowed with more than 20 honorary degrees. He also received numerous awards and presents from various national and international organizations.

It was based on von Braun's own design that Apollo 11 (the satellite that carried man to the moon) had been built with three 'stages'. The 1st stage contained food and fuel, the 2nd was the command module that housed the astronauts, and the 3rd was the lunar module that landed on the moon surface. Upon return, they left the lunar module behind in lunar orbit, then discarded the 1st stage in Earth orbit and landed in the 2nd. The total weight of the three stages was 40,000 kilograms. The rocket (Saturn 5) that carried up the satellite was 100 meters high and weighed three million kilograms. This project alone cost the United States 24 billion dollars.

It is difficult however, to estimate how much resentment and hatred has been bestowed upon him by the millions of people whom he subjected to misery and death through the successful

launching and subsequent ravages from his German V-1 and V-2 rockets. He was repeatedly asked about his role in the war and the remorse he felt (if any). Even 20 years later, his stand was unshakable. He wrote:

> *"What is a man's duty, who loves his native country, sees that it has fallen into evil hands, but also that its very survival is at stake? --------- quite a few of my German friends and relatives who fought in World War II won some of the highest decorations in combat. Yet several of these same men were later executed for their part in the abortive attempt on Hitler's life, while the rest kept fighting the external war. All of them undoubtedly thought they were just doing their duty ---------- I thought and still do, that under the circumstances, I did what was my duty."* [6]

Is this argument right or wrong?



Wernher von Braun – 1970

Corollary
Rockets

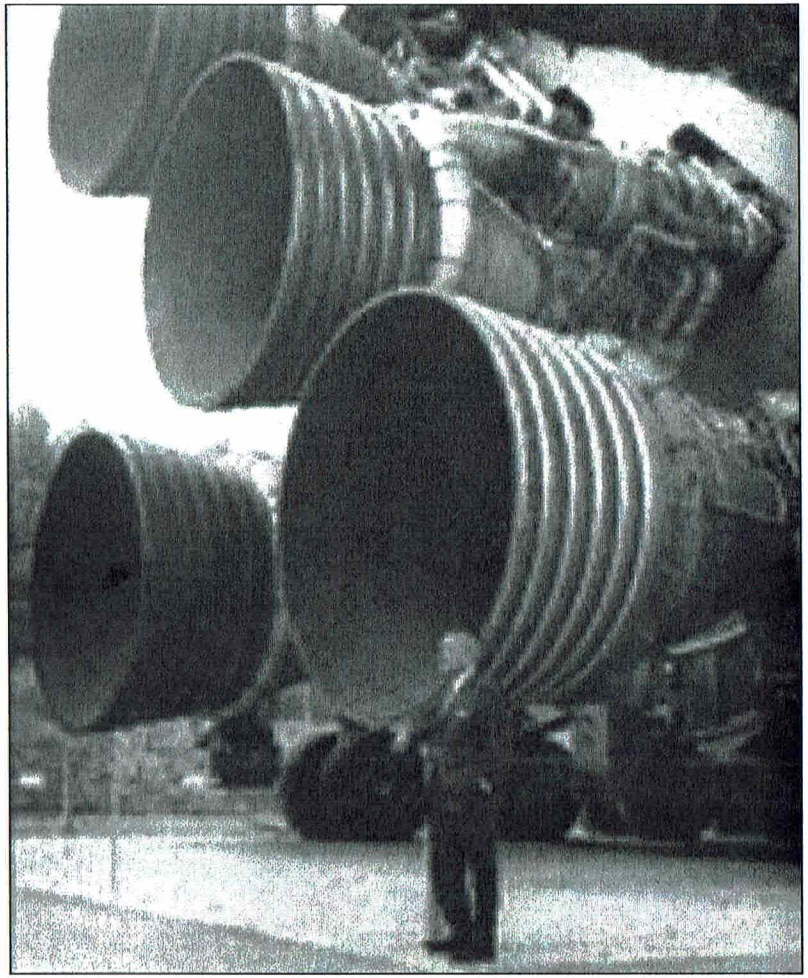
Rockets operate more or less on the same principle as jet airplanes. The jet uses pure kerosene for fuel. When this fuel is mixed with ordinary air, which is sucked-in and compressed by the motor, the mixture, upon ignition, explodes, producing gas and steam under very high pressure. Now this is allowed to escape backwards through a 'jet', and this causes the plane to be 'propelled' forward – thereby the name: "Jet Propulsion".

A rocket differs from the jet mainly in that it has to carry along its own fuel and air since when it travels in space, it cannot find any air to activate the propulsion in outer space. So it usually carries chemicals and oxygen cylinders with it.

A rocket journeying into space, or around the earth as a satellite, requires to reach and maintain a high traveling speed (as high as, or more, than 28,000 kilometres per hour). To accomplish such a feat it requires a lot of energy to lift a rocket and accelerate it to the necessary level of travel speed. The trick is to build the rocket in three parts. The first part lifts it from the ground and takes it up to a certain height, then drop off or burn out in the atmosphere. The second part takes over and with the now reduced total weight of the satellite and thinner atmosphere can push it up considerably farther. It then falls off too, and the third stage can easily get the satellite to the desired speed and height.

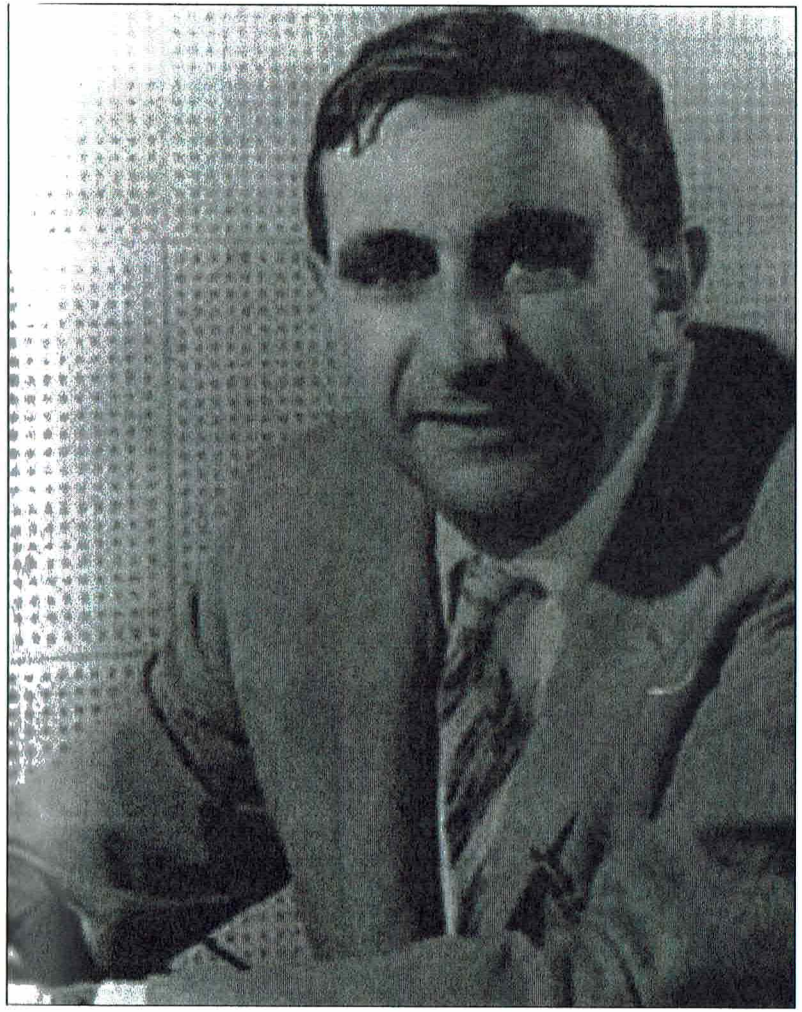
The rocket fuels (liquid oxygen and liquid hydrogen or a combustible chemical) are placed separately in large tanks and brought together through pipes into the ignition chamber where they are used. The combustion of the mixture produces huge amounts of gas, which, as we often see on television when a satellite is launched, gushes down to earth as it pushes the satellite up.

As additional force to help boost the satellite, two solid fuel rockets are installed on either side of it. Solid fuel can provide very powerful thrust, but has the disadvantage, when compared to liquid fuel, of not being easily switched off or closed down so that it is not reliable for sustained use. On the other hand, liquid fuel is so easily combustible that it can not safely be kept indefinitely in missile engines; and in time of need (say war) there is no time to refuel these missiles; so for such rockets it is always the practice to use solid fuel. Thus, there are different kinds and sizes of rockets in the world today.



Von Braun beside Saturn SC-1

Chapter 3



Edward Teller

1908-2003

Peace and the atomic bomb

"My experience has been in a short 77 years that in the end when you fight for a desperate cause and have good reasons to fight, you usually win."

Some people are just lucky to find themselves at an opportune moment in History. But then, rather than stand witness to some critical events unfolding on the stage of history, they manage to play an active role, to become actors themselves and change the course of history one way or another. Edward Teller was one such people. In order to grasp the picture of the various circumstances that propelled him to the front, it is necessary to go back in time and note a few things.

Mendeleyev had previously charted the periodic table and according to that chart, the last element on record (the 92nd) was uranium – the last heaviest element.

At that time, in their never-ending efforts to acquire more knowledge about nature and natural forces, the scientists tried to introduce forcibly, the known atomic particle (proton) into a uranium atom to see if they could build the 93rd element. They did not succeed. That was because they could not manage to produce a proton of sufficient kinetic energy (speed) that could dig its way into the heavily charged uranium atom.

But just a short time earlier an English scientist (by the name of Chadwick) had discovered that an atom comprises not only protons and electrons, but also contains a neutral

particle, which he called neutron, in the nucleus of the atom.

And because a neutron has no charge of its own and therefore cannot be repelled by the nucleus, scientists found it possible to get into the uranium atom via the unresponsive neutron. It was the German scientists who tried it first. But when they analyzed the results, they found that instead of building a 93rd element, the atom had simply disintegrated into smaller parts! The scientists were not prepared for this kind of phenomenon; and puzzled by it, simply announced their discovery to some of their colleagues.

This was the secret behind the atomic bomb; and the period was the eve of the Second World War.

This work was later repeated by other scientists to check the earlier findings. It was true that the atom did split. Calculations showed immediately that there was energy release in the break-up. Of course, the amount of energy so released by only one atom is very minute. But considering the number of atoms contained in say, one kilogram of material, the energy total of these atoms is enormous – even earth shattering (literally). What actually happens in the process is this: the neutron, upon penetrating the uranium nucleus, causes it to break up into two smaller particles and release two neutrons. These again enter neighbouring atoms releasing four other neutrons. These, in their turn, go on and release another eight, etc. The process continues until all the atoms are covered, and the total energy thus made available is simply colossal. Obviously, this

process can produce a tremendous explosion. When European scientists realized this fact, they became terrified. If German scientists built such a bomb, Hitler could not be stopped. He would bring the world under his thumb!

Jews of those times were being harassed and harshly treated by the Germans, so that the scientists and many other Jews who could, were leaving the country and seeking refuge in the rest of Europe and in America.

In Britain, it was two such refugee scientists who first realized the possibility of making a bomb.

In America too, it was the refugee scientists who had fled from Hitler's terror who came to learn of it, designed the weapon and finally built it. Edward Teller was one of them.

Teller is a Hungarian Jew by birth. He had come to Germany to pursue a higher education and to obtain a doctorate degree. Upon completion, he had stayed on to teach at the university. Then when anti-Jewish sentiment got worse and worse under Hitler's government, Dr. Teller simply moved to the United States in 1935 and took up a teaching post there.

When Hitler started invading neighbouring European countries, Edward Teller rightly shared the fear of his fellow scientists. Unfortunately, America had not yet joined the war then, and the project to build the bomb would require millions of dollars (actually it took 15,000 million dollars to complete it). So how would they persuade the government to allocate so much money to a war-effort in which they didn't participate at that time? Besides, Edward Teller and colleagues were

foreigners. In fact, in Britain, it was forbidden to employ foreigners and to let them delve into such sensitive issues. Professor Joseph Rotblat's situation is a case in point. He was a prominent scientist and later a Nobel Peace winner (1995), and even sometimes represented Britain leading delegates to other countries (he was this author's lesson supervisor and external examiner). But he was not allowed to work on the atomic project. His specific request to serve in his capacity was decidedly turned down. He was born of polish parents. He traveled to Britain seeking higher education, but when the war broke out, he was forced to remain there.

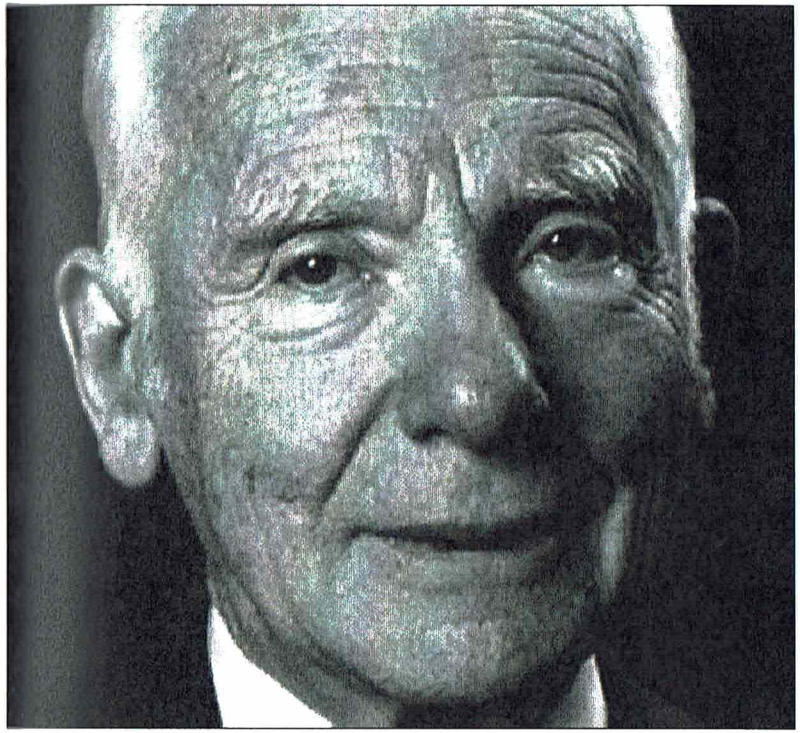
So, to get round this problem, Edward Teller in America devised a plan with fellow scientist Szilard (who actually suggested the idea first) to get the famous Albert Einstein to write a letter addressed directly to President Roosevelt himself and to warn him of the impending danger.

Edward Teller and company went straight to Einstein's residence and managed to persuade him to write the letter. This was done, and the president was convinced. The project had begun!

A short list of scientists recruited to kick off the research included Edward Teller. So he picked up his bag, greeted his family, and left for the project site. Soon Joseph Rotblat and other promising British scientists came to join them, and the work started full-speed ahead.

They worked day and night. This was an urgent task. It concerned freedom of mankind and world peace. The threat was that if Hitler got the bomb before everybody else, he would use it to conquer the world or to destroy it in the

attempt. They noted that all publications concerning uranium had been suspended. "Why?" they asked each other. One can not help wondering how they noticed a missing item out of all the multiplicities of publications in the scientific field. To follow up on any number of publications on a daily basis is in itself difficult, but to be able to notice what is missing demands alertness. The Germans, once they had discovered the 'secret', had forbidden any further publication on the subject. Soviet Union and France had done the same. So everyone had been the wiser somehow. Hence the urgency to complete the task and own the bomb before everybody else did. It was usual to work 18 to 20 hours a day. Race and nationality were not of great concern in America. Everybody who could join was invited to participate. That was how Joseph Rotblat and company came to be included in the project.



Professor Joseph Rotblat

At last, the bomb was ready. It was given field trial on July 16th, 1945 and it was perfect! There was jubilation and even ecstasy among the scientists present. They had indeed succeeded in unleashing the energy out of the atom. The quantity of uranium utilized in that test was a mere one kilogram. But the energy released was equivalent to that of seven million kilograms of coal in the kitchen stoves. Indeed the scientists deserved to congratulate themselves for their insight. But the purpose for this exercise was not to be set aside by the politicians. Two bombs were

dropped on Hiroshima and Nagasaki (Japan) and that, of course, ended the war immediately.

Edward Teller, however, was not to settle for this. He decided to build an even more powerful bomb. So he went around convincing colleagues. He then started an open campaign to get as much priority for the Hydrogen Bomb project as for the previous one.

Initially he was met with some strong objections. The scientists having witnessed with horror what the explosions caused to Japanese cities and citizens found no justification in constructing yet another more powerful bomb. There were those who had retired even before the atomic bomb had been completed when they had seen the trend of the war and the inevitable collapse of the Hitler regime (e.g. Joseph Rotblat who partly on the strength of that action recently won his Nobel Peace prize). So Teller began to be regarded as war-monger.

But he did not give up. He decided to go at it alone if necessary. At this juncture, the former Soviet Union conducted its own test of Atomic Bomb explosion. It too succeeded in making it!

And tension rose again. To make matters worse, it was revealed that some of the scientists engaged in these secret projects were actually sympathizers of communist Soviet Union and quite a number of them were spies! These latter ones were apprehended and their actions confirmed. They had already sold secret documents to the 'enemy'. This caused fear and worry. The Soviet Union would not stop at atomic bomb but would go on to make the more powerful Hydrogen Bomb.

This clinched the argument; Edward Teller's claims were paid attention to, and the work on the development of Hydrogen Bomb went ahead in earnest.

Yet, what is the theory behind the working of the Hydrogen Bomb? The key to the answer to this question came from the sun. Not long ago, it was a quandary; how the sun could pour forth such an enormous amount of heat and what is the mechanism behind such an outpour of energy? The sun emits energy into space at the rate of 90 trillion times trillion calories every second!

It has continued to do so for the past five billion years. Why is it not exhausted or at least weakened in power over such a long time? This riddle was solved in or about 1938. 80% of the sun's composition is hydrogen. When two hydrogen isotopes are forced to fuse, the two of them will make one helium atom. When one helium atom is compared to two hydrogen atoms, there is a loss of weight. Where is the missing part gone? It is now understood that the 'missing part' has been converted into energy in the process of fusion. This is a lot of energy. If one kilogram of hydrogen atoms is fused in this manner, the amount of energy obtainable is equivalent to that of burning 3 million kilograms of coal.

It became immediately obvious, therefore, that if we could manage to fuse hydrogen atoms in the same way here on earth, we could benefit from a lot of available energy. When one realizes that hydrogen is extractable from water and that water is readily available even in poor countries, it is

very tempting to try and develop the technology to tap this source of energy. This possibility was discussed with enthusiasm in various countries. It is recorded that at one time, a Russian scientist (by the name of Gamow) presented this possibility to a group of authorities, whereupon Bukarin – the mayor of Moscow – jumped up and offered him the use of the electric power station for Moscow every night. Gamow declined the offer on the grounds that even the electrical energy output of the entire country could not suffice to produce the heat requirement (of hundreds of millions degree centigrade) to facilitate this fusion experiment.

This was the very problem with which Edward Teller was wrestling. But when the atomic bomb was built, he realized that this part of the fusion problem had been resolved. The heat released in the process of atomic explosion was sufficiently high to enable hydrogen atoms placed therein to fuse together thereby releasing even more heat and explosion.

So it was clear now that who ever managed to build the atomic bomb could also build the Hydrogen Bomb.

Edward Teller's ambition and urge was to build the bomb ahead of the Soviet Union. To that end, he traveled the width and breadth of the country to recruit capable young scientists from various colleges. He then established the laboratory and set every one to work.

Today Edward Teller is recognized as the "father of the Hydrogen Bomb". This is not only because he was the instigator and the spirit behind the work, but also because it was he who

first arrived at the way the thing could be made while expressing his findings mathematically so that other scientists or even lay persons were able to understand and be convinced enough to launch the project.

The Bomb was finally made and assembled. It was tested on November 1, 1952 on an island called Elugaleb and to the surprise of every body; the island disappeared into the ocean. That explosion had a force of 15 megaton of T.N.T., which is 750 times more devastating than the Atomic Bomb.

Edward Teller had, at last, fulfilled his ambitions. But then the Soviet Union too demonstrated its capability by exploding one of its own on 12-8-1953. Thus was created the balance of power, and the so-called Cold War started.

Of course, one cannot convincingly argue that, had America not built a Hydrogen Bomb, the Soviet Union would not have done so. Building the Hydrogen Bomb seemed a natural step after the Atomic Bomb. In fact, research on both fronts was being conducted simultaneously. That apparently saved development time.

What was not obvious at that time was that so many bombs would be built in the following few years to the point of presenting a threat to civilization and even human existence. Both United States and Soviet Union competed with each other in making the bombs and loading them into missiles. On each side, airplanes armed with the weapons always stood ready for combat. Ships and submarines treaded the oceans – poised to send their missiles at any time into enemy targets. This build- up was so intense that

by 1970s the number of explosives was said to be sufficient to wipe out human race seven times over.

So whenever regional crises erupted anywhere and the two Super Powers took sides, there prevailed in the world tension, fear and worry.

Now what can be said of the role of science in this? If there are scientists, who would refrain from basic research for fear that it would lead to such a crisis, then their number must be few; and even these must be having faith in other scientists.

But Edward Teller had remained steadfast in his conviction; that America must stay ahead of the Soviet Union and it should be ready to sacrifice anything to that end.

That was why he again brought up another idea in the 1980s to shock the world. In his capacity as scientific advisor to President Ronald Reagan, he persuaded and convinced the president to launch another build-up in armament under the name "Star Wars". It was this new race that scared the world and prompted millions of people in Europe and elsewhere to stage public demonstrations in the 1980s.

What was the idea behind "Star Wars"? As presented by Teller, the idea was to strengthen the defence system against in-coming enemy missiles. If, say, World War III started, then bomb-laden missiles would start rushing towards the enemy camp. The intention was to intercept these missiles in their tracks and burn them up. One of the mechanisms suggested was to load bombs into satellites. When the bomb was made to explode, the immense radiation out-put was

then directed by lenses or reflecting mirrors focused and directed towards the enemy missile. Lasers are known to be powerful cutting tools, so that if, say, x-ray lasers are directed towards missiles they would burn them into cinders instantly. Another alternative was to send up laser beam from ground base and arrange a reflector on a satellite so it could be re-directed towards its target. It would be easy to manoeuvre the mirror to target any object anywhere. Missile trajectories are classified into three different phases, and the defence mechanism varies accordingly.

The initial phase is when the missiles are starting from their bases and climbing up. Here the laser beam will be employed. The missiles are most likely the MIRVS (multiple independently targetable re-entry Vehicles) which carry up five to ten independently targetable missiles and once in space, send them in different directions. It is intended to destroy the MIRV before it releases the missiles.

Enemy missiles, that manage to pass through this phase, will be tracked in space and blasted out with missile bombs at a distance between 500 and 1200 kilometres away. If any missiles still manage to get through then hunter rocket can be sent up where upon reaching its target will spread out its special net to make certain that it will not miss it – thus diverting its direction and destroying the target. Other special rockets are also designed to shoot at the target and destroy it at a distance of 10, 100 or even 800 kilometres away. By this means, Teller believed he could put full proof anti-missile screen around his country

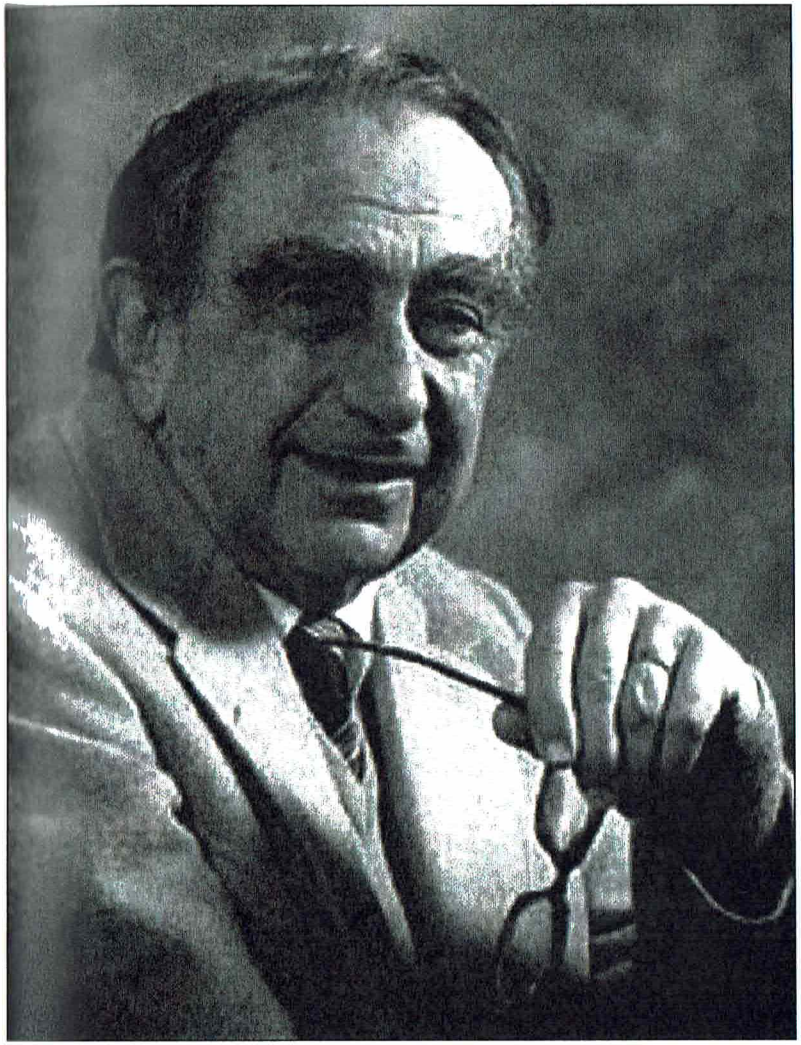
and other allies.

This project, at the start, required 60,000 million dollars. This clearly is a lot of money, which if applied to developing some regions of the globe could do a lot of good. But Edward Teller never listened. He was adamant that the project should go on.

Of course, the Soviet Union could not ignore this development. It too had the duty to protect itself and its allies, thus the pressure on the USSR was immense. Its economy could have been seriously strained if it attempted to answer tit-for-tat.

At any rate "perestroika" started in the Soviet Union. It then spread to neighbouring countries and very soon, "The Iron Curtain" collapsed. Western-style governments sprouted everywhere, and the threat of nuclear war subsided at least for the moment.

It is difficult for me to argue that these two phenomena are "cause -and-effect"! However, I think History is yet to judge Edward Teller and his role in the drama of this last half-century.



Edward Teller

Corollary
Thermo-nuclear energy

Edward Teller is recognized as the Father of the Hydrogen Bomb mostly because it was he who formulated the method and showed the way to go about building it. The fact that the fusion of hydrogen atoms does yield energy out-put has been known for quite some time. The sun emits radiation energy at the rate of 379 $x10^{21}$ Kilowatt every second for the last 5 billion or so years. It has been doing so by just this method of fusion of atoms. What is required is to create sufficient pressure and temperature to force atoms to come together and fuse. The sun, by virtue of its enormous size (it is larger than the Earth by a million times) has sufficient depth and pressure to accomplish this, the temperature at its core is estimated to reach 15 million degrees centigrade.

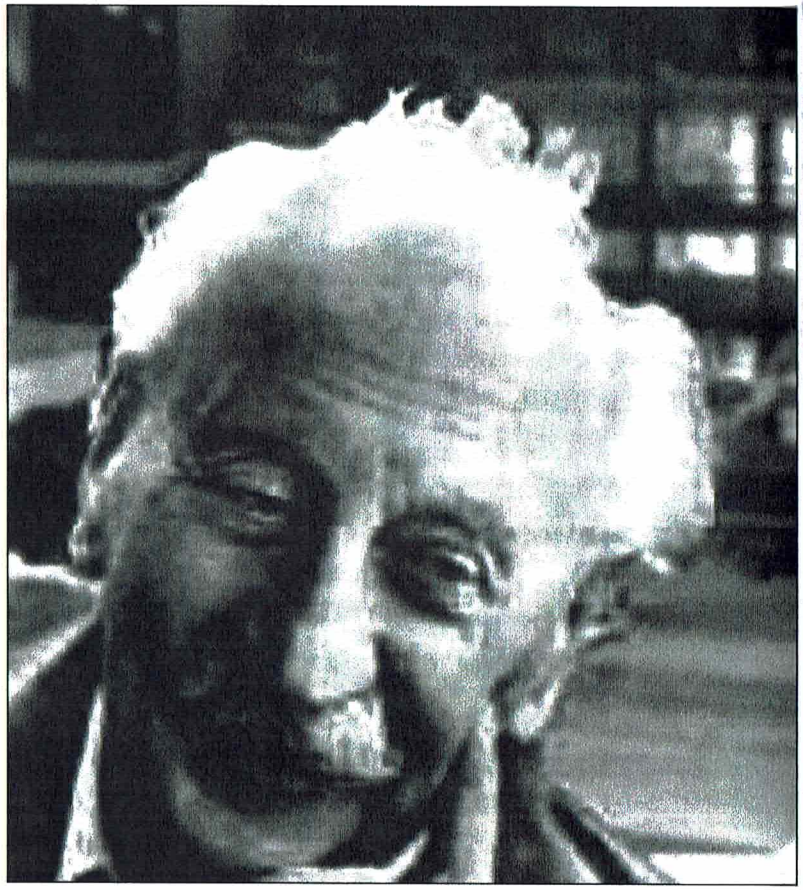
The problem with us earthlings is that we can not create these conditions here. Of course, it has been possible to explode the bomb. That could be achieved temporarily by using an auxiliary exploding device to initiate it. But to obtain a sustained output for peaceful use of the energy has not been possible yet. The benefits to accrue from fusion power are indeed very tempting. We have mentioned earlier that one kilogram of hydrogen when fused completely can yield an energy output equivalent to that of burning three million kilograms of coal. Besides, hydrogen is available in all the waters of the rivers and seas.

But the problems, associated with the production and containment of such energy, are

not easily surmountable. To begin with, one has to produce heat measuring in millions of degrees. May be here superconductors can aid a lot. However, how to contain this plasma? Under this temperature, containers themselves melt away or at least reduce the temperature. The trick to get round this problem has been to use magnetic forces to rotate the plasma charges round and round and thus avoid containers. But the history of fusion experiments so far only reveals that as one problem is solved, another one pops up immediately.

Nowadays laser beams are increasingly being used to bring the gas under high pressure and temperature and some promising results have been achieved. The sustainability and profitability of producing energy by any method tried so far is a big question. The struggle continues though, and perhaps by the first quarter of the 21st century, we will reap the fruit of the labour of our scientists and engineers.

Chapter 4



Abram Ioffe

1880-1960

Cultivating the young generation

"Absence of evidence is not evidence of absence"

The Scientists' great challenge and endeavour is to study the unknown, discover its behaviour and reveal it to the public. To discover a new thing through one's own effort is a source of great satisfaction. To publish findings for people to read and to understand and then to be able to make use of it gives the scientist, I think, the justification for having existed.

Many a time, famous scientists are appointed to be directors of research centers. That is intended partly so their fame could rub onto their subordinates and onto the youth, who then would be inspired and encouraged to take on further challenges. But of course, not-so-famous scientists could also be recruited for the top job. This could be because of their talent and ability to inspire others to get results.

Basically, it is a prerequisite to cultivate young scientists if science and technology is ever to take root and flourish in the country. Educated man-power is the essential wealth of any country, and to develop this requires close attention and planning.

Abram Ioffe was one of those far-sighted scientists who laid the basis for science in the former Soviet Union. He may not have been a shining scientific discoverer himself and he is known mostly in the East. This, in part, may be due to the polarization of East and West, but for our purpose, I believe we can learn a lot from the

strategies which he devised to train scientists.

In the former Soviet Union as in other countries, it is a great honour to be nominated a member of the Science Academy. Abram Ioffe was not only able to be a member himself but also managed to qualify his students to achieve results so that 15 of them were made full members and another 30 of them reached the status of associate-members of the academy. The question is 'how did he manage it'?

Ioffe was a simple director of a faculty in the polytechnic institute of the former Leningrad (now St. Petersburg).

The lessons given in this faculty consisted mainly of physics, mathematics and engineering. It was Ioffe himself who laid the groundwork for the establishment of this faculty. He then carefully selected talented lecturers to teach even the newcomers (usually called 'Freshmen'). Some of the courses, he handled himself. He was of the conviction that one has to lay the groundwork very carefully in order to reap good harvest. So he arranged for scientists to come down and work with junior students in order to stimulate them.

Students too, were not assigned arbitrarily. They are carefully scrutinized from the very first year of college to identify those with talents for theory or those gifted for experimental research.

To Ioffe it was not of much concern if such students failed to pass in some of the tests in the classes. On the other hand, he encouraged all students to pursue their research or follow their special interests in their spare time.

Researches were conducted in all different fields in his faculty. Every weekend he held a

meeting to review the week's progress (this is a routine practice in Europe). At this meeting, researchers come forward and present their achievements for the week, or any problems they encountered in their work. Besides which, popular scientific publications around the world were studied and reviewed and important topics are selected for presentation and discussion at the meetings. Ioffe always presided over all such meetings and found that he had to deal with very many topics every week. He finally summarized and commented on all of the topics under discussion and gave directives as to which subject required immediate attention and further investigation.

This approach to training has proved very useful to young scientists. Usually during the first exposure to these types of meetings, students find it hard to follow the agenda and are sometimes bored. Then they start to sense the excitement of front-line research, and as they understand the subject, they begin to be absorbed in it, and to figure out where their special interest and talent lie. This arrangement, where a broad field of activity is provided to students, gives them ample chance to find out what exactly they are good at and what they can do.

Students are also taken around to visit the laboratories and facilities available. In the days of Ioffe most of the equipment available was made by hand or in the nearby workshop. As a result, these machines were not even remotely approaching the highly refined and sophisticated instruments that we find in our laboratories today. They appeared crude and drab. Yet, that

was the only way possible to be self-sufficient as was dictated by circumstances. Everyone made his own tools or arranged to get it installed somewhere in order to acquire the necessary set-up for his experiments.

Research went on for long hours day after day. The topics that were dealt with varied from atomic physics to sound, magnetic theory, electromagnetic waves, heat, x-rays, radio engineering and many others. Ioffe in his capacity as the director of the faculty, had to direct the researches, and therefore had to follow each activity. He managed to do so, and even went further to make it his duty to present his findings in simple terms to the students so that they could grasp the essence (or difficulties) of it all.

Ioffe also made it his concern to promote relationship with other European countries in the field of science. Once he played host to European and American Scientists who came to attend a conference of Physicists Associations.

The meeting was opened in Moscow University, but was later shifted to other universities in turn. The trips were arranged carefully to include travel by car, train and boat.

In the course of the trips, playful competitions, games, jokes and other entertainments were staged. The participants found all this to be relaxing and enjoyable.

In the meantime, he made sure that promising students and young researchers had the opportunity to attend most, if not all, of the proceedings. From hindsight, scientists today admit and appreciate the fact that those events were important landmarks in the history of their

development in the profession.

Ioffe has other achievements to his credit. He believed that for science to flourish in a country, every region must be given the chance to develop; so he established polytechnic research centers in various parts of the country. Of course, the regional research centers pick their specialization and pursue that field of research rather than duplicate other works. So if one center was studying radio engineering, another one would concern itself with, say, low temperature physics, and yet another one with plasma physics etc. In this way research were carried out in many fronts of science.

To give a good start to each of these regional research institutes (as this is important) he transferred the best scientists from his Leningrad staff to one or the other of these new centers. These scientists took on the challenges of their assignments and persevered to achieve results. For this purpose, they had to recruit promising students and train them in the discipline. Thus, they each served as nucleus around which training of scientists and development of research activities sprouted and flourished.

That was how Ioffe and his Soviet Union laid the ground work for the speedy development of science and technology.

Finally, one lasting contribution for which his country owed him gratitude is the establishment of laboratories for research in nuclear physics. He took a firm stand (for which he was later to be blamed) that research and development in this field is something one cannot ignore at all.

So having to start from scratch, he went

around visiting some laboratories and persuaded the leading scientists to switch to nuclear physics. He then arranged for his former student, by the name of Igor Kurchatov, to re-arrange his laboratory and make it a center to co-ordinate the works of the others.

He then convened a special conference in which they collected and reviewed all the known publications in this field. Realizing where the world was heading, to convince his colleagues as to which direction their field of research should take, became easy for him.

As a result, the country was able, in a very short period of time, to catch up with the rest of Europe. Thus, the basis for the development of science had been firmly laid down.

It turned out though that not all scientists had given him support in his endeavour. In fact, he was discredited a few years later. At a congress of the Soviet Science Academy held in 1936, Ioffe was publicly censored and scorned for having wasted precious money on such unimportant projects. The congress was advised that Ioffe had caused a lot of money to be squandered and had wasted the time of several professionals by tying them down to useless laboratories that he had established at his own fancy.

However, it became clear later that when the Second World War broke out, and the United States and Germany were readying to build the Atom Bomb, the Soviet Union would have remained helplessly and hopelessly behind had it not been for Ioffe's foresight. Without trained man-power and without any laboratory, it would have been too late to start and achieve anything.

Things were made worse when sanctions were imposed on this type of research later during the war and after. So after the Hiroshima and Nagasaki bomb explosions that brought the Second World War to an end, the threat to eliminate Communism together with Nazism would, they say, have definitely been carried out. Considering the deep hatred that the then British prime-minister Winston Churchill had for Communism and later the doctrine of McCarthyism that prevailed in the United States, it was certain that an attack on the Soviet Union was inevitable and that, to them, would have been disastrous. Soviet historians later acknowledged Ioffe's efforts with gratitude.

It was thanks to his efforts that qualified labour and laboratory were already available and so his team of researchers was able to carry on and build the Atomic Bomb in time. When America came up with the Atomic Bomb in 1945, the Soviet Union followed suit in 1949. Again, when America built the Hydrogen Bomb in 1952, they did too in 1953.

The man responsible for achieving this feat is Igor Kurchatov – one of Ioffe's disciples. He was so dedicated that he searched the laboratories, recruiting capable people; organized and directed the job, secured the necessary budget from the government and did all the right things to finally get the job to completion in the nick of time. He is now recognized as the 'Father of the Atomic Bomb' in the East.

The primary mover in all these fields of activity is Abram Ioffe. Many of the famous scientists that wrenched the country out of backwardness and

propelled it into a super power status owe their achievements to his training. Alikhanov, Kikoin, Alexandrov and Artsimovich are just a few of the several scientists that reached the summit of fame in the country. As mentioned earlier, 15 of his students got to be members of the prestigious Science Academy and about 30 of them became associate members. Some of them were even presidents of the academy, and still some others had research centers named after them.

Thus, it was Ioffe who laid the foundation for progress. He organized and developed science and technology in the country. Just like sports coaches tour the country looking for talented sportsmen, pick them up, train and get them to win world records, Ioffe went around looking for talent among the young, then trained them to be scientists and enabled them to achieve results. He played a major role in helping raise the country to a 'super power' status, whereby the 'balance of power' was restored in the world and peaceful competition was made possible in such fields as space travel, nuclear energy and computer technology for peaceful purposes. This is no mean achievement on his part. The current situation in his country is of course a consequence of the political trend chosen and followed rather than of lack of training in science. Today it is more than ever clear that if we have to take our societies out of superstitious beliefs and into the scientific way of thinking, and if we have to develop Science & Technology to the present day world standard, there is no other way for us to proceed than to train and engage our man-power wisely. The problems third-world countries face today are

more or less the same as what Ioffe then faced in his country. For example, the standard of education (especially in Science) is very low and laboratory wares (even the simple ones) are most of the time imported using hard currency (if and when available). The technical know-how is so limited that even simple know-how's in industrial processes remain hidden in foreign hands (patented or licensed etc.).

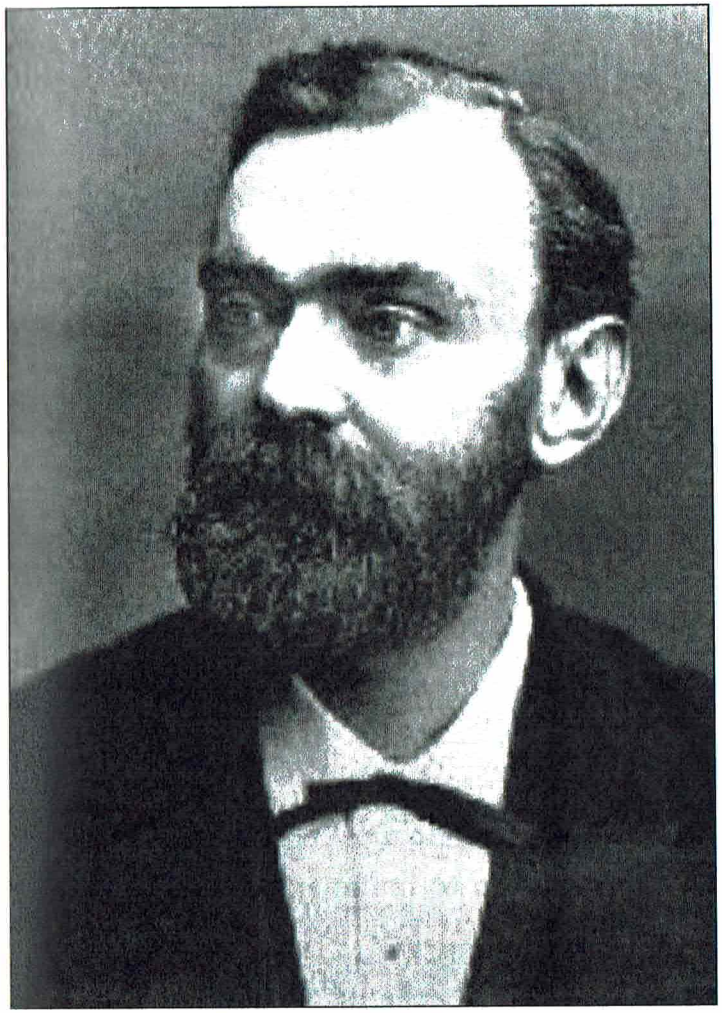
Today, it is regarded that in the United States, the depth and breadth of Science and Technology among the population is so low that it is said to be alarming. Well, what can we say of these other countries?

In this regard, it is indispensable that we have to improve the standard of education; the whole depth and breadth of it. Specifically, science & technology courses should be of high concern in both Elementary and Secondary schools! And also, conditions should be made favourable for maximum utilization of the creative power of citizens and the development of their science culture. Leading scientists of the calibre and devotion of Abram Ioffe are very essential for, among other things, selecting appropriate foreign technologies and introducing them into the country, and for devising a balanced self-supporting scheme of development in which the youngsters could be stimulated to participate effectively.



"The main scientific achievements of Ioffe relate to crystal physics (electrical, photoelectrical and mechanical properties) and X-ray structural analysis. As far back as the beginning of the 1930s, Ioffe settled on studies of semiconductors. This field has become one of the leading directions of research at the Ioffe Institute."

Chapter 5



Alfred Nobel

1833-1896

To make up for the damage

"If I have a thousand ideas and only one turns out to be good, I am satisfied."

When Nobel's name is mentioned, what usually comes up in our minds is the famous Nobel Prize. This prize has now reached beyond the million Marks in dollars, and is always the scientists' dream, since winning it guarantees him or her with the recognition and fame for great achievements.

But what sort of person was this man Nobel? How and why did he establish the Prize-awarding institution?

Nobel, to start with, was a Swedish citizen born into the upper class society. His father was an inventor and an engineer. Formerly he was a building contractor, but his business collapsed in 1833. Nobel junior was born in the same period

The father tried his hand at various odd jobs to recover past fortunes, but it was of no avail. Finally, he decided to build an armament industry. He tried to make explosives to sell to the army. But again, he was not successful so left the country and went to Russia.

The Russians received him with open arms. The minister of defence immediately recognized the importance of this man's works and made arrangements for him to get the necessary funds to establish the factory. So it turned out that when Russia went to war against Turkey in 1854, it was the anti-tanks, guns and other

ammunitions supplied by this factory that played a decisive role in Russia winning the war.

As a result of the demand and market opening his products created, Nobel Sr. became very rich. Having thus decided to expand the business even more, he re-invested all of his gains into the project. But unfortunately for him, the war ended abruptly and his services were no longer required. Nobel Sr. became bankrupt again.

The junior Nobel grew up through all these ups and downs. Later when he returned with the family to Sweden, he too started doing further research on explosives. He figured that if they could put to practice what they had learned from their investigations and experiences in Russia, the family could manage to stand on its feet again.

So, they rented a house and began experimenting again. But they did not seem to master all the intricacies of the art or science of it. In the course of one experiment, the material at hand suddenly exploded. It was so violent an explosion that the house collapsed, the technicians died and Alfred's little brother too, was killed. The father went insane and remained thereafter a sick man.

The government reacted immediately by forbidding any future experimentation with explosives in residential areas including even transportation or storage of the same. The neighbours and the people at large all hated the members of the family for the so called 'dirty work' in which they were engaged.

But Nobel Jr. had no intention to retreat. Of course, he was physically a weak person. He was

also poor in social relations and remained a lonely and aloof person. But then he was also mentally and intellectually gifted with fierce determination and courage to pursue his goal alone. So he hired a boat, went out to sea and proceeded to carry on the experiments by himself.

By this time, Lady Luck turned her gaze on him. He discovered that glycerine when mixed with nitrate salts was a good and somewhat reliable explosive. So he took out a patent in his name and started mass-producing this liquid. His product was then used to crack open rocks in quarries and also to dig tunnels through mountains and hills to lay railway tracks. So Nobel became successful and rich again.

Later still, realizing that this product in its liquid form is not prone to easy transportation and storage and is also liable to occasional explosion (as did happen a few times), Nobel proceeded with further research and experimentation, finally obtaining a solid product. He named this version 'dynamite'.

Now this was 'hot cake' on the world market. Soon, he established factories in Germany, United States, Britain, France, Italy and scores of other countries. And when World War I broke out, feuding parties on both sides were fighting each other with his armaments.

Germany in particular, had several factories that enabled it to get ample stocks. On the other hand, France, which unfortunately had earlier declined to permit Nobel to establish factory, was now without the means to produce the goods. It was faced with a crisis. However, France was able to win the co-operation of the Nobel Prize

Foundation to establish the factory in time. Its ally, Britain, which had its own factories, however, fell short of the raw material to produce dynamite, because German forces had cut off its link from the Latin American country, Chile, which was the primary source for the material. So it looked like Germany was heading for victory in the war. It was at this crucial stage that Winston Churchill was appointed Head of the Admiralty in Britain, whereupon he gathered all his forces and led an attack on German navy and won back the supply from Chile.

Now Germany faced the prospect of defeat. It appeared just a matter of weeks before it surrendered, but its scientists came to the rescue. They had earlier done some research on these materials and on the strength of that, were now capable to extract the necessary components from atmospheric air and make ammonia out of it. They made the nitrates out of this, and were thus able to continue the war.

The end result of all this fighting was that no less than 10 million people perished in the war.

Finally, after four years of bitter struggle Britain and its allies managed to prevail over Germany. This was made possible partly due to the fact that the British were able to improve over the process of dynamite production. They had managed to substitute one of the major raw materials by extracting acetone from maize crop in the laboratory. This was achieved in 1911 by a teacher called Chaim Weizman. This person, a Jew, because of this contribution to the war effort, became famous and popular among the Jewish society. He then went on to campaign for

the rights of Jews to resettle in their historical homeland, Palestine, and finally succeeded in his endeavour.

It is worth noting here, that he finally ended up as the first president of the new state of Israel, a situation that precipitated the Middle East crisis that goes on even today.

The major weapon employed in the 1st World War was dynamite. Nobel's factories were busy in the major warring countries working day and night to manufacture these weapons and arm the fighting forces on both sides of the 'front'. The revenues collected from the war ravages were from people's blood and flesh.

The contradiction in Nobel's characters and deeds is that he was personally a peace-loving person who despised war. People say that he was against any trade deals involving weapons. But his deeds stand in stark contrast to his beliefs. On the one hand, he is an apostle of peace, and on the other, a dealer of arms of destruction.

Nobel had his own reply to this. He argued that if he improved on his weapons sufficiently enough so that their destructive power is well assured, then wars will cease to be fought. If each of the warring parties fully realizes that the enemy's fire will destroy its army immediately, then no one will dare to wage war. This reminds us of the fear of assured mutual destruction between the superpowers and the resulting "peaceful co-existence" principle that prevailed during the 'cold war' period of the last 50 years or more.

Whatever the argument was, Alfred Nobel managed 355 patents registered in his name. He

was thus able to accumulate a fortune in a relatively short time. But sadly, enough, Nobel, in spite of his riches, was not a happy man. He had neither a wife nor a family of any sort. He did not have an heir. So he lived a lonely and bitter life and finally was bed-ridden. He could find neither medicine for his illness nor comfort from close friends. At last, he died a lonely death in 1896. But the will he left behind in writing made his name immortal. He had bequeathed a capital of about 33.2 million kroners (Swedish Currency) to be invested, and the profits or interest thereof to be distributed annually to persons outstanding in their contribution to the welfare of society. When one examines Nobel's testamentary requirements in detail, the award money is to be divided up into five equal parts; three of which shall be awarded to persons who made important discoveries or improvements in the fields of physics, chemistry and physiology (or medicine). The fourth award shall go to the person who produced the most outstanding work in literature; and the fifth award to the person or organization that did the best work to promote fraternity among people.

In 1968, the Swedish parliament established the sixth award fund to be provided by the national bank and awarded for Economics. This was implemented in 1969.

Nobel's beliefs and actions may still be a subject of discussions among historians, but the Nobel Prizes continue to play their role in promoting peace among people and in stimulating

scientists to make discoveries or inventions.[3]

[3] Today a Nobel award winner can receive as much as 1.12 million dollars.

Corollary
The Nobel awards

Nobel Award ceremonies are always conducted with great fanfare. The Nobel Peace award is presented by the Norwegian government while the other five awards are presented by the Swedish government.

The Nobel Prize fund was instituted in 1900 after settlement of litigation, which Nobel's relatives had brought to court in order to claim their inheritance immediately after Alfred Nobel's death in 1896.

The Board of Directors of the Nobel Prize Foundation has a duty to administer the Foundation and to nominate persons deserving of the awards.

The Board has five committees each of which has five members comprising it. There is now a sixth committee since 1969. Each committee has the responsibility to nominate worthy persons (or organizations as the case may be) in their field of research or endeavours.

The committee in the course of its duty and in the obligation to discharge its responsibility can solicit advice or recommendation from relevant sources. These could include;

a) Famous university professors,
b) Former Nobel Prize winners (laureates)
c) Parliamentarians (for the peace award)
d) Chairmen of Authors' associations (for literature) and any others.

The people invited to submit their recommendations (and any others who want to express their wishes) should do so before

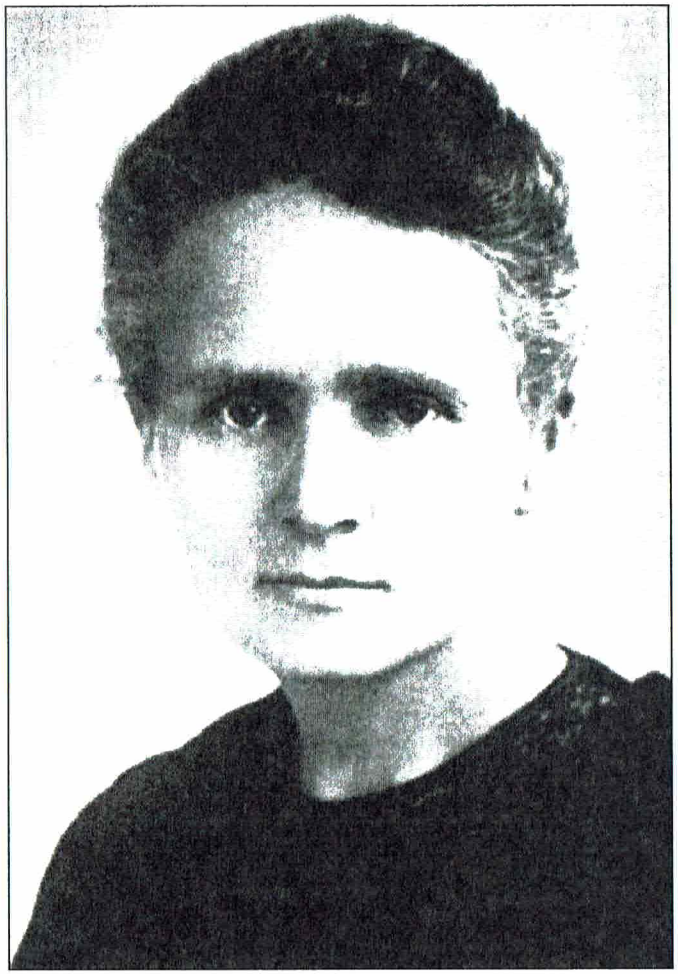
February 1 of each year and they can do so not in the name of their organization but in their own names as individuals.

The committees then, taking these opinions into consideration, conduct their own research and investigations. Finally, they submit their findings together with the supporting evidence to the Board. This should be completed by early October.

The names of the winners may be announced starting as early as mid-October. The prize itself is awarded on December 10; the anniversary date of Nobel's death. The presentation is made by the reigning King of Sweden. (In Norway, the Peace Prize awarding ceremony is conducted in the Oslo municipality).

Needless to say, the awards are presented in a grand ceremony.

Chapter 6



Marie Curie

1867-1934

Learn and let learn

"You cannot hope to build a better world without improving the individuals. To that end each of us must work for his own improvement, and at the same time, share a general responsibility for all humanity, our particular duty being to aid those to whom we think we can be most useful."

Some of our prominent scholars today are known to have started very low. They came from the poor peasantry in remote rural areas where they began taking their lessons under the feet of priests in the local churchyards. They may have even gone around begging for food, as is customary in many places. Today they are able to help other relatives in turn, to learn and help themselves.

Marie Curie had a similar history. Even in her college days, she had to make do with bread and tea alone. She had no other means of subsistence. However, she pursued her studies with diligence. Even when sleep tended to overpower her, she put her feet in cold icy water and kept on working. It is this fierce determination that helped Marie Curie to succeed and, to some measure, helped her to enhance France's reputation in atomic and medical research.

But to begin with, Marie Curie was not even French. She was Polish. Born in 1867 in Warsaw, the capital of Poland, she went to school and completed high school there. She was only 16 years of age, when she graduated with Honours

and when she was awarded a gold medal. But she could continue no further in her studies. It appears that women were not allowed into Warsaw University in those days. At any rate, her father, the only breadwinner in the family, went broke in a failed business deal, and so it fell to her lot to work and support the family. She became a teacher.

However, Marie had no intention of staying put that way. She sought a way to resolve the problem, and she devised one. She saved some money, with difficulty, and used it to send her sister abroad for training, in return for which her sister undertook to send for Marie to teach her.

So when her sister completed her schooling in Paris it was Marie's turn to go back to school. She joined a prestigious university and settled down to the challenges of hard work. She worked almost day and night. It is on record that once she even fainted of hunger and exhaustion. Finally, though, she made it and graduated in physics ahead of her class. Again, a year later, she won another degree in mathematics.

But Marie was not to stop at that. She continued to pursue her education towards the Ph.D. degree. In the meantime, she got married (1895). Again, there was no money. So the bride and bridegroom had to do without a wedding gown or a wedding ring.

Now, as regards the researches, X-rays had just been discovered in Germany in 1895 and the nature of the rays was being intensely investigated. It is known that although these rays are invisible to the eyes, they are capable of passing through human body and other objects.

They could also pass through film packages to darken the photographic films as though the films have been exposed to light.

It was at about this time that a colleague of hers by the name of Professor Henry Becquerel suffered a loss of his films to exposure. He did not know the source of exposure, but later noted that the film package had been lying near a uranium salt. Upon further investigation, he came to the conclusion that the uranium salt did emit invisible radiation that was capable of penetrating objects. He won a Nobel Prize for this discovery and a unit of measurement of radiation activity was named after him.

Marie Curie took this as a starting point and sought to discover other sources, and to study the nature of radiation.

Uranium, she knew, was extracted from pitch blend, so she arranged with some external help, to get tons of the material from abroad. Pitch blend emitted radiation even more powerful than that observed from the extracted uranium. It was therefore obvious to Marie that there existed another element in the pitch blend that emitted it. She laboured at this task and finally managed to extract an element. This was a new and previously unknown source of radiation. She named it "polonium" in honour of her country, Poland. She earned her doctorate degree and also won the 1903 Nobel Prize for physics, which she shared with her husband professor Becquerel. It was the first time that a woman was awarded a Nobel Prize.

Now Marie Curie became famous around the world. But that did not hinder, or distract her

from her work. She continued with her research and again managed to extract yet another element. She named it "radium". Marie won a professorship in the faculty and again another Nobel Prize (this time for chemistry). It was the first time that a person was awarded Nobel Prizes twice. Today her name is associated with a measure of radioactivity. To note, 1 curie is the number of disintegrations per second in one gram of radium. (The number is 3.7×10^{10}). Again, Marie Curie's name has further been immortalized by being given as a name to an element (curium 96).

Having gone thus far, Marie did not rest satisfied with herself. She trained her daughter, Irene Curie, and enabled her to become a doctor. Irene became professor in her own right and went on to win a Nobel Prize jointly with her husband in 1935. Marie Curie could justly be proud of herself as a successful mother.

Marie had other accomplishments to her credit. When the First World War broke out in 1914, France & Germany were among the major antagonists. Marie was basically not French, so if there were any neutral person in the war, it was expected to be her. But she was not. Peaceful as she was, she could not accept what she regarded as German aggression, and she believed that if one did not fight for the principles one stood for, principle alone is valueless. Therefore, when the government appealed to its citizens to raise money and specifically asked for gold for foreign exchange purposes, Marie donated her Nobel Prize money, which was still in Sweden then. She also offered her Nobel Medals to be melted down.

Then again, she set up several clinics equipped with the newly discovered rays to treat war victims. She arranged mobile services (one of which she drove herself) and moved about in the battle field helping people and the cause of war. Over a million victims are said to have received treatment at the clinics she was managing as a director.

Today radium rays are being used in hospitals, industries, research centers and other places. To consolidate the services, Radium Institutes have been established in France, Poland and Various other countries.

After the war, Marie returned to her research. In cooperation with her daughter and the latter's husband, they conducted an investigation into the fission of uranium atoms, and it is said that they were able to recognize that such fissions produced energy and also additional neutrons that went on to multiply by cascade and thus bring about explosion. However, concerned lest this would lead to making a bomb that would be dangerous to humanity, Marie simply informed the government of this possibility and let it lay as a secret. Indeed, France was, soon after the Second World War ended, in a position to further the research and become another world power in 1948.

Marie Curie's contributions had various facets and were forcefully exemplary in many ways.



Marie Curie in her laboratory

Corollary
Women in Science

The urge to find all the possible elements in nature increased after Marie Curie's discovery of radium. This element, by virtue of its long half-life and stability, was found very useful for applications in medicine and industry.

But the number of elements in the Periodic Table stopped at 92. It appeared that there could not be any more. "But Why?" the question was asked. It was then realized that all those beyond this number, being radioactive in nature, must have disintegrated in the span of the earth's age. So it was decided to build them up artificially from uranium. The idea was to add extra sub-atomic particles (neutron, proton, and/or alpha particle) into the nucleus of uranium and see if any new element could be re-created. Today 15 more new-elements have been discovered and studied.

However, in those early days of experimentation with uranium, no one knew exactly what to expect from the experiments, except that it was expected to be heavier than uranium. That was the natural outcome of addition!

So when Nodac, a professional chemist and scientist, proposed a new theory in 1934, it was immediately turned down. What she had done was to add neutrons into uranium atom. What she then found out from the experiment was that the atom broke down into smaller elements. This she revealed to her colleagues.

Yet, her discovery was shrugged off. Worse still, the great German scientist, Oto Han, mocked her, ridiculed her and caused her insults. Luckily, for the world, this line of research was thus abandoned in Germany.

In France, however, Irene Curie and company were engaged in investigating the phenomenon. She came to the same conclusion as Nodac did and said so. At last, the German scientist had to repeat the experiment himself. Alas! It was all true. What Nodac had declared four years previously was just the way things went. Now, as every one realizes, this is the theory on which the construction of the Atomic Bomb is based. The Germans had failed to realize this, and wasted four useful years of further research.

Oto Han then wrote a letter of apology to Lise Meitner. This lady, a scientist herself, had been working in Germany with him and had at the time, told him that his grounds for discrediting Nodac were not justifiable. Later, she, because of her Jewish race, was dismissed from her post and had to immigrate to Sweden. So, it was there that she received the letter of apology. Fully recognizing where this revelation would lead the Nazi government, she immediately alerted Albert Einstein and colleagues in America. Thus, started the neck-breaking race to be first with the bomb.

Had the Germans recognized the work of Nodac and had Lise Meitner not been dismissed from her post, the Germans would have had four years of advance development period to make the bomb. They could then have easily conquered or otherwise destroyed the world.

It was a spell of good fortune for the world that the Nazis did not respect or accept women's opinions. Male chauvinists are a threat only to themselves.



"We must not forget that when radium was discovered no one knew that it would prove useful in hospitals. The work was one of pure science. And this is a proof that scientific work must not be considered from the point of view of the direct usefulness of it. It must be done for itself, for the beauty of science, and then there is always the chance that a scientific discovery may become like the radium a benefit for humanity."

Marie Curie, *Lecture at Vassar College, May 14, 1921*

Chapter 7



Dmitry Mendeleyev

1834-1907

What is the composition of matter?

What is ordinary substance made of? This has been a topic of inquiry and discussion for a long time past. The Greek philosopher Aristotle taught that the basic constituents are fire, water, wind and earth.

Later studies gradually revealed that all substances are composed of elements. A pure element is a substance that does not contain different things but contains only one item – even if it is broken down into smaller and smaller parts. For example, air is composed of such gases as oxygen, nitrogen, argon etc. Water, if broken down by electric force (a phenomenon called electrolysis) is seen to be composed of hydrogen and oxygen gases. But each of these gases is not a mixture of other things and it is called an element. Metals like gold, silver, nickel and copper are also elements.

All substances are composed of such elements. Even our bodies, if we imagined them broken up into pieces, will end up in elements. But how many elements exist then? What are their individual and common characteristics?

We have seen in the previous chapter that Marie Curie, for example, has been able to extract a previously unknown element, which very soon found applications in hospitals and industries. Still other scientists continued to find new ones. But at times, the search appears to be random and dependent on chance. No one knew how to predict and where to look for any new element.

It was Mendeleyev, who tried and succeeded in devising a way to predict it. It may be suggested that the Italian Cannizzaro, when listing 60 elements in the order of their atomic weights, determined chemical repetition at regular intervals, but he stopped short of establishing a 'periodic table'.

Dmitry Mendeleyev was a Russian citizen born in the cold icy region called Siberia. He was the 17th child born to the family.

His father developed sight problem and turned blind. His mother in an attempt to support the family took a small firm on lease and ran it for a while. Unfortunately, the father died in 1847 and shortly after, the firm too burned down.

The mother, being helpless in the face of this crisis, left behind the grown up children and departed with Mendeleyev and his elder sister. She took the long track in the direction of Moscow, the capital city, with a firm determination to get work and to send her son to university. She managed to reach the city, but university officials made it clear that they did not expect any good to come out of Siberia: they declined to admit Mendeleyev into the university. Yet, the mother, aware that she was fatally ill and that she did not have long to live, headed towards Leningrad (now St. Petersburg) about a thousand kilometres away. There again she failed to enrol her son in the university. She tried medical school and was met with the same resistance. Finally, just two months before she died, she managed to enrol him at a certain college, and set him off on a good track.

Mendeleyev did not waste this opportunity. He studied hard and earned his degree. After teaching for a while, he went on to pursue his studies in Germany. It was there that he met and worked with prominent European scientists and this stood him in good stead in the years that followed.

Upon returning home, he taught chemistry and soon became a professor. But there were no suitable books available for teaching. So he decided to write one entitled, "principle of chemistry". That was when he began to ponder the problems of classifying the overwhelming jumble of isolated facts into a semblance of order.

He listed all the known elements of the time, and noted their characteristics. He put each element on a separate card and made a comparative analysis of the best possible arrangement.

Finally, and after a considerable effort, and re-arranging the cards several times, he was able to organize them in some order and classify them in a table. This is now known as Mendeleyev's Periodic Table. As every chemistry student knows, it is possible to place the elements in a specified slot in the table. Moreover it became possible to determine the characteristic (atomic weight, valency etc) of a yet unknown element that, when discovered, would fill the slot. From its position in the table, students can now simply tell if the element in question is acidic, radioactive, or inert gas, etc.

Mendeleyev, and other scientists, were thus able to predict the existence of the then unknown elements and went about looking for them.

Mendeleyev predicted and stated the properties for four elements. And when they were later discovered (one of them fifteen years later), they behaved exactly as he predicted.

We may pause here for a moment and give more details, in order to gain a better understanding of how things are arranged in nature. As will be discussed in the last chapter of this book, the universe around us is built mostly of hydrogen gas. It is this gas that is still found in abundance in any composition of the stars in the sky. The stars' light is the result of the heat generated from the fusion of their atoms.

A hydrogen atom has a small nucleus around which orbits an electron. When two hydrogen isotopes fuse together, the result is another element with two electrons in orbit. It is called helium. Further successive fusions produce elements with orbital electrons of 3, 4, 5, 6 etc. The last and heaviest naturally found element is uranium with 92 electrons in orbit.

But these electrons do not all rotate in one orbit. They fall into different orbits. The first orbit can hold one or two electrons but never more. The second orbit can hold up to eight (after the first orbit is filled); the third orbit again can hold eight and the fourth and fifth, eighteen each. Therefore, elements with 1, 9, 17 and 35 electrons are just short of one electron each to fill their orbits. These are hydrogen (H) fluorine (F) chlorine (Cl), and bromine (Br). In that respect, they are similar and fall in one column. They all have a tendency to fill their orbits by sharing an additional electron by combining with another

element.

On the other hand, elements with electron numbers 3, 11 and 19 hold a lonely electron beyond a filled orbit. These are lithium (Li) Sodium (Na) and potassium (K). These are similar in their tendency to share these extra electrons with others that need it. So elements with an electron available to share and another element short of an electron to fill its orbit have an attraction to each other and when possible unite to form a compound. That is how sodium and chlorine combine to make the common salt. An oxygen atom (lacking two electrons to fill its outer orbit) attaches two hydrogen atoms to itself thus getting us water.

In a similar manner, elements, which are missing two or three electrons to complete their outer orbits, or those having extra ones, have predictable behaviour in reacting with other substances. Those elements, with full orbital electrons (argon, krypton, neon) have no need to combine with others; they are classified as inert gases (these are also known as Noble Gases).

All these and others when grouped together in columns according to their behaviours and placed in sequence according to their atomic weights, form the Periodic Table.

This arrangement of elements is now a common knowledge. But in Mendeleyev's days, nothing made much sense and rhymed only with confusion. About 50 or 60 different elements were recognized and recorded. Their atomic weights were different (and not accurately known for that matter). Their heat capacity, gaseous nature, color, melting or boiling point etc., all appeared

haphazard. To compile all of these, try to arrange them into some order and finally succeed in the task must have required a lot of patience and perseverance. Mendeleyev must have tried many different ways before he hit on this arrangement.

This method of arranging things in some logical order (as in a telephone directory or archives files, or a dictionary for that matter) makes it possible to handle them easily and to search and locate any item in the collection.

Many of us encounter, in our daily lives, various occurrences that appear to us random and coincidental. But how many of us do really commit any of these events to memory? How many of us seek to discover their underlying cause and draw the right conclusions as a lesson for the future? We tend to treat everything as it occurs at the time and subject the event or discovery to our variable moods, so ending up in confusion and disappointment many a time.

However, Mendeleyev had a scientific training. He recorded on cards and analyzed the apparent varieties of elements that confronted him in his job. He attempted to discover the basic laws that governed these phenomena. He succeeded at last, and used his discovery to predict and help find yet more elements.

Mendeleyev is highly regarded in his country for more contributions he made in some other ways, too. For example, whenever he returned from visits abroad, he used to bring back new ideas and ways of doing things better. One occasion that is often mentioned concerns his trip to America where he visited an oil refinery. Upon returning home, he realized how, by comparison,

the oil refinery in his country was very backward and wasteful. So he took on the challenge, worked on it, and got the refinery renovated. That, it is said, saved the country a lot of capital.

How many of us have managed this sort of technology transfer? Despite several expensive foreign trips, trainings, workshops, factory visits etc., aren't there several cases where no tangible benefits have accrued to the country?

These are questions, which need to be asked. They have to be considered carefully, too. There are numerous technologies abroad, which could be put to good use here in the country. We do not have to rediscover the wheel all over again. We can adopt and improve them or modify them to our conditions.

Mendeleyev benefited from his visits abroad. He gained expertise, which he put to use at home. There is no shorter or simpler method than this.

Of course, there would be problems. The adoption and adaptation of various technologies is in the hands of private company owners. The benefits of these technologies will be made available only under license or if the owners invest in a country in need of development. Even then, unless there is "fertile ground", knowledge may not take root here, thus leaving the country in question, and its people empty-handed when the owners close up and pull out. This is known to have happened and it will again.

It requires trained manpower to understand and retain the know-how. This, in part, could depend on the policy and planning, which is the role of the government, but much depends on the rest of us to follow Mendeleyev's examples and

effect technology transfer with all due speed.

Corollary
Development of Metrology

Mendeleyev in the latter years of his life (i.e. 1892-1907) was engaged in developing metrology. He realized quite early that industries producing spare parts for instance, have to be able to measure with precision and to maintain the accuracy in all phases of production. Any significant variation in measurement and therefore in production will defeat the purpose for which the parts are intended.

There are measuring instruments in factories, in trade and in various service organizations, and unless these provide correct measurements, the results of planning, manufacturing etc., based on these erroneous measures, will of course, be in error themselves. This applies to all types of measuring instruments such as electrical, pressure, temperature and length measurements. For example, unless the weight-scales and blood pressure gauges in hospitals read correctly, the patient may suffer from the results of an erroneous diagnostic. The doctor, after all, bases his diagnosis on the measurements presented.

Measuring instruments are also liable to wear and tear, rust, loose connections, or being subject to ageing or mishandling. The resulting deviation from correct reading will incur damages to the institution and to the country as a whole.

Mendeleyev thus found it necessary to develop metrology and established an institute, which took on the responsibility of maintaining the accuracy of measuring instruments used in the

country. Today the millions of such instruments employed in various industries across the country are calibrated in a hierarchical order by this and similar other institutions.

Incidentally, there is one method of verifying measuring instruments, which Mendeleyev introduced and which remains in use even today. Suppose we use a mass of one kilogram to measure out a kilogram of coffee beans. Just because the arms of the instrument are in balance, does not necessarily mean that the weights on either side are equal. The pan carrying the one-kilogram mass could be lighter in weigh, yet it would be held in balance by friction due to rust; or the weighing balance itself may have been misaligned intentionally to indicate balance. So to countercheck the accuracy, one has to interchange the pans carrying the coffee beans and the mass of one kilogram. If the balance is maintained in both situations, then the coffee beans indeed weigh the equivalent of the mass of weight. This method of countercheck is known as Mendeleyev's method and is still used throughout the world.

The St. Petersburg metrology institute was named after Mendeleyev. It houses a permanent exhibition of his works, which is visited, by thousands of people every year. Mendeleyev's name has thus been immortalized.

Reihen	Gruppe I. - R^1O	Gruppe II. - RO	Gruppe III. - R^2O^1	Gruppe IV. RH^4 RO^3	Gruppe V. RH^3 R^2O^5	Gruppe VI. RH^2 RO^3	Gruppe VII RH R^2O^7	Gruppe VIII. - RO^4
1	H = 1							
2	Li = 7	Be = 9,4	B = 11	C = 12	N = 14	O = 16	F = 19	
3	Na = 23	Mg = 24	Al = 27,3	Si = 28	P = 31	S = 32	Cl = 35,5	
4	K = 39	Ca = 40	- = 44	Ti = 48	V = 51	Cr = 52	Mn = 55	Fe = 56, Co=59 Ni=59, Cu=63
5	(Cu = 63)	Zn = 65	- = 68	- = 72	As = 75	Se = 78	Br = 80	
6	Rb = 85	Sr = 87	?Yt = 88	Zr = 90	Nb = 94	Mo = 96	- = 100	Ru=104, Rh=104 Pd=106, Ag=108
7	Ag = 108	Cd = 112	In = 113	Sn = 118	Sb = 122	Te = 125	J = 127	
8	Cs = 133	Ba = 137	?Di = 138	?Ce = 140	-	-	-	- - - -
9	(-)	-	-	-	-	-	-	
10	-	-	?Er = 178	?La = 180	Ta = 182	W = 184	-	Os=195, Ir=197, Pt=198, Au=199
11	(Au = 199)	Hg = 200	Tl = 204	Pb = 207	Bi = 208	-	-	
12	-	-	-	Th = 231	-	U = 240	-	- - - -

ORIGINAL TABLE

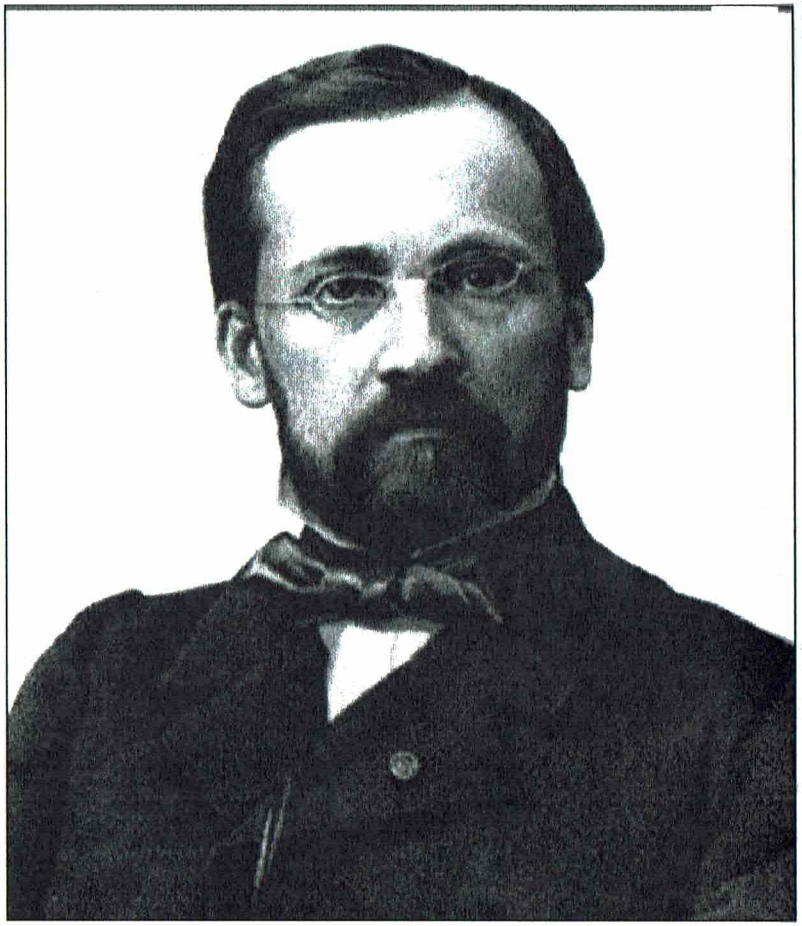
I	II	IIIb	IVb	Vb	VIb	VIIb	VIIIb			Ib	IIb	III	IV	V	VI	VII	0
1	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**	**11**	**12**	**13**	**14**	**15**	**16**	**17**	**18**
H																	He
Li	Be											B	C	N	O	F	Ne
Na	Mg											Al	Si	P	S	Cl	Ar
K	Ca	Sc	Ti	V	Cr	Mn	Fe	Co	Ni	Cu	Zn	Ga	Ge	As	Se	Br	Kr
Rb	Sr	Y	Zr	Nb	Mo	Tc	Ru	Rh	Pd	Ag	Cd	In	Sn	Sb	Te	I	Xe
Cs	Ba	La*	Hf	Ta	W	Re	Os	Ir	Pt	Au	Hg	Tl	Pb	Bi	Po	At	Rn
Fr	Ra	Ac**	Rf	Db	Sg	Bh	Hs	Mt	Uun	Uuu	Uub		Uuq		Uuh		

Lanthanides *	Ce	Pr	Nd	Pm	Sm	Eu	Gd	Tb	Dy	Ho	Er	Tm	Yb	Lu
Actinides **	Th	Pa	U	Np	Pu	Am	Cm	Bk	Cf	Es	Fm	Md	No	Lr

TODAY'S COMMONLY USED TABLE

Mendeleyev Periodic Table

Chapter 8



Louis Pasteur

1822-1895

The secret of Vaccination

"Let me tell you the secret that has led me to my goal. My strength lies solely in my tenacity."

Louis Pasteur[4] is a world-renowned biochemist who, not only advanced the frontiers of science, but also applied the knowledge to field work. His discoveries were applied in medical institutions, in agricultural farms and in industries.

Pasteur has many discoveries to his name. The first was patented in 1848. That was barely a year after he graduated from school. Previously he had managed to collect degrees in rapid succession: - a Bachelor's degree in literature in 1840, Bachelor's degree in science in 1842, a Master's degree in 1845 and a Doctorate's degree in 1847. This was a surprise even to his parents, because in his younger days, he did not have the slightest interest in learning; and passed his time drawing pictures and even switched to sculpting.

It was only much later that he appeared to wake up to science. Then he embraced it and was immersed and absorbed in it. Thus, he waded right through the academic courses and research and landed a new discovery in 1848. His reaction at his first discovery was immense. He jumped out of his seat, ran into the street and finding his assistant there embraced him, gasping, and shouting, "I have discovered"

[4] (3) No. 13; (1)

repeatedly. He told him that he was so happy and excited that his whole body trembled and his eyes could not focus on the instrument.

Such occasions of excitement are not uncommon. True, they may not appear as dramatic as a footballer scoring a goal, since the physical ability of the discoverer will, perforce; restrict his performance in that regard. But, sure enough, it is very pleasing when long-held riddles suddenly find solutions.

A certain physicist by the name of Dr. Feynman is on record as having sidestepped from a queue and danced frantically under the astonished looks of the people around him. They were queuing for their turn in a canteen at lunchtime when a colleague whispered to him the essences of what was reported in a seminar he had just attended. Realizing that this finding had just solved the riddle that had for so long racked his brains, Feynman could not restrain himself from expressing his emotions.



Dr. Feynman

We all remember the tale concerning the ancient Greek philosopher, by the name of Archimedes. The king suspected his goldsmith of not making his crown from pure gold. So he called Archimedes and ordered him to prove that it was pure gold; otherwise he would kill him!

The way to find out is to determine the density of the crown and compare it to that of gold. At the time, there was no known way to find the volume of that irregular shape. Worried of the prospect of death, he stepped into the bath. That was when

he got the idea of immersing the crown in a container full of bath water and collecting the overflow to measure its volume. It was at that revelation that he was excited, forgot to put on his clothes before he ran out to the street, and shouted Eureka! (I have found out.)

A person overtaken by emotions can express himself in quite dramatic manners. Pasteur was no exception to this.

Pasteur's attention was at one time drawn to micro-organisms. These are known to spoil food and drinks. Bread loaves grow mouldy, milk sours, beer and other drinks too, if kept long enough will spoil.

From ancient times, it was accepted that some organisms spontaneously grow from heaps of rotten material. Lice breed from dirty bodies; flies hatch straight out of cow-dung, meat when kept long enough can produce worms by itself, etc. Even mice were believed to be capable of just coming out of nowhere. This all meant that life could be created spontaneously. But as time passed, things began to become clearer. For instance, it was realized that we find worms in long-exposed meat not because they are created in there but because flies have the habit of laying and depositing their eggs in meat so that, on hatching, the young once may find food for their immediate need. In the same manner, meat gets smelly because of the bacteria in the air, which start to breed on it. If meat is boiled or cooked to kill off any micro-organism and is immediately sealed, it can then be indefinitely preserved.

Charles Darwin too, came along to explain that life begets life and further that, even large

organisms, such as humans evolved in stages through evolutionary processes from the simplest unicellular organisms. Therefore, not only life is not created spontaneously but also the original specimen of the species is traceable back to a unicellular organism for its starting point.

So what causes meat to rot or milk to sour? Pasteur studied this problem and was finally able to extract and culture the micro-organisms responsible for the damage. If, as Pasteur said, one could isolate these organisms from the air or apparatus, and prevent them from coming in contact with the meat, then it would remain free from contamination. One can even open a human body and stitch it up after an operation, without the fear of infection. Pasteur explained that if one could take the necessary precautions to keep the air and apparatus free from bacteria, the human body would then remain free from infection. If milk, too, could be boiled and sealed, or beer brewed with care and bottled, and food protected in the refrigerator, they could all be protected from bacteria and thus be safely preserved against spoilage.

As a result, the British and the French could at last dispatch beer safely by ship all the way to the far-flung corners of their colonies. Today European beer sells in our markets (and ours in America) by using Pasteur's method of preservation. "Pasteurized" milk is a daily sight everywhere and refrigerators have become an indispensable appliance. This is all because of Pasteur's scientific methods of preservation that were developed the world over. Pasteur did not stop there however.

He is perhaps best known for developing the process of vaccination. It is true though that several centuries ago, so-called "traditional heelers" in India and the Far East practiced vaccination. For instance, when a victim of smallpox provides pus, and this is mixed into the blood of a healthy man by simply scratching the pus into his skin, the healthy man will fall sick but then recover and thereafter will remain immune to the disease.

The Europeans came to learn of this tradition of treatment in the 18th century. However, there was no scientific explanation for it. It was left to Pasteur to explain that both the causes of infection and the preventive medicine against infection have the same origin; namely the bacteria. (Viruses were not known in those days).

However, people scoffed at Pasteur's claims. "How can a disease be a cure itself?" they sneered. Pasteur got mad at this. He decided to demonstrate in public that this is indeed so. He thus invited journalists, doctors, and other dignitaries to witness his experimentation. He brought out fifty sheep and injected 25 of them with the weakened germs. 12 days later, they were given another booster dose, and finally all the 50 sheep (including the vaccinated ones) were injected with a strong dose of anthrax. Two days later, the 25 vaccinated sheep where happily grazing the field whereas 22 of the others were already dead and the remaining three were dying. Pasteur was at last believed. He became famous.

Europe in those days was suffering from the heavy loss of cattle all due to anthrax. Pasteur then collected the germs from the infected cattle,

weakened them (by heat) and re-injected them into healthy cattle. The germs so treated, could not kill the cattle. On the other hand, they caused the cattle to develop immunity against them. Thereafter the cattle remained immune to any further attack by the disease.

The underlying principle, remains valid for vaccination of animals and people as well. It consists of weakening the bacteria sufficiently enough and then injecting it into a healthy animal (or human). The body will then develop an antigen, which will remain latent to fend off any future attack. The enormous economic and social benefits that accrued from Pasteur's contribution in this respect are obvious.

Another of Pasteur's contribution is his finding of a preventive method against the spread of rabies. This was in 1882. Rabies in those days caused terror in the hearts (or minds?) of people everywhere. It caused death in a horrifying manner. Pasteur therefore began seeking a solution to this problem too. He sought for rabid dogs and collected their saliva. He then filtered out the germs and after weakening them sufficiently, he re-injected them into healthy dogs. Further investigations on the disease revealed that the germs accumulated not so much in the saliva as in the backside of the brain. Again, he learnt that the best way to weaken these germs was to apply heat to them or simply store them for some time. He thus prepared the doses and vaccinated healthy dogs. Because of his continuous efforts, the horrifying disease was finally under control. Obviously, it was a great relief for every one. (For further information on

rabies, please see the corollary hereafter).

Pasteur thus made major contributions to his country and to the world at large. In honour of this great scientist, an institute was named after him, the Pasteur Institute, in Paris in 1888. Similarly, Pasteur institutes were established in various other countries (including Ethiopia) where scientists continue their research in bacteriology and treatments given for rabies etc.

Pasteur was able to register all these achievements for several reasons, among which were his natural curiosity for things around him, his urge to delve into unknown fields of research and his devotion for, and total commitment to his profession. It is true that not all of his research bore fruit. Some were just wasted. He had laboured on some projects long and hard, but nothing came out of them – often because he started on the wrong premise. Certain concepts and beliefs of the times were not based on scientific grounds and these led him astray. Yet, even this could be considered a finding in its own right. To show that certain concepts are wrong is a step forward in scientific research, which enables others to explore different paths.

Pasteur believed that fieldwork had to go hand in hand with lessons in the classroom, so he regularly took his students out for visits and experiments in factories and farm areas. It was also a lesson to others that, when farmers in the Deep South suffered severe loss of their silk harvest due to the spread of the silkworm disease, he left his Chair and his home, and went to work in the fields for three long years; and he did manage to solve the problem.

Such concern and dedication is not commonly found everywhere. He was so committed and devoted to his work that, as he wrote in a letter to a friend, he felt the nights too long and the daybreak too slow in coming to enable him to go back to work.

Pasteur's life and work should serve as a lesson for us all.



Louis Pasteur in his laboratory

Corollary
Rabies

People in Africa are terrified of rabies. As a result, more damage is caused by terror than actually is inflicted by the disease itself. The mere suspicion that a sick dog may have become rabid sends people scuttling to "Traditional medicine men" that prescribe a concoction of wild plant roots, leaves and barks for cure. The intake of this unhygienic, possibly poisonous, preparation sometimes causes vomiting and/or diarrhoea. Depending on the severity of the "dose", it could damage the stomach wall linings and remove parts of it, which is then claimed by the medicine man as evidence of the effectiveness of his medicine by driving out the small puppies that would have grown to dogs inside the stomach.

It is true of course, that the disease is fatal if untreated. However, unfounded fear and suspicion of its occurrence and the subsequent rush for local "Cure" is causing in the remote villages unnecessary and sometimes irreparable damage.

The cause of rabies is a virus. When a rabid dog bites a person, the virus passes on with the saliva into the body, and thereafter passes on to the nerves eventually ending up in the brain. There it develops and multiplies. The development time depends on the proximity of the bite to the brain and could vary from 10 days to 3 months. Sometimes it could even take one year; and recent publications now claim that it may

delay even as long as seven years.

Once the virus completed its development stage and is hatched out in the brain, then there is no remedy for the infected dog. The virus spreads through out the body concentrating more in the saliva gland. It is now easily transmitted through biting.

Yet, not only dogs are susceptible to rabies. Wild carnivores (fox, hyena, wolf, etc.) do also contract the disease. These in their turn transmit it by biting other animals, wild or domestic. As a result, domestic animals like cattle, sheep and horses can contract the disease from any such sources.

Drooling saliva is a clear indication of a dog suffering from Rabies. The dog unable to close its jaws (because it lost control of its muscles) freely salivates as it goes about. The virus actually proceeds to attack the body muscles starting from the hind. Thus, the tail of the dog dangling helplessly is the first sign of danger. This dangling, it should be noted, is different from tucking the tail between the legs that frightened dogs often do. As the numbing of the muscles progressed from the tail end forward to reach the brain, the dog dies. In the meantime, though, the dog may behave in different ways. It may turn out to be aggressive and bite at woods, stones, animals or anything that comes its way, thus causing a lot of harm before it finally collapses. Another type is the one that dazes the dog. The dog affected by this type of rabies simply roles up and lies down quietly. Even when disturbed, it is inclined to direct its bite to outsiders rather than to the family members. There is also a third type

of behaviour intermediate between the aggressive and passive types. At any rate, all rabid dogs eventually succumb to the disease and die.

A person afflicted with the disease, unless treated in time, begins to have headaches. He then becomes restless. His awareness is heightened. He is irritated or easily disturbed by loud noises, or by a breeze of air. He avoids glare of light and shuns even water. Because the muscles around his neck are immobilized, he can no longer swallow or drink water and so he avoids it.

As the disease progresses, he becomes more emotional. For example, he tends to embrace forcefully, kiss strongly or even bite his colleagues or acquaintances. When this stage is reached, the thing to do is simply to protect him from the disturbances he hates, and to lock him up in a darkened room and patiently wait for the end to come.

Regarding vaccination there are two approaches to it. The first is to immunize or vaccinate all dogs (and if possible even cats, cattle, horses, etc.) against the disease... In advanced countries, even wild life is treated and this type of treatment needs to be conducted every year[5]. However, once a person finds himself infected, the second approach should be pursued, and that demands immediate action. There is medicine available to be applied to areas of the body around the bite. This is followed by two weeks of daily injection around the belly part.

[5] In the Balie National Park (Ethiopia) more than half the population of rare and endemic wolves was wiped out by rabies in 1990-91.

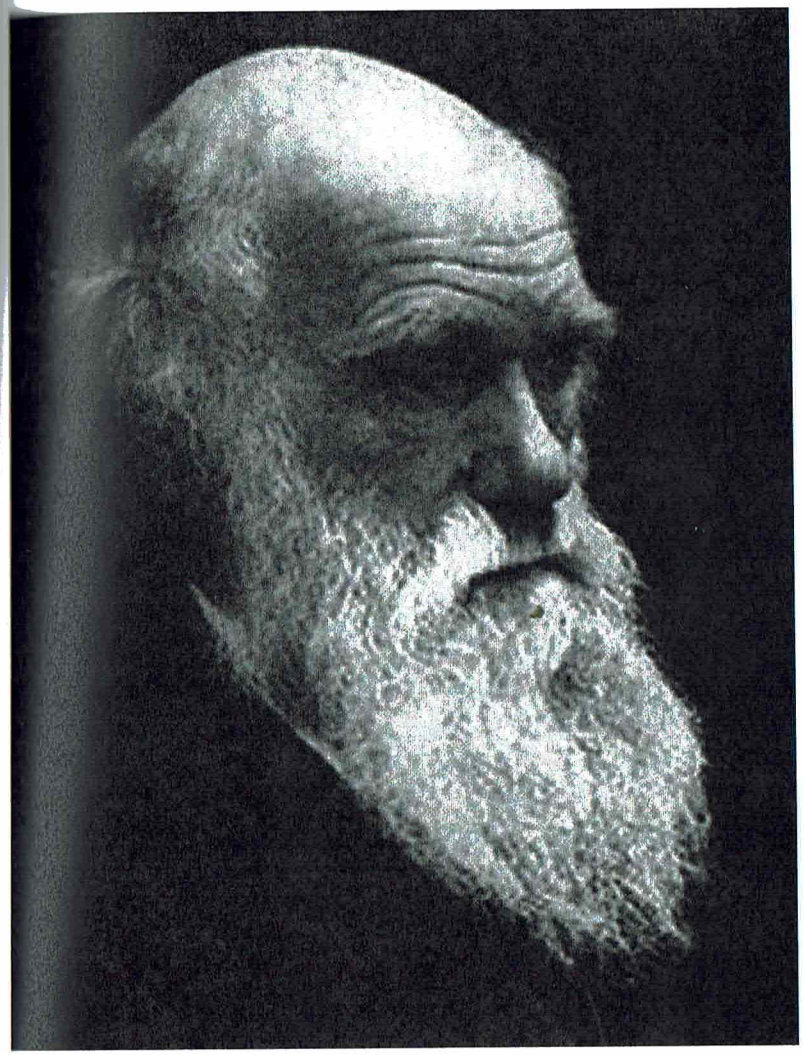
Finally, three booster injections are given 10 days apart. This is a safe and sure treatment.

Coming back to traditional medicines, I should say that they are unreliable. I should perhaps refrain from categorically declaring them ineffective, only because these claims (of their effectiveness to cure the disease) have not yet been subjected to vigorous scientific testing. Nevertheless, one should never take any chance with it, when scientifically tested cures are available.

Some chance events at times cause people to be misled. It is true that not all people bitten by rabid dogs are infected with the virus. For one thing, the virus may not have reached the salivary gland of the dog when it bit the person. For another, after several previous bites, the dog's saliva and teeth may be temporarily free of the virus. So if a few among the bitten victims, who received treatment from the traditional healer, are free of infection, the 'healer' cannot be credited with curing the patient.

Therefore, traditional medicines, serve no better purpose than to distract people from taking the appropriate treatment in time. Moreover, sadly enough, once a person has shown the symptoms of the disease, it is a mere waste of money and effort to take him to the hospital.

Chapter 9



Charles Darwin
1809-1882

The origin of Man

"We must, however, acknowledge as it seems to me, that a man with all his noble qualities...still bears in his bodily frame the indelible stamp of his lowly origin."

"If God allotted man his due punishment immediately after the committed sin, man-kind would have taken his lesson to heart", so say some people. Yet, in Darwin's case, many believed, that this had indeed happened.[6] Darwin had been a sick man for 40 years. Upon returning from his round-the-world journey, he postulated the theory of evolution and started to teach it, whereupon he fell sick and stayed that way for the rest of his life.

The theory he proposed was controversial. It created intense arguments and sometimes, serious quarrels among people. "How can man descend from monkeys?" demanded some. Well, Darwin did not say it quite that way either. He declared that living things, starting with the lowest and simplest of creatures, unicellular organisms, and developing systematically over millions of years and by evolutionary processes, managed to diversify and further develop into the variety of species we see today. On this basis, though apes and monkeys now took different paths of development, they probably had a common origin some millions of years ago. Yet, even this claim departs from the sayings in the scriptures. Even so, it is not clear if damnation

[6] (3) No. 5; (5)

from God, which brought down sickness upon Darwin, is a result of his own doing, the prize for his sin, as some believed.

Darwin had lost his mother when he was only eight years old and he was brought up under the care of his elder sister. His father was a huge man, (300 pounds) who ruled over his family sternly to say the least. Darwin always suffered under the strain of his father's imposition.

He did not do well at school either. Having been sent to university to study medicine, he was dismissed immediately. Then he went to Cambridge to study theology. He did not succeed there either. The man was more interested in horse riding. He spent the rest of his early days building up a collection of stones and fossils, mountain climbing and practising other sports. His father disapproved of all these 'lowly' inclinations and aspirations in very strong terms. He even reprimanded his son as being a disgrace and an insult to the family name. He threatened to prevent Darwin from embarking on the ship that was to take him on what turned out to be a historic journey.

This journey was a source of inspiration to Darwin. He collected fossils at every anchor port of the ship, and began comparing one with the other. He studied their differences and started to classify them accordingly. He then began asking himself how one species of animals can be found on different and vastly separated continents. Why is it that so many varieties of species could be seen in one locality? How was it possible and why was it necessary to create so many different types of animals, birds and plants? He racked his

brain for possible answers to such and many other questions. Finally, he arrived at a hypothesis. He reasoned that not all men are alike in every respect. Some are born runners. Others may be high jumpers. There are intelligent men. There are also fat and lean men. Other animals and plants revealed variations in many respects as well. Some have horns but others have poison. Some plants are thorny others are creepers etc.

Equally, the natural environment revealed variation. There are desert areas, snowy areas and others with different physical features. As a result, food supply cannot be uniformly available everywhere, so there is bound to be competition for it. Some will win while the others are bound to lose. Those that win the struggle will survive while the others are doomed to extinction. Therefore, one could conclude that creatures, which are endowed with the right features, talents etc that enable them to face the challenge and prevail over it, manage to survive while those that fail in the competition simply perish. This is the principle of "Survival of the fittest". This is how mother Nature makes its choice as to who should survive and who should perish. This variation of the environment and the subsequent competition of animals to remain fit and alive is a continuous process. In course of time, some changes are induced on the animals by temperature, by radiation or may be by other factors, and these changes will be retained if they help in the struggle for survival or will be eliminated if otherwise. Gradually, the useful traits, which help the creature to adapt to its environment and to

compete successfully, will prevail and develop further.

This explains why some creatures have become extinct while others have developed, gradually changed and adapted to their particular environment. This also explains how life can start from a simple organism such as a cell, and systematically grow, change, develop and learn to adapt. Darwin concluded that fauna and flora found on the earth today were not created individually, but evolved in the manner explained above.

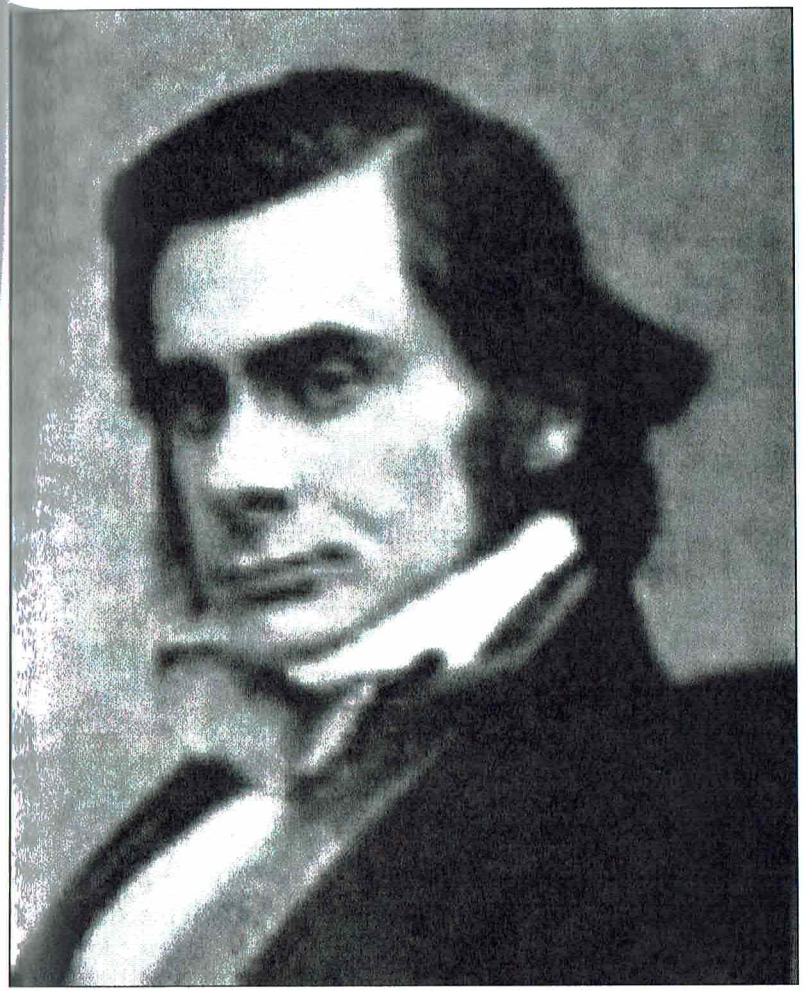
This theory caused huge conflicting opinions in the eyes of people. On the one hand, it simplified the means by which all these different species of creatures teaming in the oceans, on land and in the air came into existence. On the other hand, the Scriptures did teach that God created each type of animal separately and endowed it with life. Thereafter He watched over His creatures and on occasions (depending on prayers, fasts and appeals of intermediary officials) pardoned their sins, protected their welfare and assisted in various other ways.

Darwin's theory appeared to stand in direct contradiction to the teachings of the Scriptures. It all appeared irreconcilable. There were debates and quarrels sometimes resulting in bitter feuds. Students in those days found themselves caught in the crossfire. Their parents forced them to believe the Scriptures, but their teachers taught them otherwise. If they wanted to pass their examinations, they had to answer one way, but to keep peace with their parents they had to answer another way.

It was at this crucial moment that a direct confrontation between a scientist and a bishop took place. The year was 1860 and the stage was Oxford University in England. At a meeting of the "Association for the Advancement of Science", Bishop Wilberforce of Oxford, defended the Christian faith earnestly, and at one point mocked the scientist who as he said, was requesting the acceptance of ape as his grandfather. The scientist, Thomas H. Huxley, jumped to his feet and replied:

> *"If the question is put to me, would I rather have a miserable ape for a grandfather or a man highly endowed by nature and possessed of great means of influence, and yet who employs these faculties and that influence for the mere purpose of introducing ridicule into a grave scientific discussion, I unhesitatingly affirm my preference for the ape".*

At these words, the students exploded in roaring laughter and showed their assent in thunderous applause. Thereafter evolution stood on its own feet and science declared its independence of thought.



Thomas Huxley (Darwin's "Bulldog")

As time passed, new findings supporting the argument in favour of evolution accumulated and gradually objections against it subsided.

Darwin himself contributed a lot to this

accumulation of facts. He did research on flowering plants. It was he who explained that such plants have both male and female parts on the same plant for reasons that if cross-fertilization failed to succeed then, at least, self-pollination would ensure that the species did not die out. Cross-pollination results in healthier & stronger offshoots and is thus preferable. However, if the agents of pollination (insects such as bees) fail to visit the plant, or other causes prevent cross-pollination, it is wise to take precautions. The use of the flowers themselves to the plants that bear them is to attract the bees and/or other agents to come and visit for the nectars, whereupon they will carry off the pollen dust and possibly deposit it on another similar plant that they are likely to visit. Darwin pointed out that plants that use the wind to scatter their seeds, do not need to attract insects and therefore do not need to produce flowers.

Creepers (e.g. vines) have a relatively short life span (compared with trees) and do not have time to grow thick rigid stems for support. Thus, they are doomed to remain under the shadows of the dense forest, while deprived of essential sunlight. Yet, they adapted and soon grew tendrils to twist around other plants for support and to creep up to the tree-umbrella easily. That is struggle for existence, and they have found a way to win it, explained Darwin.

Darwin had his own reservations when it came to matters of religion. People accused him of disavowing God, but he wondered why God, who is benevolent, loving, kind and omnipotent, should permit a slave-owner to torture the poor

slave; or how indeed could He tolerate innocent children (especially of backward countries) suffering and dying in their thousands from disease and starvation? Darwin referred to some of his acquaintances, who were not believers but nevertheless were gentle and kindly people and asked why they should be damned and subjected to the tortures of Hell for all eternity.

Darwin was not an atheist, though. When Karl Marx offered to dedicate his book "Capital" to him, he declined the offer. Darwin was of a simple conviction that everything must surely be studied carefully but not to the exclusion of scientific findings.

Darwin however was not destined to lead the rest of his life in peace and good health.

Darwin's illness[7]

Darwin's misfortune in the last days of his life is in a way interesting and reminiscent of present-day experiences of many people.

Darwin fell ill immediately after returning from his five-year-long sea voyage and remained ill for the remaining 40 years of his life. It was not possible to pinpoint the complaints: - he had gastric and intestinal pains; and he suffered from palpitation, general weakness and lethargy. Sometimes his whole body shivered or he vomited. His heartbeat was irregular sometimes beating very fast. Therefore, the symptoms varied, and kept Darwin weak and confined to his home. He decided to leave London and so retired to his country home in Kent.

Darwin's problem, according to the diagnosis of the medical people was not physical but psychological. They could not ascribe his illness to any known disease, and so chose to explain it away as a mental worry of his own making, a result of his own disposition and mentality. A scholar, at one stage, declared that he had already studied the family history and discovered that along both the father's lineage and the mother's, there were cases of mental disorders recorded. He thus maintained that Darwin's troubles could be traced back to his ancestors. "It is a hereditary disease," he concluded.

Another professor pointed out that this illness

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[7] (5) pp 61-67

in an excuse of Darwin's own choosing. This professor said something to the effect that Darwin being a famous man in the world feigned the sickness to relieve himself of the burden of responsibilities weighing heavily on his shoulders. Darwin, of course, did not accept any of these suggestions and expressed his disagreement in anger; but that only made matters worse for him and caused him deep disappointment and grief.

Other doctors came up later still with yet more new diagnoses. One of them for instance declared that his (Darwin's) wife Emma was the cause of all the trouble. Emma, he said, was increasingly feeling strongly about Darwin's work, which had claimed that man descended from the apes and thus attempted to discredit God; she felt this to be un-Christian and so disapproved of it. It is this tension between the two of them that caused Darwin so much distress.

All this did nothing to help Darwin, but only to cause him more anger, disappointment and helplessness. It even worsened his condition, which in turn strengthened the doctors' arguments.

The irony of it all is that Darwin's illness had nothing to do whatever with these diagnoses, but was caused by an incident that occurred during his trip to Latin America. When staying the night in one of the villages in Argentina, Darwin had been attacked by bugs which today are known to be vectors (carriers) of the trypanosome disease. The victim of this disease expresses the common symptoms of heart problem, stomach disturbance, weakness and lethargy which Darwin then suffered.

The reason why the doctors of the times failed to diagnose the disease was simply that it was unknown at the time. It was identified only twenty-seven years after Darwin's death. Of course, it was not clinically established he suffered from the disease, but the symptoms matched exactly the complications caused by the chronic form of this infection.

Looking back now, one can imagine what distress and anguish the doctors had caused poor Darwin by their claims of his mental disturbance, hereditary disease, wife's disapproval etc., and causing the community to believe it.

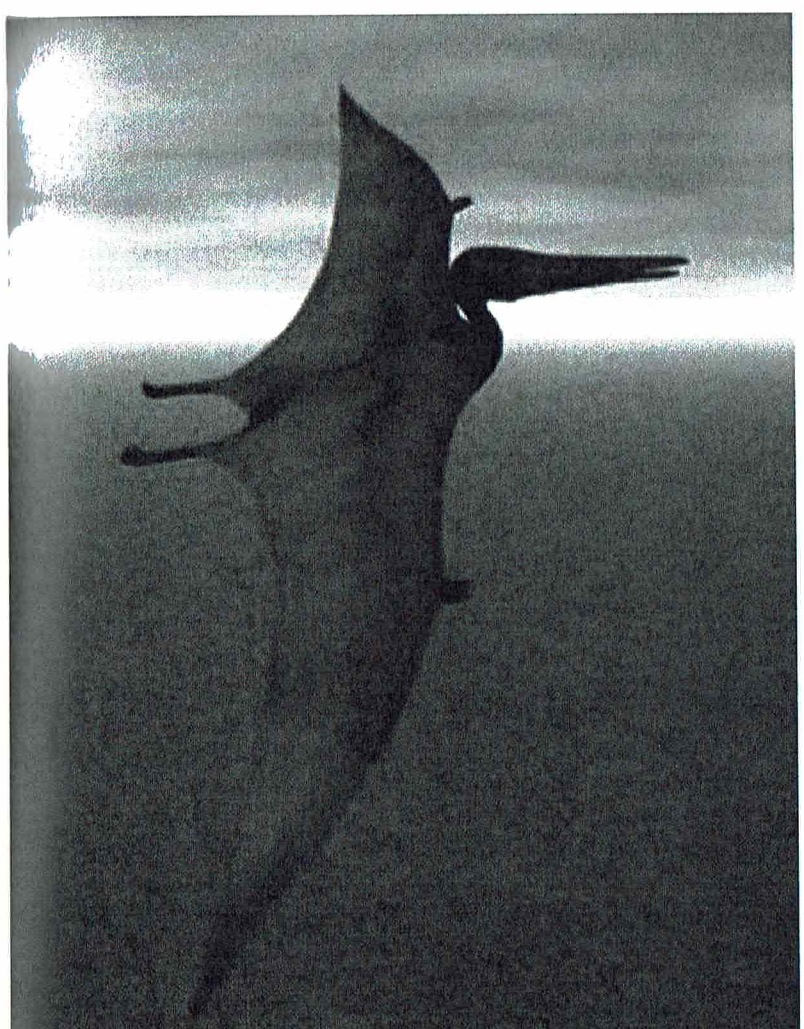
This occurrence is not just a thing of the past. In fact, this situation occurs even today. Some people upon falling ill are rushed to hospitals only to be told that they are normal. The fact is that their problems have not been, and could not be identified – therefore, they are not "sick"! Could it be of some comfort to recognize the fact that this situation has occurred in the past and still occurs in many countries as well? Anyway, Darwin suffered his long illness and died without any help available. However, his theory of evolution has greatly influenced our perception and has been considered as a landmark ever since. Despite initial apparent controversy with the Scriptures, it has now won broad acceptance by most people. In some respect, to learn of our antecedents has taught us humility, I suppose.

Corollary
Evolution

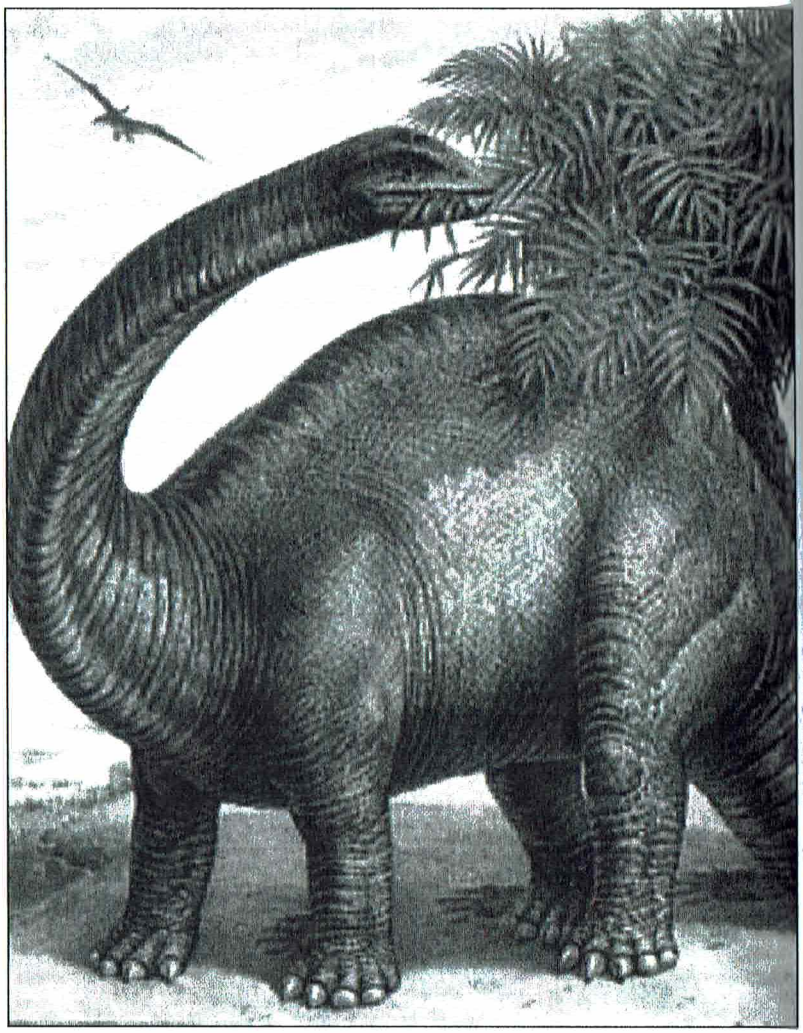
We have mentioned that Darwin's theory was then broadly accepted. To professionals who follow the details of developmental stage from lower to higher organisms, the argument for evolution is really convincing. The conviction now is that unicellular (single cell) organisms (at the level of the amoeba) evolved by a series of stages through millions of years to reach the stage where we are now. This process probably started some one thousand million years ago. At that time there was perhaps a cell composed of chlorophyll and of some other component characteristic of animal cell as well, which maybe underwent a series of mutation and evolved in two different lines, an animal cell and a plant cell. The animal cell, a type of amoeba, developed, specialized and developed again in a series of changes building up to a fish. That was achieved about 400 million years ago. Further development and specialization resulted in amphibians (the ancestors of frogs and crocodiles) about 275 million years back. Further evolution brought about the reptiles (e.g. dinosaurs) and later the mammals (dog, horse, etc.) then followed the birds.

This process was of course not a linear development; it did not follow a single line. It grew like a tree branching in every direction evolving and adapting to its immediate environment as it went further. For example, birds branched out of the main tree of evolution; but then different smaller branches (in the form

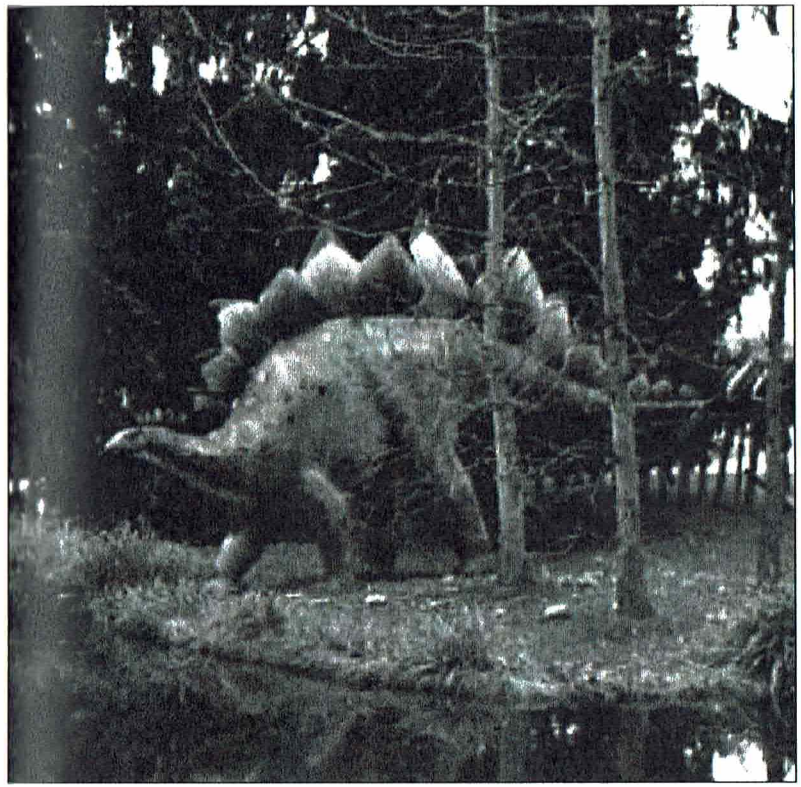
of different birds) sprouted and developed to repeat the process further on. Along the road, some became extinct as conditions of life changed and they lost the battle for survival. Among the extinct species, we could mention the tyrannosaurus and other huge reptiles as illustrated in the following pictures.



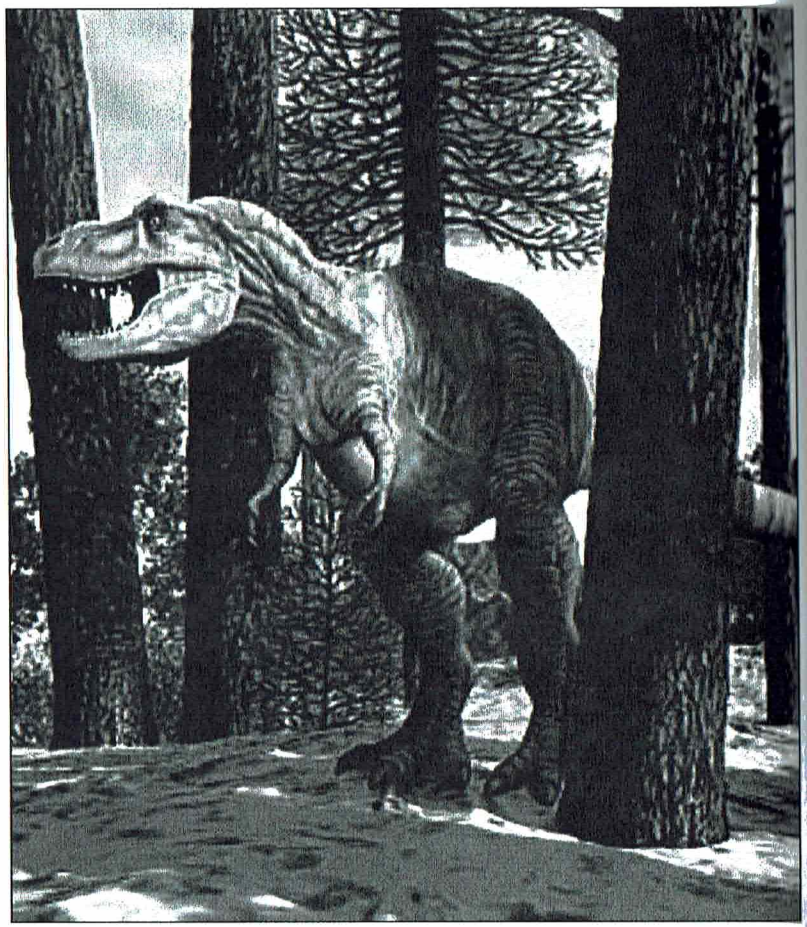
Pterodactyl – 8 meters wingspan



Brontosaurus – 20 meters in length

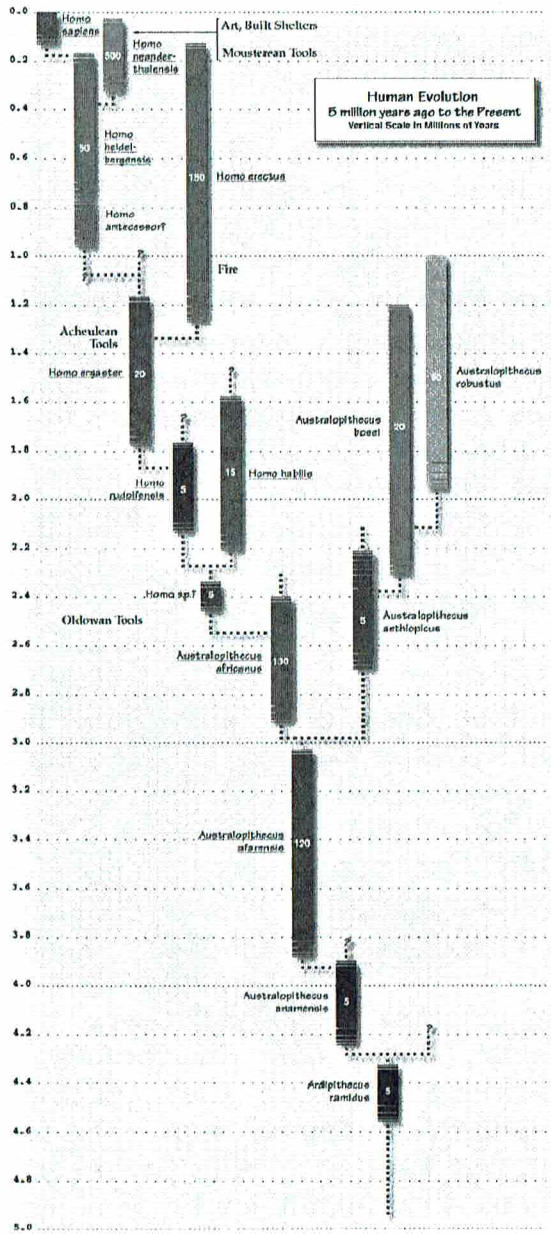


Stegosaurus (Herbivorous)
Supporting defensive armour spine along its back and tail



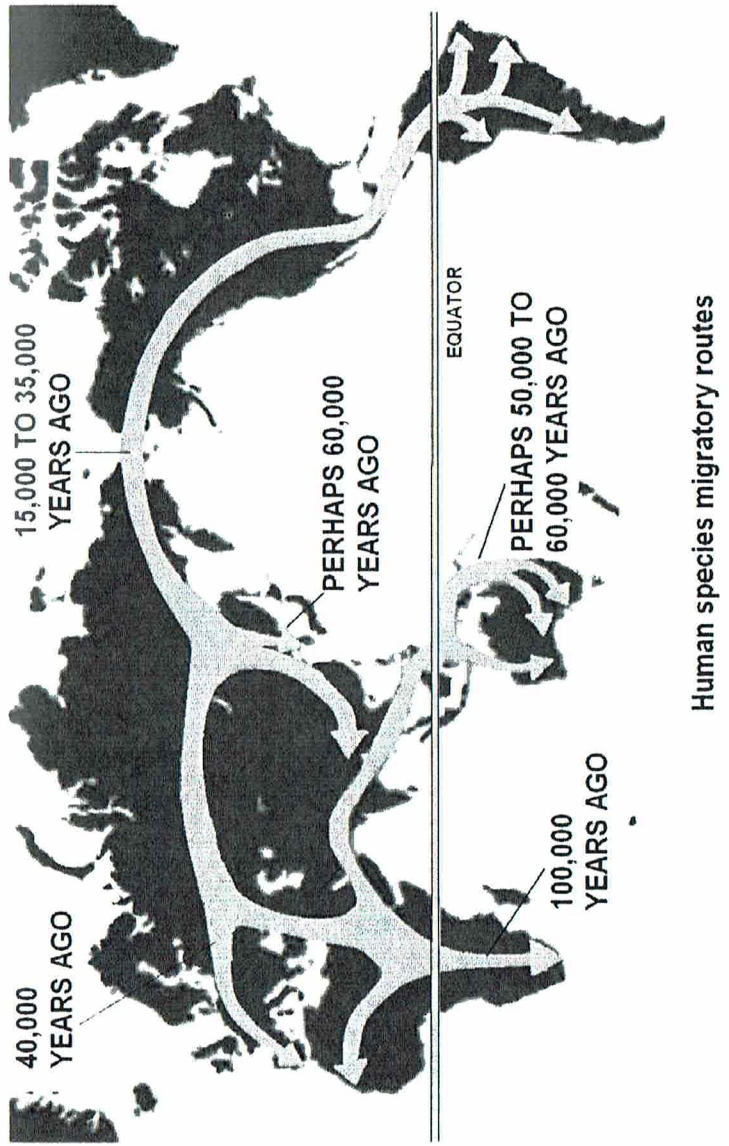
Tyrannosaurus Rex – 15 meters in length
Very dominant among all creatures

The next chart is a rough representation of the evolutionary tree.



Following up the tree, we see the species, called man, standing at the top of it. This creature admittedly stands at the top of the ladder of the evolutionary tree, but the way he got there may not have been worked out in the fullest detail. It is not possible that a four-legged monkey-type creature just decided to come down from the trees, started walking on two legs and began speaking English. There definitely were stages of development. Archaeologists have been busy searching for clues in fossils and rocks.

To date most of the findings are from Africa. The first find was from South Africa. Therefore, it is named Australopithecus. 'Australis' means "South" and Pithecus means 'monkey'. Later on, other species of monkeys were also found. Yet, they were different from each other and it was difficult to trace and determine the common parent to them all. Finally, Australopithecus Afarensis was discovered. That was the famous Lucy from Hadar in Ethiopia. It was a tremendous find. It showed just about where the tree of evolution branched. One branch of it became extinct, but the other led on to be Homo-ergaster, which further evolved into Homo-heidel. This in its turn, developed into Homo sapiens. Along the route, of course, many species have become extinct at different stages and times, e.g. Peking man (china); Java man (Indonesia), etc. The closest ancestor of ours that became extinct recently is the Neanderthal man. The fate of the still remaining species is not known yet, but our slender hope is that it will continue to manage.



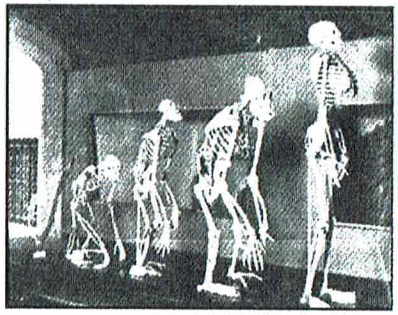
Possible human migration route from the cradle of Africa to the rest of the world.

ORIGINS OF HUMANKIND

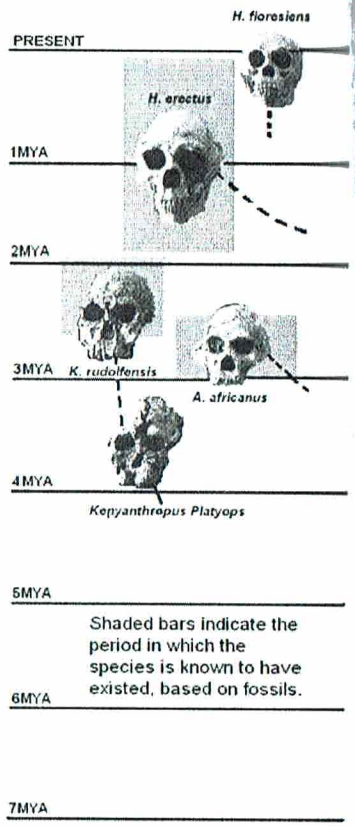
Modern humans are descended of bipedal primates called hominids, which evidence suggests, emerged in Africa 5 million to 7 million years ago.

An Evolving Theory

THE NEW VIEW: As fossil finds and DNA analysis have expanded our knowledge of our species' family tree, the old linear evolutionary model of monkey to man has been supplanted by one vastly more complex.



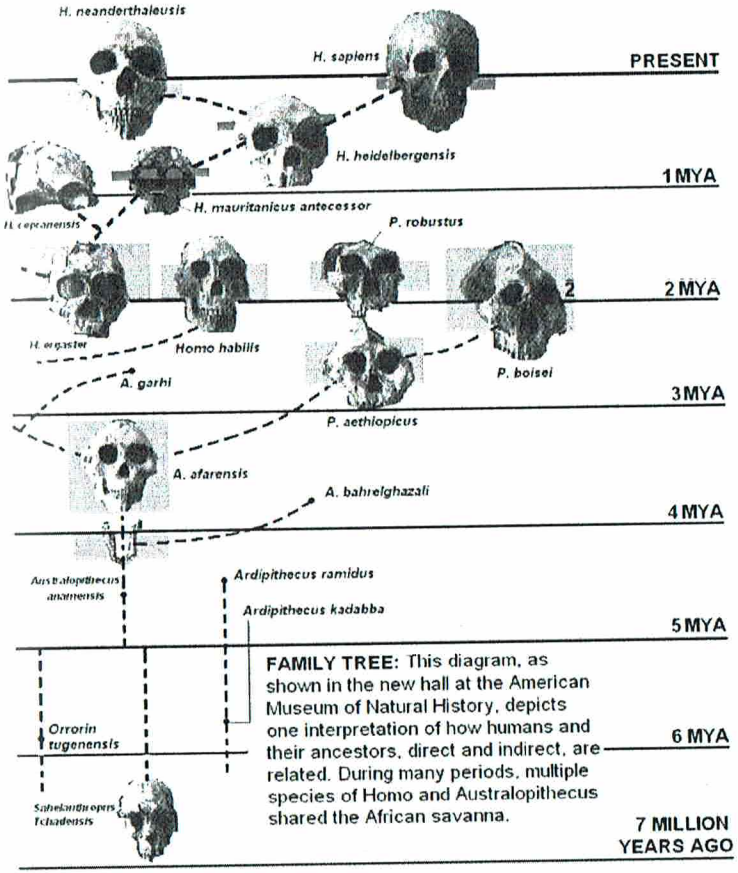
THE OLD VIEW: A 1935 museum display showing the evolution of humans.



Shaded bars indicate the period in which the species is known to have existed, based on fossils.

Various species became extinct as described above

The closest ancestor of ours that became extinct recently is the Neanderthal man. The fate of the still remaining species is not known yet, but our slender hope is that it will continue to manage.



FAMILY TREE: This diagram, as shown in the new hall at the American Museum of Natural History, depicts one interpretation of how humans and their ancestors, direct and indirect, are related. During many periods, multiple species of Homo and Australopithecus shared the African savanna.

Chapter 10



Gregor Mendel

1822-1884

What if the child is unlike the parent?

"The value and utility of any experiment are determined by the fitness of the material to the purpose for which it is used, and thus in the case before us it cannot be immaterial what plants are subjected to experiment and in what manner such experiment is conducted."

In the far distant past, it was not known if children had fathers at all. It was only known that they had mothers. Because of the nine long months, which elapse between conception and delivery, people did not comprehend the connection that exists between the two events. Therefore, it was thought that the wonderful blessing of being able to produce children was bestowed on woman-folk alone and as a result, man felt ashamed and inferior in respect of this capability.

Be that as it may, it is now known that both sexes have their own role to play in procreation. This arrangement is equally valid for animals and plants. Therefore, during Mendel's days it was known that one could pollinate plants to fertilize seeds and breed plants. What was not known then was, for example, how the parents' specific features, or any other traits, can be passed onto the offspring. Some men manage to father children looking exactly like themselves. Others may beget children looking not like them but like their father or uncle, etc. Others do not seem to bear any resemblance with the children at all. It is possible, for instance, that five or six children,

born to the same parents, can be totally unlike each other. Such dissimilarity among children born of the same womb has been a riddle for a long time; and might have caused the mother some problems too.

Mendel sought to solve this riddle and to find out any relationship between parents and their offspring's. He succeeded to throw light on it; and this achievement earned him fame posthumously.

Mendel, in his youth, showed great interest in sciences. Yet, because of poverty, he found himself unable to pursue his studies. As a result, he attended only a 2-year diploma course in philosophy and joined the monastery. There he studied theology for four years and was ordained priest in 1847.

Later, the abbot allowed Mendel to attend University to further his studies. He studied physics, mathematics, biology and chemistry for three years at Vienna University; and on successful completion of his studies returned to the monastery to serve as a science teacher in High School.

It was at this stage, that he started to do his own research. What inspired him to take up the line of research he chose was the observation he made of the fact that as plants bred, some of their seeds turned out to be black or dwarf and thus seemingly unrelated to the parent plant. He decided to cross-pollinate different plants and see what the offspring would look like.

His first choices of plants were peas and beans. Of these, he chose only one or two traits and decided to follow the changes through successive generations of breeding. For instance,

he chose to follow the variation in the height of peas – so he cross-pollinated the short and tall peas. When he collected the seeds of the hybrid and grew them, he found that all the new pea plants were tall. There were no short breeds in the lot. Mendel was surprised by the result. He had anticipated the hybrids to average in height between the tall and the short parents; or perhaps to be sorted out into two separate groups: - tall ones and short ones. Yet, his findings were different.

Therefore, Mendel reasoned correctly that even if the new generations of plants are all tall, they must be containing the traits for shortness hidden within them, i.e. they might contain 'short' genes.

Then, he took these tall plants and crossbred them. He collected the seeds and grew them. Alas! He noticed some change. He saw that for every three tall plants there was one short plant among the lot. So short plants can indeed be obtained from tall ones.

Mendel extended his experiments to include other traits or characteristics of the plants such as red and white flowered plants or round and wrinkled seeds etc. The results were all similar.

Mendel could not straightaway find the explanation for it. He puzzled and pondered the phenomena for eight long years. Nonetheless, during that period he managed to record 10,000 hereditary traits, which he had observed while breeding various plants. At last, he came forward with a new proposal, a hypothesis: - when male and female germs (sperm and egg) unite and fertilize, the trait of the developed offspring will

not be a mixture of two traits like mixing hot water and cold water to get warm water. Traits do not mix in that manner. Instead, the traits will remain separate. That must be why tall parents can produce short offspring. Therefore, we could deduce that when the offspring develops, only one of the two inherited traits expresses itself while the other one, being recessive, remains dormant. If the dominant gene is that for tallness, then the plant will grow tall. However, when this tall plant (which has a recessive gene for shortness within its seeds) is grown and cross-fertilized with a similar plant, the resulting offspring could be short. This time, the two traits for shortness combined and had the chance to express themselves.

That now explains why children may not look like any parent but look like their grandparent or uncle, etc. In a similar manner, intelligent couples can produce irrational children while their offspring in turn may be extremely intelligent (as their grandparents were). Another example – fair-skinned parents may bear albinos or dark skins infants.

Mendel's theory has helped explain away other cases as well. For instance, what determines the sex of an offspring? – was a question unanswered then. Today it is common knowledge that the egg from the female has just one type (say minus) whereas the sperm from the male has two types (say plus and minus). If the plus of the male reaches the egg first and fertilizes it, then the offspring will be male, whereas if it is the minus of the male, which fertilizes the egg, the offspring will be female. Normally there cannot be average

of the two types. Each one will remain an entity by itself. It is of course impossible to foretell which of the two types (+ or -) will manage to reach the egg first. It is purely a matter of chance. It may be noted here that the mother plays absolutely no role in determining the sex of her offspring. She merely receives what arrives first, and is therefore not to blame for any consequences. All this was made understandable on the basis of the theory laid down by Mendel.

Mendel presented his findings to a meeting of scientists and later published it in 1866. Yet, curiously enough, nobody paid attention to it. People were at the time preoccupied by Darwin's theory of evolution and overlooked this important work. Mendel was appointed administrator of the monastery a few years later. In the new position, he had the onerous responsibility of seeking ways to finance their monastic lives. He died in 1884 unknown and unrecognized as a scientist.

Fortunately, his publications had been distributed to other universities in Europe and America. Therefore, when in 1900 three scientists from three different countries, each thinking they had made a discovery in their laboratory in Germany, Holland and Austria, reviewed the literature, they discovered Mendel's works. It came as a surprise to them – the work had actually been done and published 34 years previously! Yet it had remained unnoticed until then. The poor monk has passed away unrecognized.

However, great deeds and achievements do not die with the person; instead, they find their place in history and shine into the future. Mendel is

long dead, but his fame shines on even today.

There is an interesting side-history to this progress of human development. It concerns the politics of the times. This is not altogether a new phenomenon. We have already mentioned it in the case where Einstein's Relativity theory was considered 'Jewish Science' as against 'good' German science. Mendel's Science appeared to be in contradiction with communism. The person who led the opposition to Mendel's theory was the Russian biologist Lysenko. Lysenko held the belief that human character is transmitted from generation to generation not by means of arbitrary combination of male and female reproductive cells but by the environment. If suitable conditions are created for up-bringing children, it is possible to induce permanent change in outlook. It is thus possible to cultivate human nature to bring about a bright future in the world.

Now this line of thinking was found compatible with the reasoning of the authorities in power in the former Soviet Union. Lysenko's theory was embraced and supported by the government. Therefore, he ruled that all scientific publications henceforth and all seminars in the country should be in line with his "correct" approach and that Mendelism was to be disavowed. It followed then that scientific works supporting or approving Mendel's theory were never entertained or made public in the country. Even schools were forbidden from teaching Mendel's theory.

According to the official tenets then prevailing in the country, historical materialism teaches that human social development progressed from

primitive communal life through the periods of slavery, feudalism and capitalism to communism. The conditions of communism dictate that "all people get according to their needs". For this to happen in a world where natural resources are limited, human selfishness and unrestricted greed for wealth should be eliminated by changing human nature and creating the "new man". This teaching of political science extended also to natural science. So famous scientists like Vavilov, who could not accept this line of reasoning were rounded up and sent to jail. Even Peasant Associations, which for years had been practicing crossbreeding their selected cattle to improve their stock, were discouraged and scoffed at by Lysenko.

Lysenko became famous and his name very popular. Communism too, came to be accepted as being scientific. Therefore, progress in genetic science was held back for twenty or so years in the Soviet Union. Fortunately, there was no such restriction in the West, so that now genetic engineering has reached such a high stage of development that it has opened a new vista.

The expectation among people was that the child of a scientist would itself grow up to be a scientist or something of that calibre. The fact is that it could be one, but then it could also turn out to be a simple labourer. A child born to a labourer could remain a labourer but it could also turn out to be a scientist. The environment and the standard of education provided could definitely modify the chance of success. Ultimately, however, it is the mental ability, which is the decisive factor. What a man can transmit to

his child and broadly speaking, what passes down the line of generations is not what is taught in life, but what is defined and coded in the genetic material only. This again is subject to chance when male and female parts join to form the embryo. That is why, as mentioned earlier, children born of the same mother can be so different in character and appearance.

The only factors that can change transmutable characteristics are called mutations, and these come about by radiation exposure, or chemical reactions or heat applied to the sensitive part of genetic glands. That is why one cannot just change human nature by training (or any such external factor) to create a new man.

I recall on this occasion one incident, which is a case in point. Charles Darwin was traveling in company of three foreigners on his historic journey across the Atlantic (and eventually round the world). These men were no different from the other crew in behaviour or in their habits of eating or clothing. They were civilized just the same.

However, these three people were returning to their native country and relatives. Three years back, the captain of the ship had brought them to England to civilize them and to teach them the Christian way of life. He hoped to change them from their cannibal-like behaviour and to teach them to live like Europeans. Meanwhile, they had also received some vocational training and could go back to their relatives to teach them in the Christian manner.

Yet, it took Darwin only a few weeks to realize that after some effort on the part of the three men

to influence their society, they failed and gave up on the idea. They soon mixed with their compatriots to return to the way of life they knew before they left. We all know of our colleagues who moved on to advanced Capitalist or Communist societies and adapted right away. The environment is very important in influencing a way of life, although it is not transmittable genetically.

The idea that environment can create 'a new man' should not be taken as a false notion unique to Communism's tenants. In the past, Scientists in the West have taken too much trouble trying to prove it.

The most famous quote of this attempt is an experiment that was carried on in Britain in 1833. A renowned scientist by the name of Weizman had taken mice and cut off their tails at birth. The mice would thus start their lives without tails and adapt to this condition throughout their existence. When they grew up and produced offspring's, Weizman would cut their tails also. He repeated this act through nineteen generations of mice. He stopped at the 20th and let it grow unaffected. Alas! It grew a long tail and used it exactly the same way its 20th of ancestors had done before. Inheritance of the genes for growing and using tails that long had been continuing through the generations of amputated mice. Weizman had been criticized for his poor observation in life. A Jew that he was, he must have noted that all Jewish children are circumcised by orders of the biblical Abraham; and yet despite some thousands of years since then, Jewish and Christian children are still born

the same ancient ways even if circumcision was practiced all these years. One cannot change genetic properties by external application of modifications or changes.

It is by mutation alone that permanent changes can be induced on progeny. By this method, pure tall races may beget short ones or white pea seeds yield black seeds etc. This too, of course, had to be tested to be believed. The first experiment conducted to test this theory was perhaps that of Dr. Muller in America. The year was 1927. He collected flies and exposed them to an intense dose of x-ray radiation. X-rays in penetrating through exposed bodies bombard cells, causing chemical reaction in them or just damaging some critical structures in them. This manipulation on the genetic organs will cause changes in the genes.

Dr. Muller bred the irradiated flies and examined the offspring. He found some flies with six legs (instead of four) and some others with four wings (instead of two). Others still, were without wings.

Different species come about, he learnt, only by mutation induced on the genetic constituents. The gene (now specifically identified as DNA) builds up the organism, and so any change in the gene alters the way it builds the body. This then creates a different type of organism. Dr Muller won the Nobel Prize for his work.

Today it is accepted that all these varieties of creatures populating the world came about as a result of changes induced by mutation. Now, if, as Darwin had taught, this change is advantageous to the creature, it is a welcome change. The owner

becomes more successful in life. If the change is disadvantageous then the owner becomes disadvantaged in this respect and is not welcome by the society. Therefore, it fails in life. But if the change does not affect the owner one way or another, it lives on normally.

Let us consider specific example: - if the mutation resulted in the birth of a child as limbless, say without the hands, then the child will find it hard to live a normal life, compete with fellow beings and find a mate to procreate in the future. If the change results in making the owner stronger or more intelligent, then the person will have a better chance to succeed in life, he will also have a better prospect to finding a mate and fathering several children as he wishes. Finally if the change due to mutation caused the person to have six toes on each of his feet, this can be covered up in shoes, and does not cause him any inconvenience in life. The hair of the African is curly and is thus different from both the monkey hair and the European hair. This mutational change is definitely not a liability and may even be considered as advantageous in particular situations.

So, as is often said, life is a struggle. Those who struggle successfully can survive, and those who do not will simply die out. When mutation comes into the picture, the resulting changes act to impede or to improve the chances of survival. As a result, several species of animals have become extinct, whereas the rest of us have managed to adapt better and even advance successfully.

The interesting point about mutation is that

not only has it caused to bring about different species of animals and plants, but even after human beings finally came on stage, it has continued to bring about minor changes in them as well.

One theory runs as follows: - the Eskimos (now properly called 'Inuits') are short and plumb in their physical build-up; their faces are roundish and fleshy. On the other hand, desert dwellers like the Arabs and Afars are lean and tall. This condition makes both races adaptable to their respective environments. The Eskimo has to preserve the little heat available. He cannot afford to lose much heat from his body. So the most advantaged individual will be that who has the smallest surface area exposed to the cold. That means that to be short and roundish is the best way to survive. The desert man has to manage to lose heat to keep cool. He needs to have the largest possible surface area exposed to the air. It means he needs to be lean and tall. Now, if the Eskimo is brought to the desert he may suffocate in the heat, and if the Afar is taken to the Arctic zone, he may succumb to the cold.

Another theory explains away the difference in the nose shape between the African and the European. The African nose needed to have large nostrils because he needs to expire enough to release the heat in his body. The North European will find it hard to keep out the cold with wide nostrils. Instead, he has a long and narrow nose. This serves to gain time to warm up the air as it is drawn in.

So when mutation brings about such changes, those found beneficial for the environment at

hand are welcome and survival is assured. The chance to multiply the race increases. If the change is detrimental to survival, it is defeated and eliminated in the struggle. Thus, the environment plays a decisive role in enabling or disabling the preservation of mutations.

Of course, there are people living in the same environment or locality and yet being different in make-up. One's diet does not necessarily agree with another. Some like spice, but others find it sickening. Some are allergic to some substances but a lot of others are not. Fast runners and heavy boxers rise to fame from among ordinary folks. This could be mutation come upon them or they may have inherited the right genes from their parents. Intelligence and special talents are inherited by lucky combinations or correct 'hits' like the right combination of numbers or the presence of 'jokers' in a game of cards.

Thus, bright children could be born of ordinary parents; and scholars could engender ordinary kids. That of course cannot be considered as the fault of the child. The best thing to do for a child is to provide it with a broad range of learning possibilities and entertaining activities, so that it can discover exactly where its interest and talent lie; and then to help it achieve its goal. This alone is the responsibility of parents and of the society at large. Schools have even a heavier responsibility than parents do in this regard.

At any rate, Mendel deserves the credit for having pioneered genetic engineering and research.



Gregor Mendel in the gardens

Corollary

A child born of just a single parent?

Farmers practised selective breeding long before Mendel gave it a scientific touch. Racing horses, strong bulls, high-yield cows and chicken were selected for breeding. Today such breeding is conducted with more precision. Different varieties of wheat and rice have already been obtained in this manner. Using this method, we can produce crops and fruits resistant to drought and pests, with better flavour or taste.

The key to all this is to find the appropriate gene (or DNA) responsible for the characteristic and to replace it with another one of the desirable trait.

But now, things have gone a stage further. Early in 1997, it was shown in Scotland that an individual can be reproduced exactly. So far, it needed both a male and a female to reproduce an offspring. However, it turns out that just one of them is enough for the task. The thing to do is simply to extract the genes from a normal cell of one of them, say the father, and transfer them into another normal cell from which all genes have been extracted. These genes (called recombinant genes) will proceed to build the offspring exactly the same way as they did the father in the first place.

The problem in the past was that only genetic cells multiplied themselves whereas normal (somatic) cells have this mechanism switched off and so just perform the job to which they have been assigned (e.g. muscle cells contract & brain

cells think).

Now a way has been found to induce these somatic cells into a dormant state (they stop their work) from where can be triggered the mechanism to multiply as genetic cells. The Scottish researchers took an ordinary cell from the udder of a ewe, then extracted the genes and made them recreate the original ewe. The newborn lamb (Dolly) became the exact genetic replica of the mother.

Lately, South Korea's researchers took a skin cell from a dog's ear and nurtured it to grow into a puppy (named Snuppy) which became an exact replica of its single parent. Other species cloned so far include mice, cows, pigs, rabbits, horses and cats. If this practice is extended to human beings, a man with enough money or political clout can order to duplicate himself in hundreds of copies and perhaps raise an army, all in his image. This clearly is unethical; and various countries are taking measures to forbid such trials on human beings. But then, who knows where the trend will lead in the future?

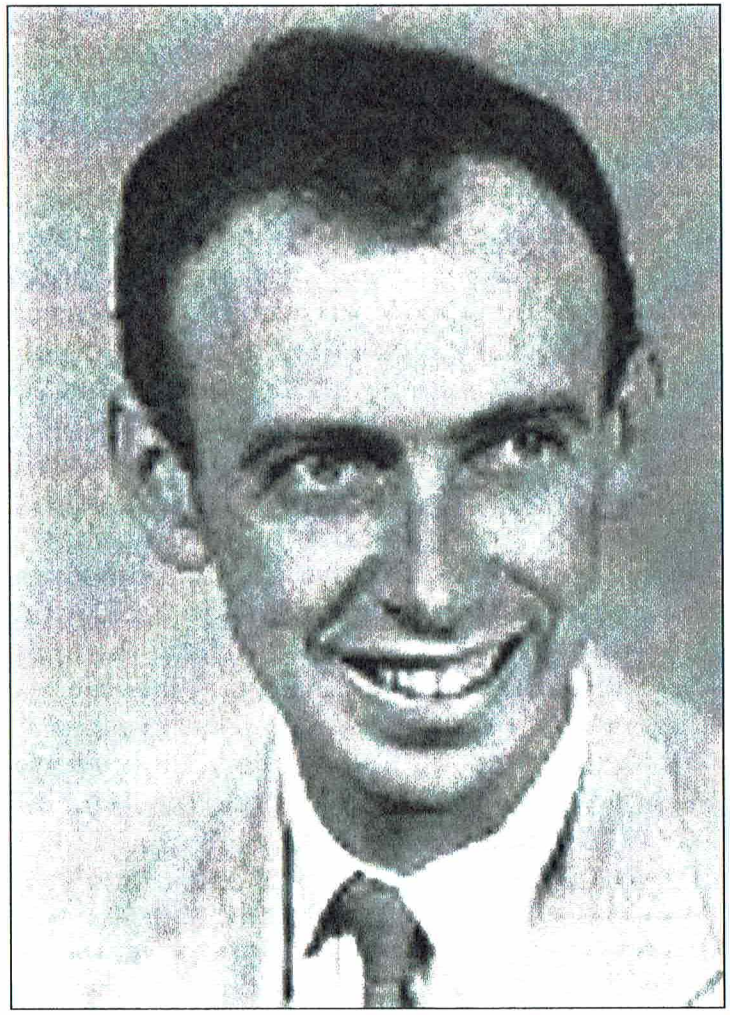


"Dolly"



"Snuppy"

Chapter 11



James Watson

1928 -

Solving the riddle of life[8]

"Biology has at least 50 more interesting years"

Civilization began in the caves of our primitive ancestors and developed to the stage where we are now exploring space and even landing on other heavenly bodies. This is made possible by the progress of science and the study of natural phenomena. The history of human progress is a history of step-by-step development; building patiently one on top of another over this long period between the cave life and now.

Of course, progress was not uniform and did not follow the same style. Some scientists are endowed with such power of mind that they see far beyond others and arrive at their discoveries easily. Some just stumble across it accidentally. Others still arrive at their discovery through a lucky combination of events, facilities or circumstances. There are even cases of discoveries arrived at in dreams. But nowadays most researches are conducted by teams or groups of people.

The problem, in this case, is personality conflict. Not all people pull together in one spirit. Jealousy, mistrust, envy and hatred come into play and spoil the team spirit. Personality conflicts observed in several research organizations are often the cause behind disruption or failure of major projects.

The case of the American James Watson doing

[8] (8)

research in England is not a bitter experience to regret, but what should be expected of a normal group of researchers co-operating but also competing with each other to 'strike the mine first'. I have chosen to present it in some detail to create awareness in our young researchers. It all started in 1951. The riddle of the times was "How does life regenerate itself?"

Mendel had already shown the way by which traits or characteristics are passed on through genes in the reproductive cells from generation to generation.

But what are these genes? How do they transmit such traits as color or intelligence? How is it that the characteristics of male and female do not add up when the sperm unites with the egg? This is like asking why a cell (of the father with two hands) uniting with a cell (of a mother who has two hands also) does not produce a person with four hands. What exactly is it that prevents this from happening? How actually do inert chemicals like the genes manage to build up a life? In short, what is the key to the secret of life? These were the type of questions being asked then, and the key, of course, lay in understanding exactly what genes themselves are.

The scientists had no doubts, even then, that genes were nothing other than proteins. Our bodies are built of proteins. There are of course thousands of types of proteins available. We employ different types in our muscles, nerves, cartilages, enzymes and vitamins. So a gene must be one of such types and cannot be very different.

Yet again, the gene must be different from all these. For one thing, a gene directs the building

of these proteins for all the different purposes required, and for another, it has the capacity to divide itself for fertilization purposes. This division too, must be an act of duplication, otherwise when a cell divides into two; the two off-springs will not look alike. If not, it means one will gain one part of the mother cell and the other another part (such as one will get the nose part and the other the mouth part). But this does not happen. So the gene must be dividing in some suitable way.

Therefore, the challenge was to understand the workings of the gene. To do this, one has first to determine its structure and composition. The chemicals making up the parts must be known and the way the bonds are arranged must be figured out.

"Who can do this job?" was the next question. Biologists refrained from tackling this problem because it requires a vast knowledge in chemistry; they were not quite up to the challenge in that regard. On the other hand, Chemists did not want to delve in the field of biology of which they do not know much. On top of that, this work required the use of mathematics, with which no one dared to tamper. So everyone hoped that somebody other than himself or herself will take up this task.

James Watson was just completing his doctorate dissertation in biology. His professor had long been aware that in order to understand genetics, one has to learn chemistry in addition to biology. He felt too old himself to come back to the classroom as a student and learn chemistry. So he decided to assign this promising graduate

to the task.

Looking for a suitable laboratory, he chose to send him to a professor in Denmark. He obtained a scholarship fund for him from Washington and packed him off to study the genes.

Upon arriving in Copenhagen, Denmark, Watson finds, on closer inspection that the situation is not as he desired it to be. The chemistry research went along a different route, and the biology research did not delve into chemistry deep enough to be of use to him. He was left half way between two streams of research. Besides, his grant permitted him only one year's stay. So he began to worry.

Looking for ways to save the situation, he learned that there was a seminar to be held in Italy. After securing the consent of his supervisor and that of Washington, he headed for Italy in the hope that he might meet other researchers and plan his activities a little more appropriately. Upon arrival in Italy, he found that the seminar participants were divided into two distinct groups. One spoke Italian fluently and was interested in the proceedings of the seminar. The other group spoke good English but not Italian, and having come away from the snowy winter of Northern Europe, the participants were more interested in basking under the Mediterranean sun than in taking part in the seminar. So open air tours and visits got more attention than anything else did.

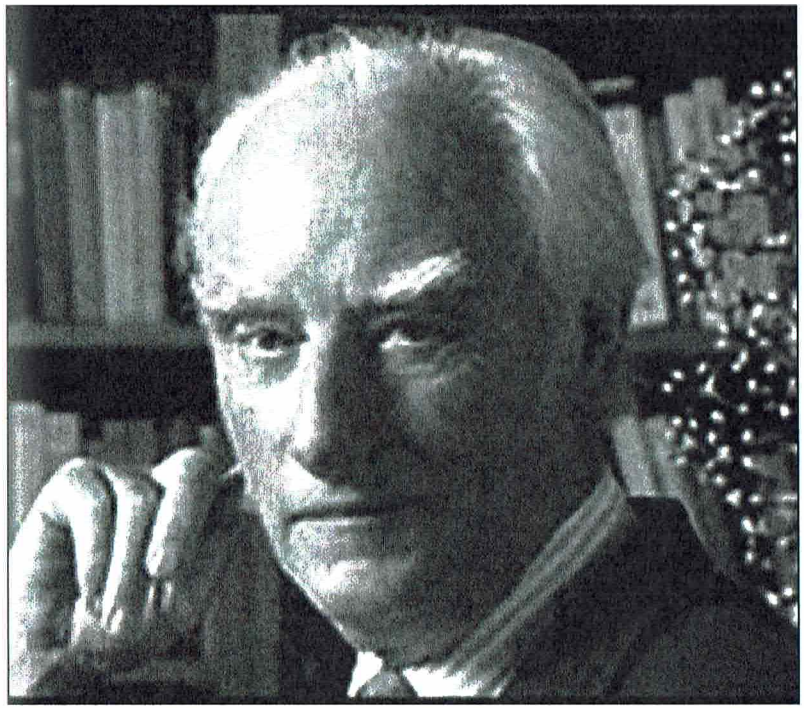
But there was one participant from England who had come on behalf of an anticipated eminent scientist who had failed to come himself. This junior researcher, by the name of Maurice Wilkins, took this opportunity to present his own

modest work. He had brought along some pictures to illustrate his point.

It was these pictures that excited Watson. The contention was that even if protein was the building block of life, there was DNA molecule in all living cells and perhaps this factor was responsible for transmitting traits down through generations. Some experiments made on viruses seemed to confirm this proposition. But nobody had any idea what this DNA actually was.

The picture Morris displayed during the seminar was a picture of DNA. Well, it was not a picture of one DNA because it is too small to be identified in a picture. What Morris had done was to collect a high concentration of the DNA solution and to let it crystallize. (A crystal is a visible form resulting from the regular alignment of the small entities.) Morris had prepared x-ray photographs of these DNA crystals, which he presented at the seminar. Watson was understandably excited by the presentation. Yet, Maurice soon made it clear to Watson that he intended to pursue his own research without any meddling or interference from him. Watson's hopes of joint work were dashed instantly. He returned to Denmark dejected and discouraged.

On arrival, he sent off a letter to Cambridge, England half-heartedly enquiring if he could transfer there. To his surprise, he received an immediate positive response. He packed up and left for Cambridge. The person who was assigned to work with him was a certain Francis Crick. He was a physicist by training but had switched to biology to unravel the secrets of proteins.



Francis Crick

Francis was no ordinary bloke. In fact, he was regarded with fear among his colleagues. His mind was so sharp that when an idea was suggested to him, he grasped it and jumped ahead to suggest an even better idea. That embarrassed many aspiring researchers. Besides, Francis had a habit of going round to the various laboratories and socializing with the workers, so that he knew everything about what was going on anywhere. Therefore, researchers were on their toes when he arrived for fear that Francis might

easily crack the problem upon which they had been labouring for so long, and get the credit for it. As a result, they shunned him as much as they could.

The authorities too, did not like him. Francis, when he laughed, just roared. His laughter was so loud that it was heard all around. The University's Chairs avoided him because they felt Crick showed disrespect for their authority once too often.

Yet, everybody realized the power of his brains and so, in their own interest, did not distance him too far.

Francis, as always, had the feeling that the secret of life lay not in the proteins but in the DNA, but he was stuck with a problem: - A close friend of Crick's, a Maurice Wilkins was handling the work in London.

It is not courteous to interfere in other people's work, good English manner does not allow for such behaviour. But Francis did not expect Maurice to show any progress in the field, because he knew there was a conflict between Maurice and his workmate Miss Rosalind Franklin.

It was at this stage that Watson came into the picture. Watson made it clear on arrival that his concern is DNA, and so the two were glad to find each other and both looked forward to a fruitful endeavour.

As they settled down to work, they decided to try their hand at replicating the work of Linus Pauling. This eminent American scientist had just published the model of protein. This publication had of course, reached them immediately as it did

everywhere else and they wanted to repeat the work. This is a common practice in the scientific field; everyone puts the new findings to the test to confirm or disprove the claim. This is how science builds on a firm basis as it advances forward.

However, Watson and company had other reasons for pursuing this avenue of research. They sought to know if this method could be applicable to DNA as well. They were certain that Pauling, having known the components of protein (carbon, hydrogen, oxygen... etc.) would surely proceed to arrange the models of these components in different forms and x-ray them until he would hit on the form that yielded the same pictures as the films of the DNA crystals.

Watson (and company) built the models, but they had no pictures of the crystals with which to compare their results. The pictures were in the hands of Maurice. They thought of making their own films, but then assembling the equipment and mastering the technique, itself would take about a year, and Watson just did not have the time. They approached Maurice about it. He told them that in an attempt to smooth down relations between him and Rosalind, he had handed over all of the pictures to her. Rosalind, for her part, did not see the point of these people meddling in her affairs.

So the only choice left to them was to wait patiently for Rosy (Rosalind) to present her papers at a seminar the following month. They hoped to see the pictures and learn the details.

The day came and they attended the meeting. Rosy presented her papers and her pictures. What came out of that meeting was that the

woman was a very highly trained person and that she sure did apply her knowledge well to the task at hand. The pictures themselves were of high quality; nevertheless, they were not divulging the details of the DNA structure. This, Rosy announced, had to wait until she had improved the technology in the near future. She regarded this presentation merely as a beginning.

They then proposed to her to build models using known components and comparing them to see if they tallied with the DNA crystal pictures; but she regarded this crude form of research as child's play (or a monkey's game).

Watson felt fenced in. To make matters worse, Francis lost all interest in this work, because he ran into another problem of his own making-- he fell out with the authorities again. The trouble started when he noticed a scientific magazine about a research finding that his immediate boss and the director of the institution, Sir Lawrence Bragg, had published jointly. They had left his name out, and did not acknowledge his contribution. Francis said that it was he, who brought up the idea in the first place. After exchanging harsh words with his boss, he decided to take up with the director to expose this 'theft'. Sir Bragg took a stand saying that he had never heard that Francis had contributed anything to the findings. Francis was equally adamant. He did not believe that Sir Bragg could have failed to hear of his participation when he, Francis, had been going round announcing it to everybody around him.

Sir Bragg was already at the end of his tether with Francis and now the lid blew off. He told him

that he was terminating his contract and threw him out of the office.

By then, Francis was in deep trouble. Watson was in a jam also. The work was stranded.

Later, some arbitrators came round and explained, on behalf of Francis, that he was the one who hit upon the solution published in the journal, and that he deserved some acknowledgement. Sir Bragg was persuaded to pardon him, considering the fact that Francis had tremendous potential to contribute to the benefit of Science. The pardon was granted, and the atmosphere was cleared again.

A few days later, another colleague of Francis, called Max, received a letter from a friend, the contents of which he showed to Francis. The friend, being a mathematician, had formulated an expression defining a pattern of exposure of x-ray diffracted from helical molecules like protein structures. Francis, pondering this method, trying to understand it, sensed that some thing was fishy in the procedure. He could not lay his finger on it, but felt that a conclusion based on this, might be faulty. So he took it to another colleague and showed him the work. They agreed that there must be something wrong in the treatment.

So, Francis went home and stayed up all night thinking about it, and by morning, he had figured out what was wrong. He hurried to do the correction and to write it out in the form acceptable for publication. He feared lest Max's friend realized his mistake and amended it before sending it for publication. Having prepared it so, Francis ran to show it to his friend who, he

found, was equally intrigued and been working on it all night. They compared their findings and having agreed that essentially it was all the same, they submitted it jointly for publication.

Francis was thus on top of his spirits again; and the work with Watson proceeded in earnest.

But the structure of DNA became too illusive. They knew that Pauling in America has established that a protein molecule is helical in shape. X-ray pictures confirmed the fact. Therefore, it was reasonable, Watson thought, that DNA could also be helical in shape. They searched for all literature published on this subject and reviewed it. They knew what sort of atoms or elements went into the making of a molecule. Analytical chemistry has enabled scientists to use acids and other chemicals to dissolve and crystallize or isolate, in various ways, the different components that make up the giant molecule. Even the ratio of their composition has been worked out to some extent. The problem was just how all these parts joined to one another. This was the riddle.

After exploring various approaches, Watson decided to build a three-chain model. So he got the workshop to make him an imitation of the various kinds of atoms, and started joining them up. The bonds and the angles of the joints had of course to be according to the rules dictated by chemistry laws. Gradually a structure began to emerge. Watson hoped that if there were a few chemically unbalanced forces in the bonding, these could be sorted and rectified by comparing its picture with the x-ray pictures of DNA crystals. The structure took up a helical shape.

Now that created a sensation and a sense of anticipation – they were on to something. The only question was where to get the x-ray pictures with which to compare their newly developed model. They had an idea and extended an invitation to Maurice and Rosy to come up to Cambridge to survey this new 'creature' of theirs.

By then, the news had made the rounds that some progress was in the pipeline and even Sir Bragg waited in anticipation of some announcement. He had, in the past been stung, when the American, Pauling, beat him to the discovery of the structure of protein molecule, and now Sir Bragg was anxious to get even with him by the discovery of DNA in his laboratory.

Rosy and company agreed to come over from London, and so careful preparation was made to receive the group. Francis, of course, would be the 'master of ceremony' since he could talk and double-talk to manoeuvre his way through a maze of trouble. At any rate, no one else could dominate a talk when he is around. When Rosy arrived, she made it clear that she was not interested in any dilly-dally and demanded to see the model. After some introductory remarks, the model was presented and uncovered. Rosy blew up! "Is that what you called me for?" she fumed. She did not need any further explanations. She knew that DNA could never be of this model. Queries after queries followed. In a minute, the whole theory collapsed. She left everything in tatters and took the train back home.

When this news reached Sir Bragg, he too felt ashamed. He believed this mess was the making of that talkative Francis who could have done

better had he babbled less. The issue again unsettled the calm that had been restored a while ago by the arbitrators. The director felt that the DNA project should be left to Rosy's group and Francis had better be dismissed. He could stay only until he wound up his Ph.D. Work. The situation was made worse when Pauling from America got wind of this impending discovery and announced that he would come over to look at the model. It was going to be utterly embarrassing to be humiliated by this presentation. Sir Bragg could not be expected to bear with all this.

Fortunately, though, Pauling was prevented from coming to England. His application to obtain an exit visa from America had been refused. The man had apparently been running science and politics side by side at all lecterns he mounted and his "peaceful co-existence with Soviet Union" campaign being covered from his scientific research (and hence government) funds, had caused discomfort to the Administration. This announcement was a relief for Watson and Francis.

On the heels of this development followed another piece of bad news for Watson. A letter from Washington reminded him that the grant originally awarded to him was for a scholarship to pursue his studies in Denmark. Since he had chosen to go to Cambridge of his own accord, the scholarship was to be terminated shortly. Watson was in trouble again. He had wasted much time going around Europe, and he was now to return home empty handed. To save the situation, he tried to investigate the simple tobacco-virus in the hope that he may get one publication out of it.

However, these viruses are built on DNA anyway, and so the problem boiled down to the same issue. So Watson decided to give the three-chain model another try.

He instructed the workshop to prepare large numbers of atom models of different colors to use in building the DNA structure – that would take a whole two weeks. What would he do in the meantime? He decided to use the small number of atoms at hand to build a two-chain model. This helped him to pass the time. At any rate, come to think of it, why shouldn't a two chain model work? Nature in fact prefers two rather than three. Two feet, two hands, two eyes... etc are all in pairs. So he went ahead and built a two-chain model.

The principles of logic dictate that to reach the right conclusion one has to be able to start from the right premise. But sometimes as it so happens, false premises have led to the right conclusions, as in the parables. Watson's argument in favour of binary arrangements may not 'hold water', but the fact is that he arrived at the right conclusions. He discovered the secret or replication of the genes and hence of life.

It did not happen immediately. He fiddled with the model for sometime trying to bind one atom to another in a way that could make sense. He always started by placing the main strands in the middle and building the other small components around it. The main ones are, of course, the sugar and phosphate chains. The other remaining ones were adenine, thiamine, guanine and Cytosine. He was trying to fit them around the main strands but he could not. Then an idea occurred

to him. He thought of interchanging their positions. He placed the main strands on the outside and placed the others on the inside. And lo and behold, 'The Heavens opened'. Every thing became crystal clear. The riddle was solved and the replication method became obvious.

The four radicals have different lengths of bonds. Yet, when adenine is coupled with thiamine (with hydrogen bonds between them); it is exactly symmetrical with Cytosine coupled with guanine. This symmetry allowed the exchange of positions without affecting the external shape of the sugar phosphate strands. This is true, of course, only as long as adenine remained with thiamine and the other two are together. See diagram below.

Now this turned out a beautiful structure. The sugar phosphate strands twist about on the outside with the base pairs connecting like rungs of a ladder in the middle. The whole thing looked like a spiral staircase. But that was not all! The way it replicates itself (or regenerates) during cell division for multiplication was now clear. The DNA spiral can easily separate into two halves, simply by separating right down the middle. In that situation, each strand will serve as a base for the synthesis of another new strand to match it. That is because if, say a sugar chain has adenine as its base, it is only thiamine that can bond to it; none of the others can connect to it. Once thiamine is pulled in and bonded, then a phosphate molecule is locked on to it. The same situation applies to guanine and cytosine. Thus, if there are enough ingredients of molecules in the

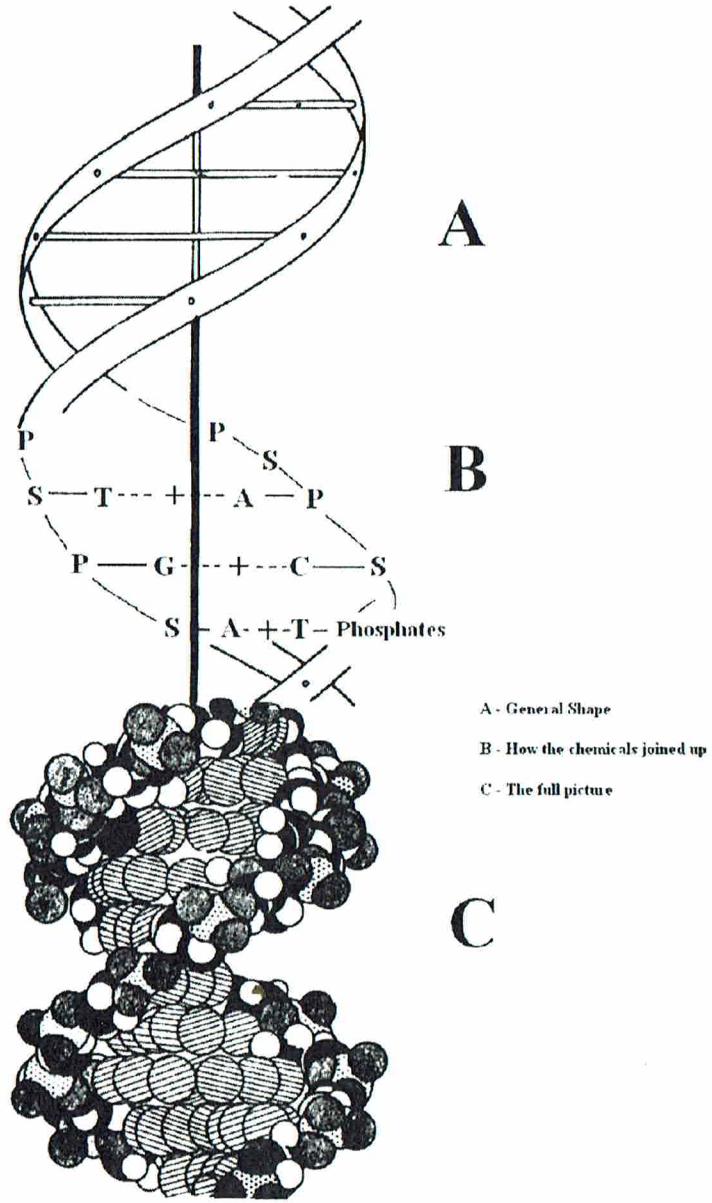
soup, DNA can easily split and form two DNA molecules exactly identical to the original one. This was a revelation. That was how the DNA or the gene was able to replicate itself exactly!

A living cell can, and does synthesize its food only by the guideline issued from the DNA. It is clear, therefore, that the DNA directs the cell to prepare these molecules. Once that is done, then the DNA begins to split into two-strands and each strand completes itself from the prepared material in the cell body. It then directs the cell to divide into two parts with the DNA's going to each of the parts. The cell has thus duplicated itself. That was the essential trick used by cells. The amoeba divides into two, and so do our cells. Each one is exactly like the other and that is how life begets life!

When this revelation downed upon Watson, one can imagine his sense of satisfaction. Well, he was not as expressive as his mate was. But he needed not bother. Francis turned the world over. He announced the discovery loudly to everybody in hearing distance. He went around the campus breaking the news. Letters were dispatched in every direction and the world learned of the discovery in no time. Of course, they deserved the credit. The two together and with Maurice were awarded the 1962 Nobel Prize.

In retrospect, we realize the contributions made by Rosalind Franklin. It was she who first compiled the evidence and made the x- ray films of the structure of DNA. She expressed her displeasure at Watson's demonstration of the three-chain model because she already knew that the sugar phosphate strands lay on the outside

and not on the inside of the helics as was confirmed later. Unfortunately, it was not to be her name that became famous in the world. Worse still, the lady became a victim of the radiation emitted from the x-ray in her laboratory. In those days, the effect of intense radiation exposure on the body was not understood enough, so that the necessary precautions were not taken. She lost her youthful life to cancer in 1958. She had kept to her workstation even after she knew of her terminal illness, and had worked to the last few weeks of her death. It is on the strength and sacrifice of such people that science is built.



DNA – Three forms presentation

Corollary
The progress of genetics

The discovery of DNA structure has brought about a big advancement in genetic engineering. We had learnt from Mendel's days that genes are responsible for transmitting traits from one generation down to the next. Now Watson and company have shown that a gene is just three or more segments of the DNA structure. DNA is, relatively speaking, a very long strand made up of a number of genes connected in series. Therefore, if one of the genes is the responsible factor for, say, shortness, then one can cut it out and replace it by another gene that is a factor for tallness. Then on, the generations that follow, will have this factor for tallness. In a similar manner, other traits for color, shape or mental power can be improved by genetic manipulation.

As a result, genetic engineering is now opening frontiers in different fields. Suddenly conventional ways of improving stocks are becoming out-dated. One used to crossbreed animals and plants to improve their quality. Strong bulls or race horses used to be selected for breeding purposes. This method has worked all right, but it was not foolproof. There was always an element of chance in it.

Now, precision work is becoming the order of the day. Once the gene for the trait of speed has been determined, one just removes it and replaces the required gene for better speed. This is only a matter of engineering. Then the living cell will be allowed to develop and grow, and presto! We have

a super-racing horse.

In this manner, Japan and India have achieved improved types of rice and wheat. Experiments have been conducted in Europe too; pigs, sheep, goats and chicken have produced better quality offspring.

This suggests that developing countries can increase their crop-yield using this technology. For example, the traditional food crop for Ethiopia is Teff. This crop has such a short stalk that it has not been possible to use modern harvesters to reap the crop (as for barley and wheat). The grain also tastes sour when fermented and baked so that stomach-aches and ulcer, common afflictions in the highlands, are ascribed to the bread of Teff. These situations could now be improved to make healthy and nourishing crops for the people living in this area.

To date major advances have been registered in several other countries. Scientists have been able to isolate useful genes and synthesize them. These are then built into another organism, say bacterium, which then start to produce the required item. For example, we are already producing medicine useful for human beings. Insulin has already been produced in this manner. Enzymes and different kinds of proteins essential for human beings have also been produced.

In farming and animal husbandry, plants and domestic animals can be bred, which are resistant to pests and diseases. This avoids the need to use insecticides and herbicides, which have their own side- effects. Such treatment for coffee, cotton and tea will be a highly welcome

benefit. Advanced countries are working on an even higher level than this.

Considering the research, in which Watson was engaged since his Nobel award, we see that he started to determine the role of each gene in the organism. We have seen that DNA is a chain of genes slung together in a row, and these genes determine the traits of the individual.

Sometimes a single gene determines the trait, say for height. But sometimes it takes a number of genes to define a trait like intelligence etc. Yet again, a gene may be responsible for more than one trait. Now all this has to be sorted out and tabulated. The difference in the structure of each gene (the number and arrangements of the base pairs of the segment) has to be determined. Well, this is not an easy task. The relatively long strand of DNA itself is not visible to the eye or easily detected by microscope. The engineering task of cutting, splicing, and analyzing the gene is thus no easy job. That is why one country alone cannot provide enough qualified manpower to deal with the hundred thousand genes present in the cell. On top of that, the cost estimate for such a project (known as Human Genome Project) runs into billions of dollars. That is why Watson has been trying to finance and carry out the project with the help and participation of Japan, Britain, France, Germany and other countries. Although Watson has now resigned for other reasons; the project is in progress and is estimated to be completed in 10 years or so.

Once that has been accomplished, it may be possible for us to build life itself ! DNA, as we know, is made up of a pair of sugar & phosphate

molecules with two pairs of chemicals forming the rungs of the ladder. These molecules are now known and can be synthesized. So if they are connected properly, it means that DNA is constructed. Now DNA can replicate itself. DNA is also responsible for engendering proteins and these are the ones essential for life.

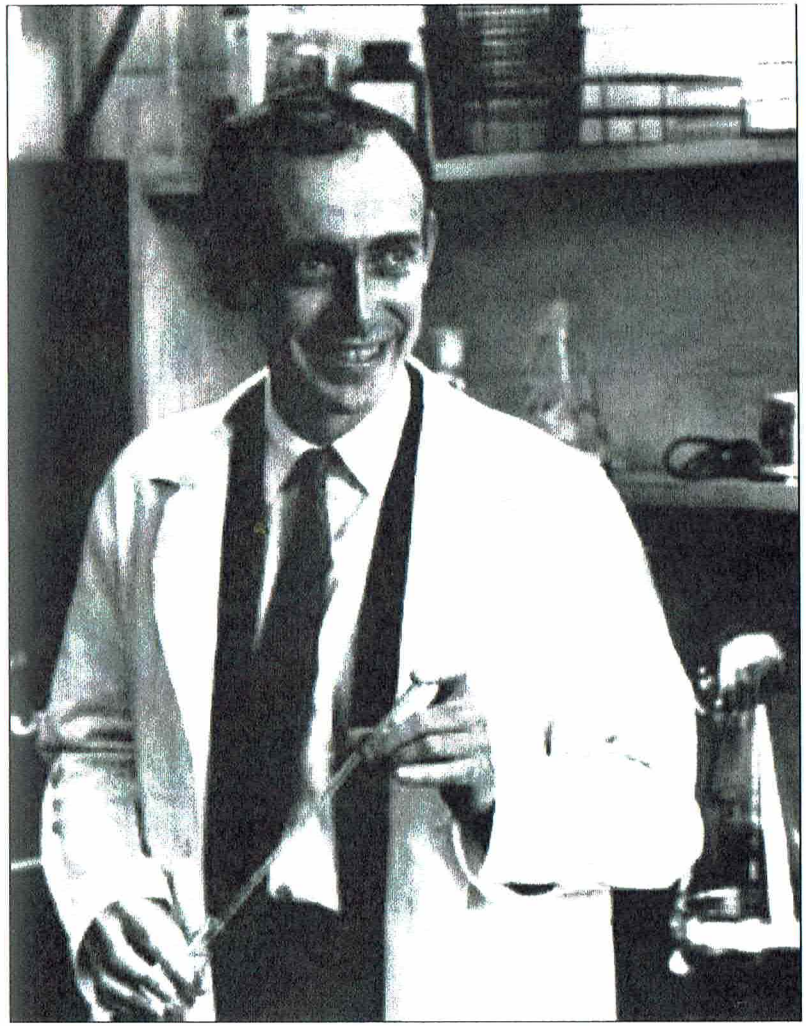
True, there are thousands of protein types. Each type is responsible for a certain activity and we need several types even for just seeing, smelling or tasting functions. However, all of these types are made up of amino acids and there are only twenty-four of them – these combine in different arrangements to form the proteins required. (Note that only twenty-six alphabet letters are required to make sentences that make books and encyclopaedias.)

These amino acids are built under the instruction of DNA. This instruction is coded in the combination of the base – pairs of the four molecules (adenine etc.). A gene, we have seen, consists of three of more segments (or rungs of ladder). Each rung (or row) has four different possibilities of building from the four available base molecules. Three rungs therefore have 4x4x4=64 different possible arrangements together. Four or five segments have correspondingly more choices. So a gene can be coded or arranged to produce any of the amino acids, hence proteins.

It follows that since organisms are composed of different types of proteins, which in turn can be built by the DNA; it is possible to construct the required set of DNA to start the process of life *in the laboratory*. Architects design a building in

every minute detail of it and put up the picture long before the excavation work is started. In the same manner, one may design the sort of creature wanted and then go about building the DNA to manufacture it.

Where this technology will lead us to is not yet certain, but, sure enough, it raises many grave ethical issues.



James Watson

Chapter 12



Aklilu Lemma

1933-1997

Observation versus seeing

The riddle that gnaws at the heart of every honest citizen is why backward countries remained backward. A few hundred years back, all countries were more or less at the same level of development. Going back in time to the period before Christ, the Middle East appeared the center of civilization. Queen Sheba is mentioned in the Bible and admired in Ethiopian history for her travels to Jerusalem to witness the progress achieved by King Solomon and his people.

Later in time and up to the eve of the Industrial Revolution, it was China (where Marco Polo went) and the other Far East countries that led the way to civilization. In those days, the continent of Europe was in the "Dark Ages". America was not even discovered by Columbus.

In short, revolutionary changes started only recently. All the technological wizardry that we witness today is the product of the last few hundred years. It used to surprise me when I met famous scientists, whose works and discoveries I had learnt in school, attending conferences. I had thought that such people would not still be alive. I see from biographies that many of the prominent scientists in history were still alive after I was born. So I get the feeling that discoveries were a recent phenomenon.

Why was it that the African continent was left so far behind in civilization? If civilization is such a recent phenomenon, why were we still dozing when others woke up and ran?

Various explanations can be proposed. I think

the major reasons are the physical features and the climatic conditions of the continent. It is a rugged mountainous region deeply dissected by gorges and valleys resulting in isolate areas where people cannot meet and mix freely. If people do not come together, they cannot learn from each other and there is no stimulation for improvement. There is no trade and there is no progress.

Tropical diseases are another factor. These sap the energy – both physical and mental – of the inhabitants and make animal husbandry very difficult. Tsetse flies, for example, cover almost half the continent and afflict both humans and animals. Malaria is another tropical disease that still plays havoc with people. The remedy for it was to spray DDT in every house of every village in an attempt to break the development cycle by wiping out the parasite. But now that DDT has been discovered to have undesirable side-effects and since the mosquito has developed resistance to it, the campaign, which already cost the continent hundreds of millions of dollars, is in limbo.

Bilharziasis or schistosomiasis is another debilitating disease for which a cure was not available until recently. The parasites responsible for this disease harbour in the liver, pancreas, spleen and intestines of human beings, and upon breeding in millions, impede the normal functions of the organs thereby causing pain and even death to the victim.

These are some of the factors, which scourged millions of Africans over the centuries. It took a long time to bring the problem under control,

partly because these tropical diseases are unknown in the temperate zones of Europe and therefore, did not interest the scientists. Besides, there has always been the problem of funding such research by governments whose first allegiance is naturally to their respective countries. We are reminded of Darwin having suffered for forty years, because the disease was totally unknown in Britain then.

But eventually, when the "Scramble for Africa" began, the extent of the problem in Africa was recognized. In fact, "White settlement" was impeded for several years due to the lack of protection against these parasites. The fact that the African race was able to survive at all is a major achievement in itself. However, it remains a fact, the features and environs are major factors, which hinder progress.

A situation of one such scourge occurred in a region called Adwa in Ethiopia in 1964. The Ministry of Health in Addis Ababa received a report of the tragedy in the area and a request was thus submitted to the national university to send qualified staff to investigate the case. The university assigned a team of biologists with Aklilu Lemma as the team leader to tour the region and to report on its findings.

Dr. Aklilu Lemma was a fresh graduate who had just completed his doctorate works in pathobiology and had joined the biology faculty of the university. He was born in Jijiga (then a part of Harar province) on September 18, 1933. He attended elementary school in Harar and completed his secondary education in General Wingate School in Addis Ababa. He pursued his

college studies in Addis Ababa University and graduated in 1955. He then went on to John Hopkins University in the United States where he earned his D.Sc. in 1964. He was employed as a lecturer at Addis Ababa University when he received his assignment to Adwa.

Aklilu was surveying the afflicted area when he came across a small pool of water where villagers were washing clothes. In those areas, as in other remote areas, it was hard to find soap so people were using Endod for washing clothes. The word Endod is a vernacular name given to what is known in scientific jargon as phytolacca dodecandra. It is a tree that produces small-size berries, which can be collected, dried, powdered and mixed with water to produce a foaming detergent. Thus, it has similar effects as soap when used for washing clothes.

Aklilu was passing by the pool when he paused for a while and noticed some dead snails floating in the stream where the villagers were washing. Walking up the stream, he observed some other snails in the water, but these were alive. This observation marked the beginning of what was to result in a fruitful research and international recognition for Aklilu. He wondered what must have caused the death of the snails down stream – in the pool. He asked for some suds from the washers and put some of the live snails in it. In a few minutes, they let off small air bubbles, then bled and shrivelled to death. So Endod was the cause of their death. Therefore, Endod can serve as a Molluscicidal agent to control Bilharziasis, since the disease is transmitted by small parasites, which use snails

as their host for breeding. Now then, if snails could be killed readily by Endod, the disease can easily come under control. This is of benefit not only for Adwa or even Ethiopia, but for most other developing countries as well.

But does Endod attack only snails? Or does it adversely affect other marine creatures too? If it kills other water-born creatures, then its utility is very restricted. Hence, it became necessary to determine just how little is enough to kill the snails without affecting the other creatures. This is where Aklilu's research began. But very soon, it started to diversify.

Senior students from the Biology Department were mobilized to collect snails from ponds and lakes around the city. Then Endod mixed in water at various concentrations was laid out in glass beakers and the snails placed inside. After 24 hours, they were removed, washed in fresh water, given a recovery period of another 24 hours and the number of dead snails was then counted. This gave a promising result. Further experiments on the effects of temperature, light, storage, age of snail etc., on the Molluscicidal activity of Endod were conducted. Field trials around irrigation canals and lake shores were carried out. After that, Aklilu launched the program by announcing the pursuit of his laboratory research and field-observations through seminars and symposia to local and international interest groups. The response was immediate and the interest was high.

Aklilu expanded the work. He established an institution and diversified the activity. To begin to understand the phenomena, snail breeding was

started up, the cause of death brought on by Endod was investigated and which component of the Endod was the active ingredient was also studied. For example, the berry, bark, stem, leaves and roots of the Endod plant were all analyzed. Cultivation of Endod, extraction of the active component, preparation of detergents from Endod and other side-effects, if any, were all surveyed.

The actual mechanism of infection causing the sickness and the need to fight the snails in order to interrupt the life cycle of the parasite became clear. The parasites responsible for human infection are the larvae (cercariae) that are released from the snail into the water. These enter the body through the skin of the legs, hands or body as people wade in the water. They then enter the blood circulatory system and find their way to the liver, intestine or bladder. There they grow to become adult worms and mate. Thousands of eggs are produced, half of which find their way out through urine and faeces into water. The larvae upon hatching swim around looking for snails to enter and continue the cycle.

To break this cycle of development, the measure taken in the past was aimed at treating all infected people to rid them of the disease. But this had not been possible. One reason for this is that the victims are, for the most part, people of Developing Countries who do not have the necessary toilet facilities in the fields. Another reason that could be cited may be the high cost of synthetic chemicals that need to be imported. Spraying these chemicals in the rivers, ponds and lakes of a wide region is very costly.

This is the reason why Aklilu's announcement of the Molluscicidal effect of Endod was received with enthusiasm and high hopes. On the strength of this encouragement, Aklilu established the Pathobiology Institute under the umbrella of the University of Addis Ababa. He sought for funds and obtained some from foreign donors. He proposed to enlarge the activities to include other related tropical diseases, which tended to be ignored by scientists in temperate climates. Leishmaniasis was one of these diseases that were transmitted by mice and moles. It attacked the skin and invaded the tissues causing pain. The diagnosis was elusive in local hospitals and the treatment was not easy. Field studies were conducted and surveys made in the country.

Trypanosomiasis was another problem. This disease attacked cattle in their thousands and is transmitted by blood-sucking insects. The people, whose mainstay in the rural areas is cattle, are economically affected when their scraggy cattle become unable to provide traction or milk, and even die. Again, research and field surveys were undertaken. Samples were collected and the distribution of the disease in the country was mapped. Other branches of research on flies and insects that act as vectors for diseases were also investigated. At this point, scientists in other countries interested in one or other of these activities came to join the research. Some brought along their own equipments and funds; others sought international sponsors to support them, but all were provided with laboratory space and manpower to train.

The Pathobiology Institute soon gathered

strength and flourished. The facilities were expanding and up-to-date. One of the more conspicuous instruments at the time was a nuclear energy source given as a grant. It was a cobalt-60 gamma radiation source that was housed in a separate little block away from the laboratories.

The source emitted powerful radiation. Now this radiation is of the nature of x-rays and can penetrate even deeper into tissues and other objects. It can thus easily cause damage to life, but if used in a controlled environment, can help sterilize or weaken micro-organisms.

Louis Pasteur had already shown that some micro-organisms, if sufficiently weakened and then injected into the body, can stimulate the body to produce antigens that will thereafter defend the body against further infection – which is the principle of vaccination. While using this powerful radiation in a controlled environment, it was attempted to irradiate the germs suitably and inject them into cattle, sheep and dogs to investigate the effect. Seed crops and fruits were also exposed in samples to see if new mutations could occur.

This burst of activity in radiation works demanded protection measures for the workers. Marie curie, and Rosalind Franklin, we have seen, lost their lives due to high exposure to radiation. Hence, there was the need to establish a radiation protection service. But it became at once clear that x-ray technicians in hospitals around the country needed the service as well. X-rays were used for diagnosis (e.g. bone fracture) for therapy (e.g. Cancer) and for radiography in industries

and workshops. All the workers engaged in these fields had to be included in the service planned.

A radium source was secured from abroad. With this as a standard source of radiation for calibration purposes, film badges were used to monitor exposure. Thus, a new laboratory for radiation protection was established in 1975 and it extended its services to all x-ray technicians in the country.

This is one illustration of how one concern leads to another, and activities grow and expand in many directions. What initially started as a study of the effects of Endod on snails grew into an institute whose activities branched out into several new but related research and development activities.

Development is dynamic in the sense that once started and handled properly it can awaken and stimulate related activities thus diversifying and multiplying itself at an increasing pace. The Pathobiology Institute became the center for information dissemination on these diseases, a training ground for research students while providing services to other people wanting to use, say the radiation source, for their own researches.

As regards Endod itself, research is still going on both at the national and international levels. So far, sixty-seven brands or types of Endod have been identified in Ethiopia alone. Of these types, number 44 is said to be highly resistant to pests, easily cultivable in different regions and with a high yield of berries to the tree. Several countries, Kenya, Tanzania, Zambia, Brazil and the Philippines among them, have now received samples of this variety for cultivation and for

continued research.

There are indications that Endod has other uses besides killing snails. Obviously, it is used as a substitute for soap to wash clothing. This has been in practice in Ethiopia for generations past. Aklilu had intended to combine these two benefits. Instead of preparing Endod as a Molluscicide and going around to spray it over lakes and ponds, he suggested to prepare it in the form of soap, so that people can buy it and go about using it in rivers and ponds thereby serving the double purpose of washing as well as killing the infectious snails. This practice will reduce costs enormously and ensure continued application even in remote areas.

One should mention that Endod could as well kill fish and leeches. People used to apply Endod to rivers and ponds to float out the fish en mass. This makes fishing easier than hooking fish one by one. But this adverse effect of Endod on aquatic creatures can be avoided by careful application. Snails stay near the banks of running water and in shallow areas of ponds, whereas fish swim in running water and deeper parts of the water, so that application of Endod intended for snails may not cause serious harm to fish and the like.

Further uses of Endod might include abortion, dandruff, malaria eradication and lightweight cement blocks (due to its foaming effect). Other possible uses have been indicated in other countries. Researchers in the United States, Canada, Denmark, Finland, and Japan have been looking into these possibilities. International organizations like UNIDO, UNICEF, and WHO,

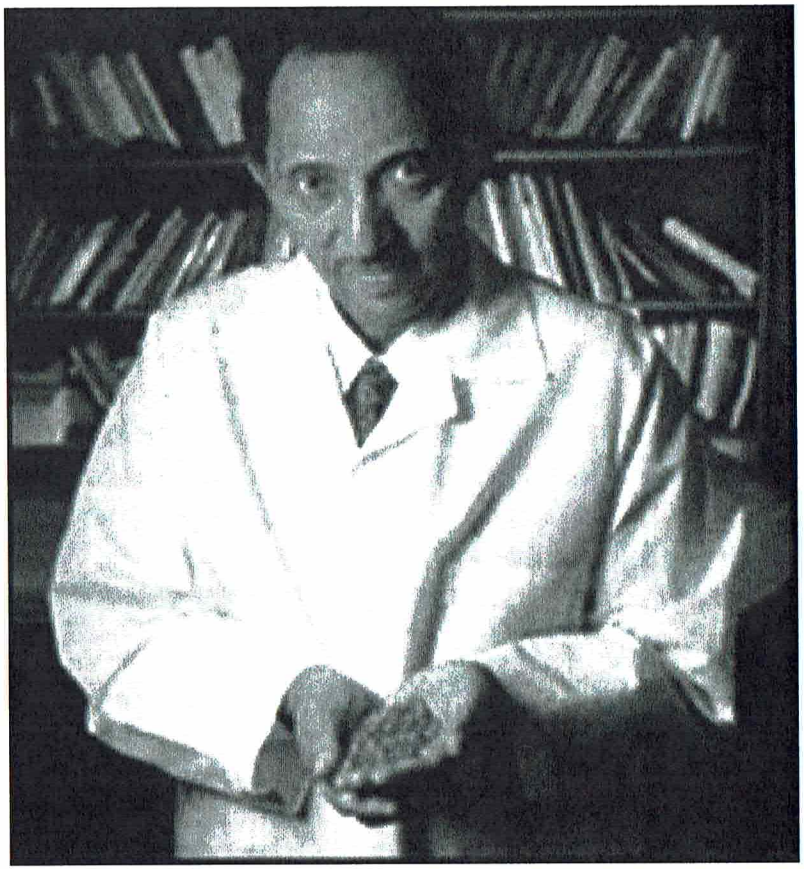
have also shown interest in the hope that these findings may address some of the problems of Developing Countries.

Dr. Legesse Woldeyohannes is now leading the Endod project in Ethiopia. He replaces the late Dr Aklilu Lemma with whom he had been cooperating for several years. In fact, it was Legesse who identified Endod variety No 44 and introduced it to the world. He is currently heading the Ethiopian Endod Foundation and coordinating other related activities.

As a result of their joint effort to pioneer the Endod project to help alleviate the poor man's problems, the two have been jointly awarded in 1989 the Right Livelihood Award prize. This recognition by such organization was very gratifying to them and indeed helped in further promoting the research effort. The 3rd international workshop on Endod was held in Addis Ababa in 1990 and it hosted about 40 eminent scientists from 12 different countries. This is evidence of the fact that Endod is winning worldwide attention and recognition.

This, of course, is a source of joy to us. But Endod cannot be the only plant worthy of further investigation. There are several different kinds of plants growing everywhere. In Ethiopia, for example, there are 7000 kinds of plants as reported by scientists. Of these plants, about 1500 of them are endemic to Ethiopia. Perhaps some, if not many, of these plants can provide a cure for some of our afflictions. Perhaps still, some may hold the key even to the losing battle we are waging against the ravaging diseases of the world. This of course is for scientists to

explore and investigate. Scientists of Developing Countries have the duty to face up to this challenge and contribute their mite for the well-being of their people.



Aklilu Lemma with grains of Endod

Corollary
Bilharziasis and Endod

Bilharziasis (or schistosomiasis) is a disease, which is caused by a worm called schistosoma that infects the liver, intestine or bladder to cause swelling and pain. It is spread by infected people contaminating the water with the eggs of the worm in their urine and faeces. The eggs, once in the water, hatch and release larvae (miracidia); these then swim about in search of snails, and upon finding one, enter the body and continue their development. After a couple of weeks, hundreds of Larvae (cercariae) are released daily from a snail, and these swim about looking for human beings. As peasants wade about washing, drinking, bathing, or irrigating the fields, these cercariae dig their way through the skin, enter the body, and settle in the liver, intestine or bladder. Here they complete their development and in turn, produce eggs in their thousands. Half of the eggs may then be evacuated through the urine or faeces while the rest remain in the body to cause pain and weakness.

Depending on the type of Bilharziasis (urinary or intestinal) they cause damage to the bladder and kidneys (thus causing blood-release into the urine) or they cause swelling of the liver and spleen, which results in fever and diarrhoea. The stools may also be stained with blood.

Therefore, to break the lifecycle of the worm, the one easy way is to eradicate the snails. Now this can be achieved by applying Endod to the waters. So cultivating Endod on a large scale and

spraying the waters with it appropriately, (thereby killing the snails) will rid the people of the disease.

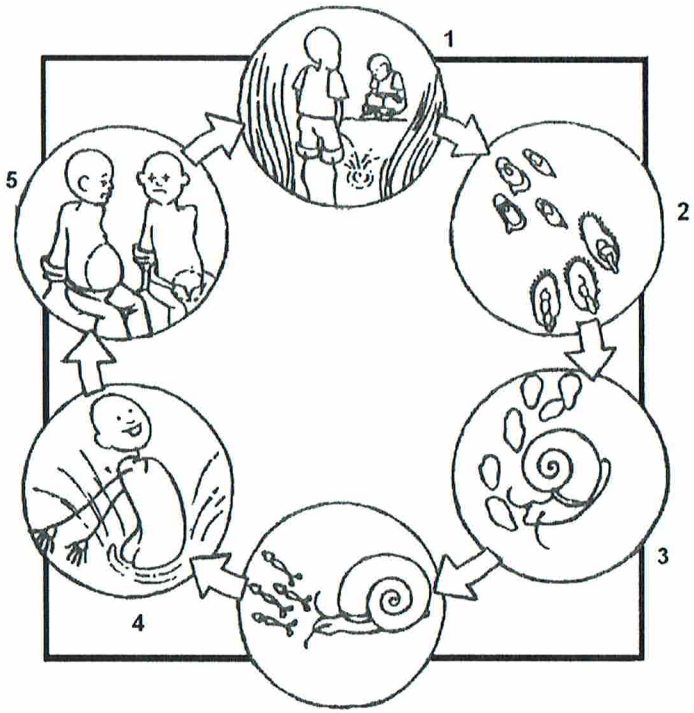
Cultivation of Endod is now a well-established procedure. There are male and female types of Endod – the male produces only flowers. It is the female that grows the berries. So to cultivate the plant, branches are cut from the female tree and stuck obliquely into the ground. The cuttings may be about 30 centimetres long and with two or three nodes each. When the plant grows and produces fruit, the berries are collected green (i.e. before they mature to redness) and then dried (to prevent rot or loss of potency). This is then powdered, dissolved in water and sprayed on rivers etc. If used as soap for washing purposes it obviously yields double benefit.

The amount of Endod required to kill almost all snails in the stationery body of water is sixteen grams per one cubic meter of water. For running water, it is recommended to be up to twenty grams per cubic meter. Working out the measures all in volumes turns out to be one litre of Endod powder in thirty-eight cubic meters of water.

Application of Endod to a large body of water (e.g. lake) requires attention. It will not be necessary to spray the whole surface area. Instead, it is enough to limit the spray to the banks where aquatic vegetation shelters the snails and where people come in contact with water. Three meters around the lake or pond is a good rule-of-thumb to spray Endod powders. The frequency of application may be once every three months (to catch newly – hatched eggs that may have been left behind after the snails were

eliminated). To maximize effectiveness, spraying should be done in summer or dry season when snail populations are concentrated in reduced water volumes

Bilharziasis is a disease widely spread mostly in East, West, and Central Africa and also in Brazil, and in South East Asian countries.



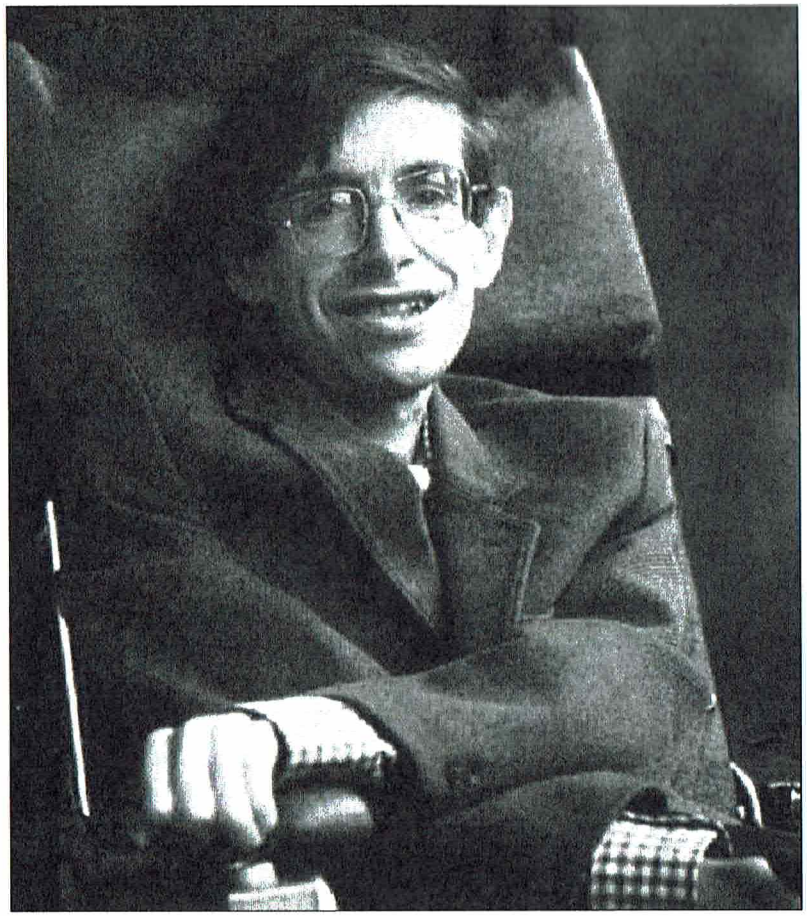
Bilharzias Lifecycle

Legend:

1. When an infected person relieves into the water
2. the eggs hatch and
3. enter the snail
4. the cercariae finds a host
5. multiply in the intestine and bladder

...the cycle continues.

Chapter 13



Stephen Hawking

1942-

How may it all have come about?

"I think computer viruses should count as life. I think it says something about human nature that the only form of life we have created so far is purely destructive. We've created life in our own image."

It is a long time now since Stephen Hawking has been expected to die. A year after graduation from Oxford University, Hawking fell victim to an illness. The year was 1962. The doctors were puzzled at first, but soon learned that this was a fatal disease and Hawking had no more than two years to live.

Hawking's condition soon began to deteriorate. He felt a loss of dexterity and paralysis that made it difficult for him to lace his shoes and later even to talk. Gradually he began to lose control of his voluntary muscles.

Then he reached the stage where he could no longer walk. He became confined to the wheel-chair. Then he lost his speech; he could no longer talk. Thus, he had to suspend his studies for the PHD degree. Broken-hearted by his son's misfortune, Hawking's father approached the teacher to help him get the degree before his death. The teacher, sympathetic though he was to the boy, declined the request. Hawking was very depressed when he learnt of his eminent death. He spent the next two years listening to classical music and reading science fiction books. Occasionally he drank to help himself forget his fate.

Finally, all body movement ceased. He could

move none of his limbs. This is a motor neuron disease. There are two types of muscles in our body: The voluntary and involuntary muscles. The voluntary muscles are those we use to move our body parts (hands, feet, neck, etc.) at will. The involuntary muscles control heartbeat, brain activity and all those others over which we do not have voluntary control. Hawking's disease was the type that paralyses the nerves controlling the voluntary muscles.

Hawking finally lost control of all his voluntary muscles. He could not move any of his body parts. But strangely enough, his condition started to stabilize at this point. Death itself was no longer imminent. His spirits rose again. Today Hawking is still alive. True, he needs close attention from helpers. He will remain helpless, for instance, if his head dropped onto his shoulders or forward, he needs someone to raise it back to the head support of the armchair.

But what does this man do for a living now? He is a professor in Cambridge University. He is a physics teacher and a researcher in theoretical physics. He is regarded by some as the foremost scientist alive today.

Einstein had been grappling for the last thirty years of his life trying to formulate the grand unification theory that encompassed all the forces of nature i.e. gravity, electro-magnetic forces, and Strong-and Weak-nuclear forces. He did not succeed and the struggle continued after him. Scientists armed with the most powerful computers at hand are still labouring at the task. It is now over forty years of ceaseless work to solve the problem and no one has succeeded yet.

It is the conviction of many scientists that it will have to be Hawking who can 'crack the nut' at last.

Hawking's brainpower is stupendous. He can work out several pages of complicated equations without the need of paper. His power of memory too, is immense. He is known to have remembered even the page number of a minor mistake in an equation he read in a book some years ago. Other examples of his feat in remembering past events could be quoted. This talent is perhaps unique among present day scientists.

Now, what exactly is the riddle that is bothering Hawking? The question put simply reads, "How is the universe created?" [9] Of course, religion can provide an answer to that but Hawking wants tangible facts, which can be understood clearly, tested experimentally and thus scientifically proven to be acceptable.

Asking this question did not start with Hawking. Scientists have been asking it and attempting to find answers to it even from the days of Einstein. To grasp the essence of the question, we may go a few steps back and review the background information. To begin with, what is the universe?

We know from the elementary schools that our earth is a planet that revolves around the sun. There are eight other planets too that revolve the same way. The sun itself, though it looks big, is quite an ordinary star that appears big only due to its closeness to us. There are 400 thousand-

[9] (2)

million other stars in our neighbourhood. These are collectively known as the Milky Way. This is a galaxy, and there are other 125 thousand-million galaxies in Space! This is only as far as we could see today, and there could well be more of them beyond our vision. The totality of these stars including the space and gas in between forms the universe.

All of these stars are in motion. They move at different speeds but they all move in such a manner that they appear to have started out from a certain central point. The scientists of today believe that some fifteen thousand million years ago, a Big Bang occurred and matter and energy whirled out throughout the universe. Apparently, the effect of this gigantic explosion still affects the stars and galaxies flying out in all directions today.

So going back in time and asking ourselves "where were we a million years ago?" 10 million years ago?' etc., we work out the equations defining the situation then.

This work made a significant headway during Einstein's period. Einstein, having introduced the subject of Relativity, turned his attention to this task. He was convinced that the laws of nature in their totality can, and should be, expressible in the form of an all-encompassing equation or set of equations. We know for instance, that if a car is traveling at a fixed speed along a road, we can calculate its position an hour ahead. If a stone is thrown vertically up at a known speed, we can determine how far it can climb and when it will fall back to strike the ground. In almost the same manner, we should be able to calculate from the

known speeds of stars flying out from the center of the Big Bang, where they would be after a given period of time. We could also determine where they were and how hot they were in the thousands of years past.

Einstein had put some equations in place, which went a long way to define the state of the universe. There are, of course, some difficulties in defining the equations precisely. One of them is that the law that governed and defined the universe then is not the type that we are experiencing today. Today the dominating force governing the stars is gravity. It is gravity that spins the earth round the sun, that propels the sun and the other stars in our galaxy in their own orbits, and finally, even the whole galaxy together with other galaxies in their respective directions. We are held to earth by gravity and our satellites revolve around due to gravity.

But going back in time, we learn that it was not gravity but the so called 'weak-nuclear force' that played the major role during the time when matter was close together and the temperature was very high (this is the force that governs radio-activity for instance). Before that period, the electromagnetic force played the dominant role. It still spins the electrons around the atom and is the cause for light waves and radio waves so useful to us now.

The strong force, which was called into play in the early seconds of the birth of the universe, is the strongest force. It still holds the protons and neutrons of the atom together. Incidentally, had one or another of these forces not existed, the stars would not have formed, the sun and planets

would not have been the way they are, and, we would not have been here!

Scientists generally accept that initially all of these forces, being inherent to matter, were all combined and united into one force at the birth of the universe. It is that single all-embracing force, which is required to be understood. In other words, the aim is to unify the four known forces into a single mathematical representation. This is the problem. It is the issue that has engaged Hawking's mighty brainpower to this day. The Grand Unified Theory! What would result from solving this equation? Would it reveal the fundamental nature of the universe? Hawking's hope is the "complete understanding of the universe; why it is as it is and why it exists at all".

If the search leads to that revelation, it will be very gratifying. It is true that there are many yet unsolved problems in life. For example, we do not even know the mechanism of thought, i.e. we do not know how we think. So we may not be sure if the problem at hand, when solved, will settle all our questions. Of course, past experience shows that when a scientific problem is solved, many other related phenomena become clear. Even, apparently unrelated ones come into focus and get explanation from such unsuspected sources.

At any rate, the riddle is there to be solved, and although we cannot foretell which riddles will be then clarified – we are all anxious to get to the end of this matter.

But what is the theory of the history of the universe today? We may review it shortly as follows:-

Mendeleyev's Periodic Table has shown that

there are 92 elements and perhaps more in the universe. All these must have emerged from fusion of the basic element hydrogen. Even today, three-quarters of visible matter is constituted of this gas. It was perhaps about 13 thousand million years ago that these elements began to be formed by the fusion of the hydrogen atoms under heavy pressure and temperature. Quasars, now mostly seen on the edge of the universe, are believed to have been formed then. That period is about a thousand-million years from the Big Bang (creation of the universe).

Hydrogen atoms took their present shape about 500,000 years after the Big Bang. The fast electrons must have cooled down enough to fall into orbit of the atom.

Tracing our steps back in time, we reach within three minutes of the beginning. It was at this point that protons and neutrons united to form the bare atom. This scenario can be recreated in the laboratory using accelerators, so that scientists are fairly confident of the validity of their equations.

We are now getting closer to the beginning. At about 10^{-2} second, the universe was so hot – about $2x10^{11}$ degrees Celsius – that matter was created and annihilated continuously in energetic collisions. Matter and energy, so close and compact then, was spreading out fast.

At 10^{-10} second, the entire universe was about the size of our solar system. It was at this stage that the four types of forces mentioned above were together for the last time. Modern laboratories equipped with powerful accelerators can, we are told, reproduce this condition exactly.

Gravity, as a force, was separated from the others just before this event point. The other three had separated even earlier in time.

Going a little further back, we reach the point 10^{-43} second after the beginning. This is the critical edge up to which scientists are fairly certain of the validity of their equations. But beyond that point, nobody is yet sure of what went on.

We have seen, in the first chapter of this book, that time and speed of motion are inter-related (i.e. the faster the speed, the slower the time). Now speed itself is length or distance covered per unit time. So time and space are connected. In fact, time and space are so related that one cannot think of one in isolation of the other. This, by the way, supplies the answer to the question that we as children used to ask i.e. "what remains after the end of the universe?" And what was there before Creation?" As we cannot imagine time without space, then if there wasn't space, there wasn't time either, and when space is no longer there, then there is time no more. So the question of "before space was created," or "after the end of space," cannot be asked because time did not exist then. The two appeared together.

Today it is generally accepted that time and space came into existence together. The question remains though how they started at all. There is no answer as yet. Scientists are racking their brains to crack the mystery, and everybody else is curious to know the answer. There is no success so far.

Hawking has taken on the challenge and with

his head reclined on his wheel chair, he is wrestling with the problem as the other scientists around him wait patiently and hope that he may bring them the answer.

True, the body of knowledge accumulated so far is immense. We know exactly what was going on when the universe was a million years old. We can reconstruct the conditions when it was a hundred years old or even less-say a year or alas, even a week. Theoretical physics has taken us back to the time when the universe was one second old and even fractions of it!

But even a fraction of a second is a time counted after the creation of the universe. What is required is to know how it was created first (i.e. at zero time).

Whether this is possible or not, is not yet known. So far, science has not been able to provide the answer. It is here, naturally, that philosophy and religion are sought to supply the answer. When people fail to explain away certain phenomena, they do not rest until they have found some explanation and so they tend to resort to religion. We always had explanation, say for lightning, even if science had not come up with its explanation of electric discharge.

The creation of the Universe (i.e. at zero time) still seeks explanation from religion. To recap the teachings of the Bible, God created the Heavens and the Earth. That was the beginning. Other creatures came on stage later in time. Science tells the same story. The universe was created. Then followed everything else. Of course, not all this process of creation and development took place in just eight thousand years. It has taken

thousands of millions of years to evolve to this present stage. But this is a matter of reckoning the time lapse and this is not a grave contradiction.

On the other hand, science itself teaches that entropy goes in one direction. Things tend to disorganize, disintegrate and disperse with the passage of time. People die; and the body disintegrates with the passing of time. Buildings crumble and fall into rubble. Metals rust and wear out, etc. Everything tends towards disintegration. We do not see the reverse happening. Stones do not gather of their own accord to form themselves into a three-storey building nor do small pieces of gears and levers assemble themselves into a watch. This requires an external force to do it. In the same manner, it appears that it requires an external factor to build natural elements to form living organisms like ourselves. It is our existence that gives meaning to the existence of the universe. This is the position adopted by most people nowadays.

Some scientists have opted to go back to studying and exploring the holy books of various religions. Perhaps the secret of life in general, lurks somewhere in the bosom or shadows of some past and forgotten teachings. Perhaps we have over-looked some details somewhere. So we have to look at every nook and cranny, dig up and explore the earth and scan the sky, study sciences, philosophies and religions and do everything else possible in search of the ultimate truth. It is human nature to struggle to know, and this impulse will inevitably surge ahead.

In lieu of Conclusion

Now we have covered some of the aspects of the lives of scientists. We have scanned their childhood experiences, their ordeals and exiles, their financial, political and social problems and finally the effect of their works on society all in the manner the size of this book permits. What remains perhaps is to mention that we need not put all scientists on a pedestal and idolize them but consider them just as ordinary humans as we are. "What does a scientist look like?" asked a teacher of his pupils. His intention was to stimulate the children to aspire to be scientists themselves. The responses he got shocked him. The children replied something as follows;-

"He is an absent-minded person always decanting flasks and beakers."

"He wonders about wearing white overalls."

"He is one with uncombed messy hair and can't see without eye glasses," etc.

The children's concept of a scientist was not encouraging at all.

True, a lot has been said and written about the wisdom and intellect of scientists. But this may tend to make them remote from the rest of us. So let us mention some of their weaknesses to show they are only ordinary humans subject to frailties.

Competition among colleagues is one major force that drives research. "Publish or perish" is a common saying in their circles. Publishing is the key to recognition and in the long shot to the possible chance of winning a Nobel Prize and being placed in the annals of history. Serious

scientists draw their strength from such springs of hope or at least from the desire to contribute their mite to society.

As a result of such intense competitions between colleagues, there is a tendency to cover up one's on-going work until after publication and to shield projects against leaks or theft in the meantime. There have indeed been cases where quarrels have erupted and claims made against theft of one's research findings. A case in point is the claim made by French and American scientists to have discovered the "Aids" disease. The issue was settled by a special committee convened to investigate the matter. Similar conflicts arise between individual scientists quite often.

Some cautious researchers devise their own methods to protect themselves until the time is due. For example, a certain scientist, having discovered a substance that turns into a superconductor at-180^{0}C sent his findings to the publishers and intentionally changed the name of the substance. Only after he was certain that the publication was to be issued, did he go and rectify the 'error'.

But there are others who raised a lot of dust. A fairly recent example is that of Stanley Pons and Martin Fleishman. These scientists jointly announced that they had discovered a method of fusing light elements to release energy for use. Of course, this will be a milestone in human history. The reason is as follows:-

We have known for a long time that our sun pours forth so much energy by the mechanism of fusing light elements and releasing the energy

therein. The element is hydrogen gas. Our scientists too, were able to build the Hydrogen Bomb based on that principle. Yet we were unable to utilize this fusion energy for peaceful purposes because we did not know how to control the process systematically. It was possible to get the elements together to explode, but not to control the explosion to supply a steady flow of electricity. This possible source of energy is so enticing that everybody is anxious to get at it. The reason is that the fuel, hydrogen, is available from water, and water is affordable by every one including Developing Countries. So to unlock this energy is regarded as something similar to 'bringing heaven down to earth.'

So now, when Stanley Pons and company claimed they had made it to this discovery, it was naturally a tremendous achievement. This was a historic achievement, perhaps the best in the century. But then how to protect this secret from theft or false claim until they made it public? Sending it for publication, they feared, would take time and something might go wrong in the meantime. The best and simplest way was to convene a group of newsmen and announce it to them. So they did just that. The news was broadcasted immediately and the world came to learn of it in no time. Aware of the fruits of the discovery, everybody was delighted. Excitement, hope and ambition rose in every corner and every one talked about it. The two scientists, needless to say, became famous overnight. This all took place in March 1989.

But on closer examination later, the finding was not valid. The conclusion they had drawn

from the phenomenon they witnessed was wrong. It was for reasons other than fusion that the energy was released in the process. So the claim, it turned out, was false.

The interesting point is what took place between the time of their announcement and the time of disproof. Various laboratories in different countries claimed to have performed the experiments themselves and confirmed the findings. There was a race to be among the first (if not the first) to perform the experiment and thus to share in the glory. Even Developing Countries like North Korea announced the confirmation of the finding in their laboratories.

Other scientists came up to claim their rights to the discovery. They vowed that it was they who had done the experiment before and were therefore the rightful owners of the benefit. Courts were designated to examine the case, and lawyers were appointed by the litigants.

In the meantime, the State allocated a large sum of money, no less than 4.5 million dollars, to develop the required technology within six months and be able to tap the economic benefits before other countries (like Japan) snatched it and ran away with it. Other States and countries too were known to have taken their own steps, though the amount of money involved was not announced. But one can be sure that the total sum allotted is no small amount.

This shows how fierce the competition is between scientists and laboratories to get ahead and register discoveries. Examples abound in all different branches of science (as is also illustrated in this book) how intense the struggle is to get

results.

Since first-hand experience is a better illustration than reading about it in reports, I should lay down my own experience to show such weaknesses. The urge to announce new things or events is so compulsive as to make one intolerably impatient to withhold, especially during close competitions. I had the good fortune once to work in an astronomical observatory tracking satellites. One night, as I was surveying the skies with a camera, I caught a bright object, which I could not find on the star chart. "Where has this object come from which is not marked on the map?" I asked myself. I had known that comets coming towards the sun from the depths of space suddenly appear visible as they approach us. I had also known that the name assigned to a newly discovered comet would be that of the person who saw it and reported it first. So I took an immediate decision. I decided to report this new finding before others did. I measured its magnitude and position in the sky and dispatched a telex message to headquarters.

Having done that, I sighed in relief and satisfaction. It was pleasure. I needed neither food nor sleep – it was just sheer bliss. But it was later revealed that it was only a planet I had seen. Planets, because of their revolution around the sun, do not appear on star charts as they do not have a fixed place. Now this wandering planet had just crept into view at that unfortunate moment and had misled me. That planet still angers me, but I well understand the situation Stanley Pons and company were in, when they took that measure to announce their findings to

newsmen.

The types of people that do not deserve any apology are those who seek fame using fraudulent methods. I remember a case of a certain biologist based in Australia who became world-famous by his ability to perform experiments that confirmed certain theoretical analyses. Many scientists were grateful for his having confirmed their claims, and he was even proposed for a Nobel Prize. But on closer scrutiny, it was found that he did not get the results from experimental data but merely by "cooking" results, that is, by arranging figures so as to fit the theoretical predictions.

This is a wicked attempt to earn fame or glory by fraudulent methods. This is a disservice to science and a drawback to progress and should be condemned. The person's name is now associated with this treachery, and I am not sure if he likes it the way it has turned out.

But that is science. The virtue of it is that it is not subject to manipulation using fraudulent methods. It is the recognition or study of the laws of nature irrespective of people's wishes and desires. It cannot be taken for granted or accepted by majority wish but has to be able to be subjected to experimental verification by anybody who cares to check. That is why science is able to develop steadily on ever more firm and unshakeable grounds. The evolution of science is also the reason why our way of life is much better today then it was in the days of our ancestors.

Of course, one can argue that science has two faces in the sense that it has both advantages and disadvantages.

On the positive side, one can cite recent

achievements in space science, the satellites that travel in space and explore other heavenly bodies. Nearer at home, the telephones, televisions and other gadgets that amuse and entertain us can be mentioned. Being able to watch and enjoy football championship matches being played thousands of kilometres away on another continent, from the comfort of one's lounges at home is undeniably a major achievement. Health, transport, and industry can draw up a long list of impressive major advances made in science.

On the debit side, one can point out the 'progress' made in the conduct of wars. For example, in ancient times when people quarrelled they beat each other or perhaps even bit each other. Later when bows and arrows arrived, it became possible to attack from afar. This was 'a major advance' of sorts. In due time, the gunpowder arrived. This was a devastating weapon. It is said that soldiers, under order of their commander, fired this terror weapon at their enemies. But then, of course, the smoke belching out filled the air and hampered their vision to the extent that the soldiers could not see even their commander or indeed even each other. So the battle stopped until the wind 'benevolently' swept away the smoke.

Other inventions followed in the form of poison gas and nuclear bombs. It is now possible to wipe out the entire human race in a world war. This, in its own way, may be termed 'progress'.

To date over 1500 major wars have been fought. There are, of course, thousands of smaller ones that history has not recorded. All these have

been the cause for the ensuing human suffering, blood-baths and horrific deaths. This is the dark side of science, or to put it properly, it is the application of science to the detriment of man.

Looking at the benefits of science, we have mentioned how it helped raise us from the state of savagery to the present age of computers and satellites. How was it possible to achieve all this? Well, it was step by step, patiently but steadily. It is by the untiring effort and selfless devotion of researchers dedicated to their work that all this wealth of knowledge is accumulated.

These individuals called scientists are not of any unique brand. True they are the **Pillars of Creation**, but they did not have a common background nor were they afforded some special privileges. Some among them, like Mendeleyev for instance, were poor orphans; others like Von Braun were born to government ministers. There were bright and not so bright students among them. Louis Pasteur, Stephen Hawking and James Watson were bright from the start. But then there were so-called stupid and vain pupils like Charles Darwin, and even dropouts like Albert Einstein. There are, even if small in number, those lucky ones who stumbled into famous discoveries and thus changed the thinking of the world; some even solved riddles in their dreams. But there are those who by dint of hard work and persistence managed to score results, and these are the majority in number.

It is the sum of all these findings consolidated by engineering that made certain countries advanced, and transformed a couple of them into superpowers.

But the pity is that the benefits of this body of knowledge have not seeped enough into the rest of the world. As a result, the difference in the standard of living between the developed and under-developed countries is sky-high. Of these two groups of countries, one has members who suffer from malnutrition and disease to such an extent that some die of hunger; while the other group has members who, failing in their attempt to control their diet and to keep their over-weight in check, succumb to death. Of course, we are all mortals but to die from lack of food is very sad and tragic.

This situation came about because of the failure to benefit from existing science and technology applications. The problem with Developing Countries is that we have not been able to partake of the advantages of using modern technologies. It is of course a waste of time and effort to try to 'discover the wheel' all over again; instead, it is wise to transfer existing modern technology and use it where appropriate.

Equally important though, is the need to develop one's own science and technology-base and to train work force. It certainly requires trained personnel to be able to use advanced technologies. However, it is not possible to send people abroad to train in all the fields of activity required for the country. It is indispensable that a country should develop the capacity and the infrastructure to train its own work force to guarantee sustained growth.

Therefore, it is vital to strengthen the base of science and technology in all the necessary branches. Science popularization should be

carried out among the masses and especially in the schools. When vocational technical schools as well as advanced development centers can produce enough qualified manpower, this can attract entrepreneurs to the country and also enable to retain their know-how.

Of course, the need for lead scientists should be obvious. To start with, to import appropriate technology (transfer of technology) requires careful analysis by the elites. Again, to plan, device and conduct research to develop local technology requires high calibre professionals. Research findings that led to discoveries in coffee bean quality, in Endod Molluscicidal effects, in false banana nutritional value and in other fields as well were the result of the dedicated work on the part of our scientists. The main concern of scientists in advanced countries today is mostly in the fields of space exploration, atomic energy, computer technology, Defence and other related matters not quite urgently required for Developing Countries. They cannot be expected, of course, to set aside their own interests and to work on ours instead, so it befalls us to fend for ourselves.

Finally, it is essential to provide leadership. People like to have idols to imitate. To lead by force of example, by dedicating oneself to work is thus the way to stimulate people. It will promote participation in the necessary campaign to develop broad scientific culture among the people. Investing in the people is important since ultimately, it is the citizens of the country that are the wealth of the nation, and it rests on their shoulders to solve their own problems.

There is a saying that 'two heads are better

than one'. Three, four or more are, by deduction, still better than one. That is true, of course. But then leadership is important too; and this is embodied in individuals. Discoveries emerge from individual heads. Even organizations are headed by individuals. This is not to undermine teamwork, yet it is equally true that individuals make up the team and that wise leadership is essential. This all goes to show that we have to look for talent in youngsters, then cultivate and nurture them and then be able to benefit from their good leadership even in science.

We have seen enough examples in this book of how it is individuals, possessed of strong will, perseverance and tolerance in the face of misery, who were finally crowned with success and reached the pinnacles of fame.

To recapitulate a few cases:-

Marie Curie became a double Nobel Laureate by working her way through colleges, studying day and night, some times putting her feet in ice-cold water in order to overcome sleep. She had even fainted of hunger.

Louis Pasteur too, left behind the comforts of his home and stayed out in the farms for three years studying the disease that killed the silk worms. We know he did manage to solve the problem. That is what is meant by dedication to work.

Even today, there are scientists who work tirelessly from dusk to dawn. Some I know work straight up to eight or nine o'clock in the evening. All this is mostly to contribute their knowledge for the good of society.

Coming back to our own situation, there is

indeed a lot to be desired from our scientists.

Questions beg to be asked: - How to transfer appropriate foreign technologies into the country? How to adapt them for local use? What relevant issues appear in publications and technical documents that could be used in our situation? Etc.

It is now possible to surf the Internet. It is possible to contact professionals almost anywhere to help solve problems and to get useful suggestions. These could be substantiated by carefully designed research. There is simply ample opportunity for scientists to contribute to this society of ours.

People in authority may be expected to help them by putting in place the right policies to facilitate transfer of technology, to train manpower to promulgate appropriate laws and regulations to reward technological renovations, all to enhance development. Political, cultural or administrative obstacles, if any, could be eliminated. This will promote freedom of thought and action, transparency of management, creativity and fair competition, all of which will clear the air for speedy progress in science and technology as in others.

The precondition for all this is of course a fierce determination and complete dedication to work to the maximum capacity and capability. Nothing less is expected of professionals in science and technology as of any other responsible citizen.

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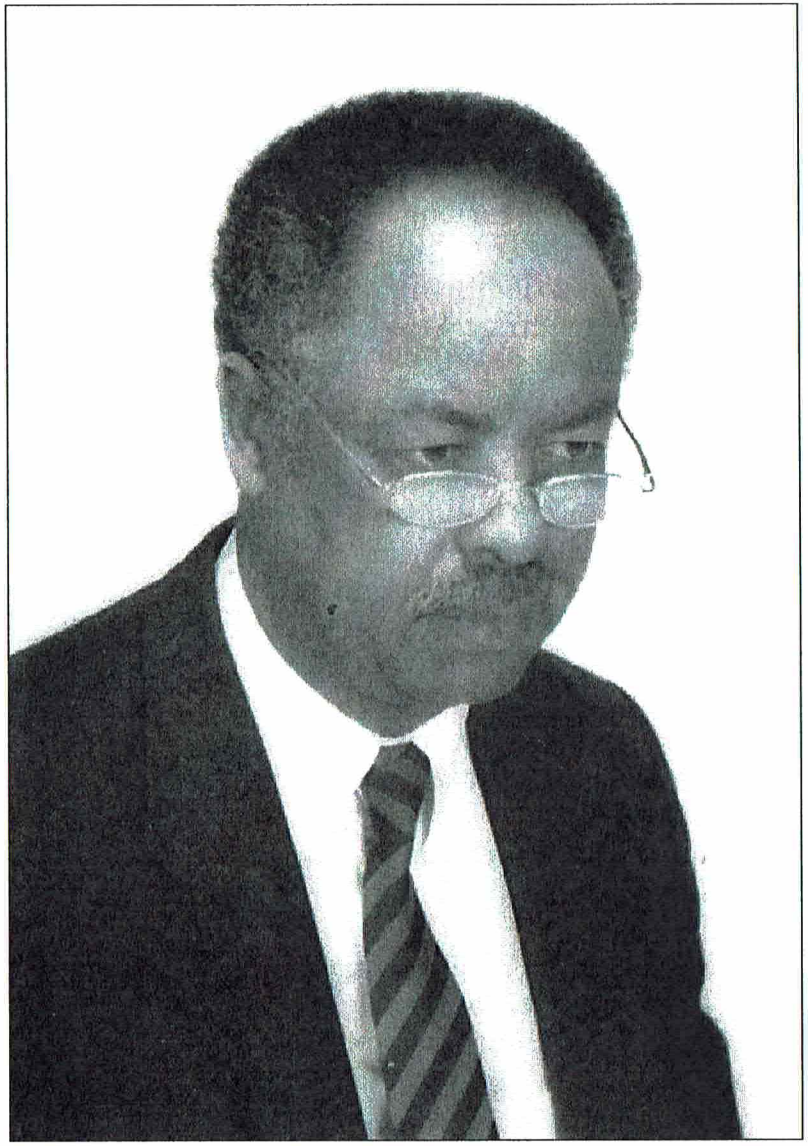
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About the Author



Tafesse Muluneh

Tafesse Muluneh was born in Holeta, Ethiopia to a district lawyer. He attended school, graduated with B.Sc. from Addis Ababa University, Ethiopia (1966), and obtained M.Sc. from University of Surrey, England (1970).

He worked for two years at the Smithsonian astrophysical observing station in Debrezeit Ethiopia (1966-68); and later at Addis Ababa University part lecturing and part running the Radiation Protection Service mostly for hospital X-ray personnel.

He then joined the Ethiopian Standards Institute (later upgraded to Authority) in 1976 and served as General Standards Engineer, Head of Engineering Standards Division, Head of Metrology Department, and finally as General Manager of the Authority until he retired in1996.

He dedicated his life to advancing Science and Technology in Ethiopia. With the firm conviction that progress comes through the application and utilization of modern technology, he worked to disseminate technical knowledge among the populace.

Towards that end, he wrote and published the following books:

HOW IT WORKS – explaining the workings of 15 utility gadgets commonly seen in public bars (coffee machines, refrigerators, clocks, TV, radios, etc.)

NUCLEAR ENERGY – its historical development, the mechanism of producing it, and importantly, the uses and abuses of it all.

THE OTHER WORLDS – a lesson in astronomy and the concept of evolution.

SCIENTISTS – describing the works and discoveries of 13 scientists

In an attempt to fight bigotry and dogmatism and to promote mutual understanding and tolerance in the community, he laid out a comparative analysis of 15 religious denominations in Ethiopia (Orthodox Christianity, Islam, Jehovah's Witnesses, and Catholics, etc.).

Finally, as President of Ethiopian Chess Federation, he wrote and published a chess book that comprised of three parts – for beginners, for regular players and for tournament players – all in an effort to encourage the youth to exercise in deep concentration and analytical thinking.

Of these works, the present book is the one we have in the English version.

Pillars of Creation

Darwin says that we descended from the monkeys.
He looks like a monkey himself; that is why!

Nobel kept tinkering with dynamite; the result--he got his house blown up, his father maimed and his brother killed.
Serves him right. The crank.

Einstein says that with appropriate speed of travel one can slow down time, implying that the father, if he traveled fast enough, will end up younger than his son.
That is Jewish science for you.

Von Braun tried to send a rocket into orbit; but the thing fizzled on the launching pad.
All that money up in smokes. Isn't he German?

Pasteur says to prevent disease, you have to inject the disease into the person.
Oh! The French.

Watson and Crick played with models of molecules and now say that they know the mechanism of cell replication, and hence the secret of life.
Get the English and American to work together, and that is what they come up with. Pooh!

Initial reactions are thus not all positive. But then Science keeps marching on; and as we reap the benefits, our lives get richer, fuller and more enlightened.
This is an interesting compilation of the history of major discoveries chosen from major fields of Science; and the corollary to each chapter updates the status of the ensuing science.
A boon to teachers, students and the public at large.

Tafesse Muluneh.

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