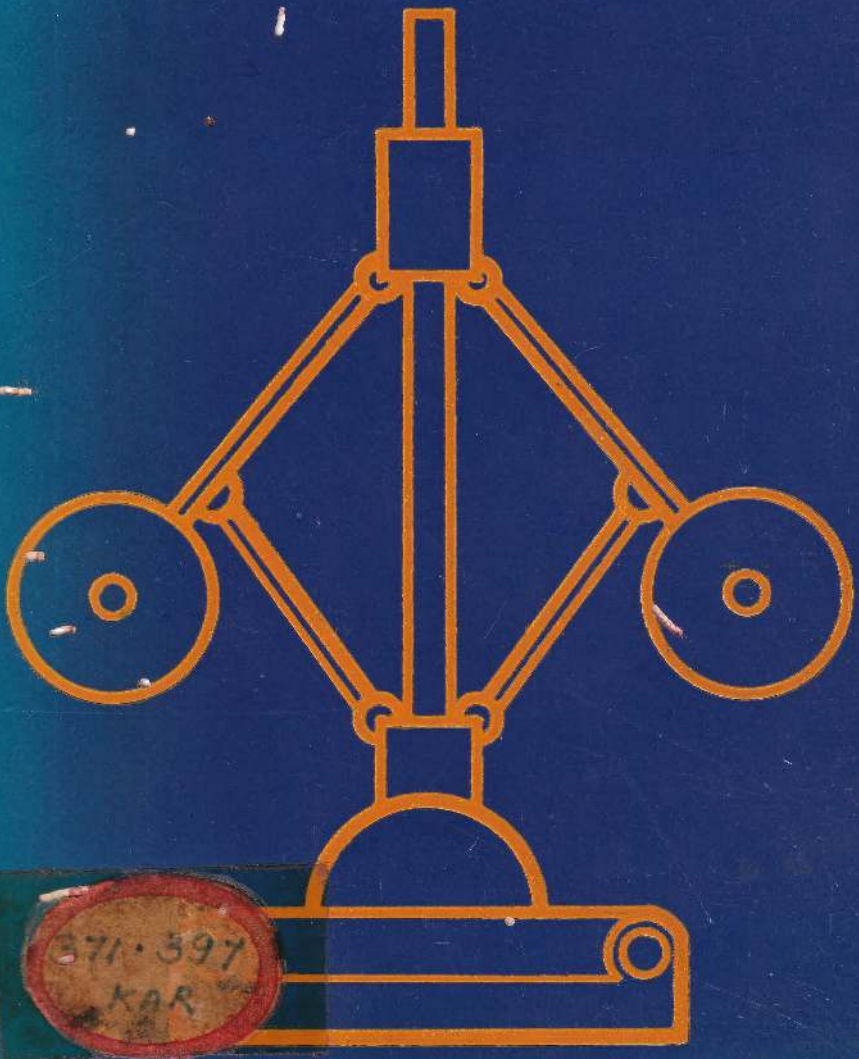
SIMULATION AS A MEDIUM OF EDUCATION



With best wishes from the Author

Priyadarsan Karunaratne

22/3/82

SIMULATION
AS A MEDIUM OF
EDUCATION

BY

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To my brother

JUSTICE AIYADURAI SIVANANDAN

who showed me how beautiful duty is

when performed.

Message from Gurudeva

SIVAYA SUBRAMUNIYASWAMI
Head, Saiva Siddhanta Church,
Hawaii.

Education is the birthright of the soul. It has its own laws and these laws governing the soul are found both now in modern science and ancient Saivite Scriptures.

May this book be well read.

SIVAYA SUBRAMUNIYASWAMI

Saiva Siddhanta Church
Post Office Box 10
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1. 16. 1982

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CHAPTER I

INTRODUCTION

In ancient times when man was still governed by indigenous customs, education was confined to a process of practical training in the art of obtaining food, clothing and shelter. There was, however, no conscious process of instruction on the part of the society. The child acquired the necessary knowledge through imitation. His amusements and other pastimes were mostly role-playing which in fact is also a form of imitation. The boys learnt to hunt by imitating the actual performance of the task by the adults and girls, similarly, applied the same methods to learn their house-hold duties.[1]

The "role-playing" referred to above is the early ancestor of what are now called "simulation methods". These methods can be applied to any area of sensory activity: aural, visual, tactual and kinesthetic. A communication system of this magnitude has wide possibilities. But its application in the field of education is not as encouraging as it should be.

The reasons may be as follows:—

1. Non-availability of materials and facilities.
2. Reluctance on the part of the teachers to break away from traditional methods.
3. Differences of opinion among educationists as regards the true values of this method of communication.

The first and second reasons are irrelevant to our work. But the third one is important and it is of vital significance to all educationists. It can retard the progress in methodological research and thereby even undermine progress in education.

Secondly, knowledge is increasing more rapidly now than in earlier years. A statement attributed to Robert Oppenheimer places the rate of expansion at twice every ten years.[2] Furthermore, what is available for learning is practically infinite. To add to this problem of ever expanding knowledge we have also the problem of shortage of teachers. One of the possible ways

by which this problem can be solved, at least partly, is to develop new and improved methods of communication.

Simulation methods have not been exploited satisfactorily and we shall do well to examine this area for what it is worth. The treatment of the subject shall be:

1. Descriptive.
2. Explanatory.
3. Experimental.

On the question of experimental verification it is wise to caution ourselves against certain inevitable obstacles. Firstly we must keep in mind the facts about inheritance. The basic conditions for learning are cast into the human system through heredity and this (heredity) determines the limits within which practice has its influence.[3]

Conditions being pre-cast as they are, what valuable data can we hope to get from experiments if we happen to choose for our study subjects who do not possess the "required framework?"

Is it possible for us to pick out a subject at random and train him for a particular performance. say, to win a gold medal at the Olympics?

Or is it possible for us to bring him up as a University teacher? Such things cannot take place as there are certain limiting factors set into that developmental framework, also by the influence of heredity.

Secondly, we must also take into account the environmental conditions which play an equally important role in controlling a performance. The fact that a person can play a game well on one day and very badly on another day shows that heredity alone does not determine the quality of performance in a given task.

A good illustration of "limiting factors" and their implications in experimental research in life sciences can be found in Blackman's work on carbon assimilation. The facts as reported by Blackman and which are relevant to our work are as follows:-

".....Let us consider first the case of assimilation. We can recognise five obvious controlling factors in the case of a given chloroplast engaged in photosynthesis:

1. The amount of CO_2 available.
2. The amount of H_2O available.
3. The intensity of available radiant energy.
4. The amount of Chlorophyll present.
5. The temperature in the chloroplast.

"In theory any one of these might be the limiting factor in the total effect and it is comparatively easy to experiment with (1), (3) or (5) successively as limiting factors.....

.....Many experimenters have indeed done this without premeditation. The experiments of Reinke* in which with increasing light the rate of assimilation (as measured by the bubbling of Elodea) suddenly ceased its proportional increase and remained stationary while the light increased yet another tenfold, I interpret as probably a case in which the supply of carbon dioxide was the limiting factor: its limits of arrival by osmosis being once reached no further increase of assimilation was possible.....

.....When the rate of a function exhibits, in experiment, a sudden transition from rapid increase to a stationary value, it becomes at once probable that a "limiting factor" has come into play.....

.....To conclude this section on limiting factors, it seems to me instructive to point out that in the equality of all conditions except one — which is the essence of the "control-experiment" method of investigation may lurk a dangerous pitfall if either of the equalized conditions becomes a limiting factor in itself.....

.....Suppose that it were proposed to test the effect upon assimilation of some specific factor that should have an augmenting effect what more natural than to place two similar leaves side by side under similar medium conditions for assimilation, one subject to this factor and the other not? This would be the typical "control-experiment". Yet the assimilation of the two leaves might be equally limited by the small amount of carbon dioxide in the air, or, if this were augmented, by the moderate light or by the low temperature; thus equal assimilations might be obtained and a negative result announced though the specific might really show an augmenting effect were another factor not limiting the assimilation....."[4]

The reader can now understand the difficulties which we have to face in carrying out experiments in our field of study where the subjects are more complex than plant life. Once again, in the words of Blackman: "The way of those who set out to evaluate exactly the effects of changes in a single factor upon a multi-conditioned metabolic process is hard". Fortunately our task here in this project is not to test the efficiency of simulation as a method of communication but to study its values as a medium of education.

Experiments will either be carried out in or cited from the field of practical skills. For, in these areas of study, learning is brought about by the training of the senses through a process of error-correction. The function of the intellect is kept at a minimum and the system (learner) behaves more or less like an automatic machine. Under these conditions "recall", which is accepted as a standard measure of learning, is unfailing and virtually instantaneous. For example, a swimmer even after several years of inactivity does not pause to think as to what he should do when he jumps into a pool. The moment he falls into the pool, his actions become automatic. Obviously the behaviour is precomputed and this is possible only if the learner is in possession of certain "desired experiences" related to swimming. It is believed that such "experiences" can be brought about through a process of simulation. And our duty shall be to illustrate this point of view experimentally if it cannot be determined otherwise.

In summing up the aims and purposes of this project we are tempted to look back on what Artistotle said centuries ago:

> "The development of a particular idea, curiosity to solve a particular problem, is not a matter of accident in the history of individuals or of nations. At one period the possession of a science becomes a want, its problems force themselves on the minds, and are importunate in their demands for a solution. At other times and other circumstances the interest may be unfelt and it may be almost impossible even to conceive the problem."[5]

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CHAPTER II

FUNDAMENTALS OF LEARNING

Sir Joseph Larmor in his observations on "The Principle of Least Action" says:

> "The great desideratum for any science is its reduction to the smallest number of dominating principles".[1]

Circumstances being what they are the applicable limits of this concept can be equalled only by those of that immortal classic of Le Chatelier:

> When a system in equilibrium is subject to a restraint it adjusts itself in such a way as to neutralise the restraint.

In other words these two statements quoted above can be applied practically to anything that is subject to scientific considerations, the former on account of its implications and the latter because of its flexibility.

As we are attempting to make a scientific study of the learning process, it becomes obligatory on our part to reduce the subject (learning) first to its "smallest number of dominating principles".

This is a formidable requirement, for, we have to deal with a subject which is still in a state of flux because "the educationists have not yet reached agreement upon the most appropriate concepts to use in stating our problems and in interpreting our data".[2]

Under these circumstances the only scientific law which can favourably accommodate such a phenomenon is the principle of Le Chatelier.

The reader may, quite legitimately, regard it as presumptuous on the part of the writer to make such decisions before making an investigational study into the applicable possibilities of Le Chatelier's principle. As a defence the writer can say that a principle is a model for the standardisation of scientific observations, and as Professor Donald Mackay says, 'the role of a model is to serve as a kind of template which we hold up against the real thing in order that any discrepancies may stand out more clearly and guide us

towards the making of a better one. We judge a model to be useful, therefore, not merely by its predictive success but also by the clarity with which its failures can be interpreted, and lead towards refinement'.[3]

Similarly, an already recognized principle is also a model that can be used to serve as a "template" which we may hold up against the proposition in order that any discrepancies either in the principle or in the observations may stand out more clearly and guide us towards the establishment of something more precise.

Let us now see whether Le Chatelier's principle is flexible enough to include the learning process. We shall begin the inquiry by first asking the question: "Why does an organism learn?" The invariable answer is: For self-preservation. This is true of all life-processes, including man.

When there is a change in the environment which brings about a disturbance in its system the organism makes use of its learning to free itself of the restraint, if there is any, and restores its system back to equilibrium, not necessarily to the original state. As Guilbaud says: 'In all examples of this kind the animal shows its adaptation by behaviour whose final result is to bring back to normal the disturbed variable or variables'.[4] He supports his view by quoting what Pavlov had said earlier: "The animal responds to modifications of the environment in such a way that its reaction is directed towards its own survival. As it is a physical system of definite form and extent, it can continue to exist only as long as it is in a constant state of equilibrium, with the forces external to it".[5] Now if we hold up Le Chatelier's principle against the observations of Guilbaud and Pavlov the reader will be surprised to see more similarities than discrepancies. The following extract from the Journal of Chemical Education (March 1958) will make our claim virtually indisputable:

> "By and large Le Chatelier's principle not only makes sense, it makes uncommonly good sense. So much so that various writers have described it as a 'principle of moderation', a 'principle of action and reaction', a principle of adaptation.....
>
> .....This..... is a principle of broad and general utility and it can be applied not only to chemical equilibrium, but to equilibrium states in any physical system. It is indeed possible that it can be applied also with good success in the psychological, economic and sociological fields."[6]

Our purpose here, is not to establish the validity or reliability of Le Chatelier's principle but to satisfy a condition in our scientific procedure of analysing the learning process, namely "to reduce it to the smallest number of dominating principles".

What we have said so far is sufficient to show that Le Chatelier's principle, in the absence of a more precise law, can accommodate the learning process favourably enough to enable us to proceed with our investigations of the subject in question.

What we now need to know is: What constitutes learning and how is it brought about?

We shall examine this problem with reference to two examples of learning activity namely:

1. Thorndyke's study on the learning behaviour of the cat.[7]
2. Karl Von Frisch's study of the communication system of the bees.

Thorndyke, in order to explain his theory trained a cat to stand up at a given command. And it was carried out as follows:—

A piece of fish was held up in front of the cat and the command "stand up" was given. On account of the simultaneity of the visual stimulus (fish) and the "command" the cat stood up. After a few trials the fish was omitted and the command given. The cat, however, stood up — of course, in anticipation of getting the reward — fish. This does not mean that the cat was learning English. It would have done the same thing even if the words "sit down" instead of "stand up" were used.

What the cat had done was to learn to recognise an auditory signal and then respond to it in a desired manner when the signal was repeated. Nevertheless, some form of learning had taken place. And it can be determined as follows:—

1. Acquisition of knowledge (learning to recognise a signal — "stand up").
2. Utilisation of knowledge for the performance of a task — (standing up when the signal was repeated).

In the next example *i.e.* in the behaviour of the bee the activity is as follows:—

At first the bee wanders around aimlessly in search of food. Then by accident or by being attracted by the scent, it arrives at a flower. If there is any food it collects whatever it is able to carry and flies back to the hive. On arrival, it discharges the cargo and then performs what, according to the author is called a "dance". This "dance" (Fig. 1.) which consists of a series of circular and semi-circular movements has now been established as the means by which the bees exchange information — about the availability of food in the neighbourhood, the amount, the distance etc. In the language of the communication engineer the "dance" is referred to as a process of "coding".

Here again we find the two functions mentioned earlier and which are peculiar to learning. The first, *i.e.* "acquisition of knowledge" is the discovery of food in the neighbourhood while the second, "utilisation of knowledge for the performance of a task" is the collection of food for the colony.

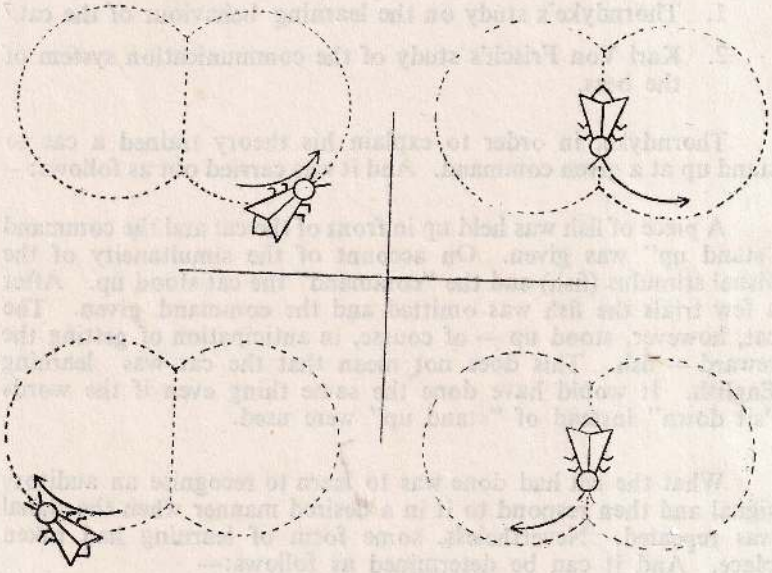

Fig. 1. ("*The Dancing Bees — Frisch*")

In the second example, however, the performance of the task was carried out in two ways:

(*a*) Individual action.

(*b*) Collective effort.

In individual action the task was performed by the member concerned while in collective effort the "knowledge" was first shared with the others before the mission was accomplished. This "sharing" of knowledge is called "communication". As it is of vital interest to us we shall discuss this subject separately in the next chapter. In the meantime let us see if the bee has anything more to enlighten us on the question of learning. As we have pointed out earlier the "foraging" bee, having discharged the cargo performs a "dance" to inform the others about the availability of food in the neighbourhood. Karl Von Frisch, the author describes the behaviour as follows:—

"On the part of the comb where she is sitting she starts whirling around in a narrow circle, constantly changing her direction, turning now right, now left, dancing clockwise and anti-clockwise in quick succession, describing between one and two circles in each direction." [8]

As the teacher bee performs this dance, the unemployed bees which are sitting close to the dancer start following her and in the process imitate every movement of hers. Most probably they were interpreting her message to them. At the conclusion of the dance the learners fly off to the hunting ground to collect more food for the colony. On their return the new recruits will perform the same "dance" to inform still others about the discovery and so on the whole hive will eventually "share" this knowledge to perform the task as a collective action.

What is most interesting is the way the bees vary their dance patterns to communicate different ideas.

If the feeding place is close to the hive the message is transmitted through a "round dance". But if it is further away the medium of communication is a "wagging dance". As the distance increases the dance becomes "more and more stately like the slow waltz with a straight waggle run".

The following account by the author shows how effective this system is.

"Using a stop-watch we found that the bee travels along the straight part of the waggle run between nine and ten times in a quarter of a minute if the distance between the hive and the feeding place is a hundred metres, four to five times at a distance of a thousand metres, twice at five thousand and barely more than once at a distance of ten thousand metres....." [9]

In continuing further the author says: "the agreement between measurement taken on different days, different years, or even different colonies is simply amazing". [10]

Another point of interest in this system is the provision made for direction-finding. During outdoor life the bees make use of the position of the sun in relation to their hive (Fig. 2). While

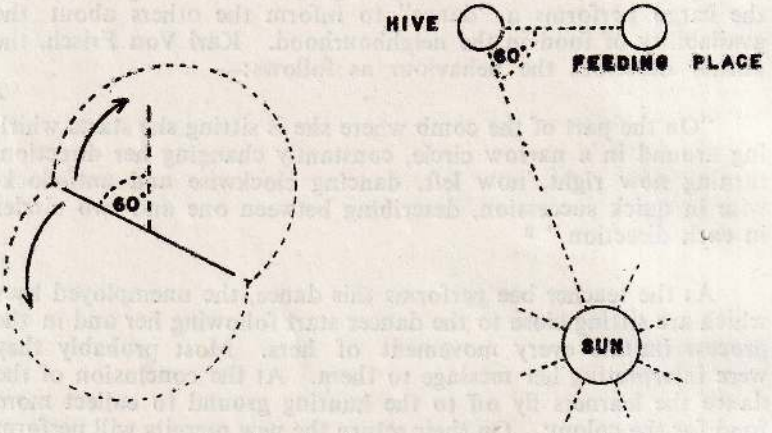

Fig. 2. ("*The Dancing Bees*"—*Frisch*)

following their leader in their dance the bees notice their own position with respect to the sun and by "maintaining the same position in their flight they obtain the direction of the feeding place." Inside the hive where it is dark the bees make use of gravity to determine the directions. We can thus see that communication includes two distinct processes:—

1. Formulation of the message into perceivable representations *i.e.* coding.
2. Direction of the coded message towards the intended destination.

When a system is directed to meet a given target it (the system) is then said to be "controlled."

The word "control" when used in the context of learning does not mean "prevent" or "restraint". It means "to stabilize" or "to regulate". When we "regulate" a system our intention is to conserve energy. For example, if a motorist has to be warned about a double-bend on a highway, it is necessary for the authori-

ties concerned to set up a sign-board with the word "Danger" and a Z-like symbol prominently displayed on it. The word "Danger" carries the intended message and the Z-like symbol directs this message towards the specific objective. If the Z-like symbol was not included in the sign-board the motorist would not know the type of danger he was heading into and he would be wasting energy unnecessarily in trying to imagine the actual nature of the problem.

Again let us take the flower of Poinciana regia (flamboyant). There is an odd petal which spoils the symmetry of an otherwise beautiful flower. But it was not intended for us. This "odd" petal is a sign-board which tells the bee where the nectary is. When the bee arrives at the flower it knows exactly where to find the food (honey). So without wasting much time and energy it (bee) performs the task of collecting food for the colony and flies back to the hive. Here again the underlying principle is "Conservation" of energy (effort).

"Conservation" or "control" of energy is one of the most essential requirements in the performance of any task and it is the ultimate determinant of progress, evolutionary or otherwise. It is rather unfortunate that many people including educationists have not realised the values of this principle. No wonder, we are for ever fighting a desperate battle for survival. It is time we brought this principle to the notice of every one.

This concept *i.e.* "control" takes its origin from the Greek word "kybernetike" which means "the art of helmsmanship". The following report tells us how this idea (control) evolved from the above mentioned Greek root:—

"In 1894 Ampere, writing his ambitious 'Essay on the Philosophy of the Sciences', in which he attempted to classify the whole human knowledge, felt the need for a term to describe the study of 'means of government'. He chose to appeal directly to Greek, and translated the Greek 'kybernetike' into French 'cybernetique'.

French dictionaries such as 'Littre' and older editions of Larousse recognised Ampere's new term; though it is doubtful whether the word was actually used in France between 1834 and 1948.

When it eventually reappeared in the French press in 1948, it was not in connection with the writings of Ampere, but a translation of the title of a book in English which had just been published.

The first review of the book carried the title 'Une nouvelle Science: la Cybernetique', Vers la machine ā gouverner'. Here was Ampere's concept reappearing, but linked now with that of the machine.

The book in question was by an American Norbert Wiener: 'Cybernetics, or Control and Communication in the Animal and the Machine'. In it the author described how he himself coined the word to designate a group of studies which had not as yet fully taken shape — deriving it from the Greek 'kybernētēs', which means steersman. He seemed unaware of the Greek Kybernetike of Plato and imagined that the term was a new one." [1] Metaphorically speaking "kybernetike" means "the art of governing" and that is where "Civilization" begins. One should now understand why the world looked up to the Greeks for guidance in Education.

Basically, controls are divided into two types:

1. Direct. 2. Feed-back.

The fundamental difference between the two is that in the former all actions are governed directly by the "brain" while in the latter the final decisions for the execution of a task are made by "localised analog computers". In psychological language this behaviour is referred to as "reflex action".

As there is nothing particularly significant about direct control, we shall confine our attention to the study of feed-back control only.

"Feed-back Control" is also called automatic control in contradistinction to direct control. Such arrangements are indispensable in the performance of complex tasks where several actions have to be carried out simultaneously or within a very short period of time. For example, if the driver of a car decides to stop a vehicle suddenly to avoid an accident he will have to perform the following functions almost at the same time:—

1. Apply the brake.
2. Apply the clutch.
3. Signal his intention to the other users of the highway.
4. Release the gear.

Imagine the situation if these actions have to be effected by oral commands from the Instructor! The results will be just the same even if the actions have to be carried out by direct commands from the brain.

The following observations by Sir Cyril Hinshelwood shows that even the living cell has found it useful to apply this principle (feed-back control) for the performance of her tasks:

"Most cell reactions are mediated by catalysts of protein-like character called enzymes. The formation of the enzymes in the cells can be induced by the substance (substrates) which they can transform: and their activity is sometimes inhibited by the products of their own action. The repression by a product of the reaction which produces it (well enough known in Chemistry) opens up the possibility of feed-back control".[12]

Intuitively people were aware of this principle (feed-back) for a long time but they did not think of it as such then. For instance, the theory of Karma, which, for centuries, has been a guiding principle of life, particularly to those in the Orient, is based on feed-back control. When something unfortunate happens to us, we take cover under this concept to keep our system in equilibrium.

What about false pregnancy? It is also an instance of feed-back control. This phenomenon occurs mostly in married women who are childless and who do not want to be so. When they are thus disturbed the system develops symptoms of pregnancy in order to maintain the mental equilibrium of the person concerned. Again, let us take the following passage concerning the origin of the Universe:

> "In contemporary astronomy, theories of the origin of the Universe have acquired more prominence. These theories, like those of the origin of life, cannot be tested as the explanation of what actually happened but they are more scientific explanations of possible events. This I think is because there have been two main rival theories: the "steady state" and the "original bang" idea. Competition between the two theories has resulted in emphasis being placed on those critical observations which might refute one of them. As a result, observations have been made and more importantly, would their significance have been realised if the steady state theory had been the only theory available". [13]

If we examine the above text carefully we will notice that the two theories of the origin of the Universe constitute a feed-back control

net work for the mutual development of both. Eventually this rivalry will lead to the acquisition of better knowledge of things and events. This is what is most desired in a theory.

And so on if we once start looking for this principle there may not be a limit to the number of examples we are likely to run into. As a philosopher once said, "Metaphorically and somewhat speculatively, we can think of all the efforts of all classes of humanity throughout the course of history as a vast collection of actions under feed-back, in which the results already attained control the approach to an Ideal, initially ill-defined, and to some extent discovered in the course of the action itself".[14]

Whatever claims we may make about the ancestry of this concept it was James Watt who in 1790 first recognized the practical values of this principle. To prove his point of view he developed a mechanism to regulate the speed of rotation of the steam engine.

This mechanism as shown in Fig. 3 consists of two weighted

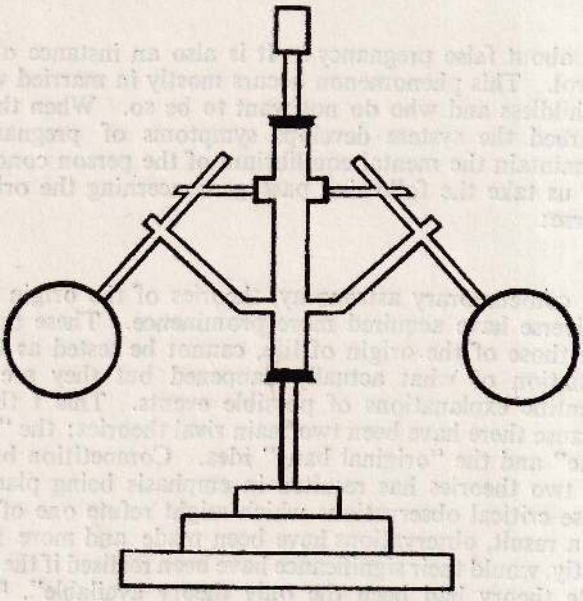

Fig. 3. *James Watt's Governor*

spheres suspended at either end of two movable arms which are in turn attached to a collar encircling a vertical shaft. This shaft,

capable of rotation around a central axis, is coupled on to the engine such that when the speed of rotation of the engine increased the shaft turned faster.

When this occurs the spheres move outwards due to centrifugal force and in the process brings about a reduction in the supply of steam to the engine. This forces the engine to slow down.

Similarly, when the speed of rotation of the engine decreases the reverse action takes place to bring the system back to equilibrium.

Watt's idea caught the imagination of many and the application of this principle to mechanical devices became more and more popular, firstly as a novelty and later on as a useful labour-saving method.

Even though people could see many similarities in behaviour between animals and machines educationists frowned upon the thought of equating man with a mechanical device. Consequently the application of the principle of feed-back control to education was not very promising. Even now people do not take kindly to the idea of explaining human behaviour in terms of mechanical operations. If we must progress we must dispel any misconceptions. We shall commence our task with reference to a specific example, namely: Learning to design a Teaching aid. The cut-out model of the well known Temple of the Tooth in Kandy (Sri Lanka) designed and published by the writer in 1964 under the title, "Visual Aids in Education", will serve our needs adequately. The writer having conceived the idea of preparing the cut-out model, visited the temple periodically and made a close study of the various buildings, their shapes, relative positions, etc. He also took several photographs and made a further study of the subject in question. From these forms of "experiences" direct and indirect (photographic) the writer formulated the plan of the book. This is the intended output and it is a product of brain-function.

He then translated these ideas into a system of perceivable codes. This included, among other things, verbal descriptions of the task, sketches of the buildings, listing of component parts etc.

Next, the writer drew the designs directly on the raw material (white card-board) strictly adhering to the intended dimensions. These are the constructional codes. The writer himself provided the labour for economic reasons.

During the whole process of preparing the designs the writer was gaining experience in the art of executing such work. At

first, due to lack of experience the output did not reach the required standards. By incorporating the effects achieved from the first experience with the second, the writer was able to produce better and more refined designs. With still more experience the writer was able to improve further the quality of his performance. The cause of his progress was not just repetition of experience but utilisation of "Controlled" experiences *i.e.* experiences which have been modified by past actions.

As observed by Jurgen Ruesch and Weldon Kees, "Feedback" (control) refers to the process of correction through incorporation about effects achieved by his own actions, the information so received will influence subsequent actions. Feedback of information thus becomes a steering device upon which learning and correction of errors and misunderstanding are based."[15]

Completion of the designs is not the final stage in the formulation of the Constructional code. The prepared designs have to be tested for the following:

1. To see if all the pieces are included in the designs.
2. To see if these pieces fit into their respective places during the construction of the model.
3. To see if children between the ages 11 and 13 for whom it was intended could construct the model without much difficulty.

These tasks were carried out as follows:—

The designs were photographed and then enlarged to the required dimensions. Several sets of prints were made. One set was used by the writer to construct the model in order to test the accuracy of the designs. The remaining sets were given to children belonging to the age groups 11 — 13. All tests proved successful. The designs were accurate and complete. And the children who were asked to construct the model did so satisfactorily.

Here again we see the values of feed-back control.

We can see this principle functioning, often without our noticing it, even in a simple task such as letter writing. We first make a mental plan as to what should be the nature of the letter. This is the intended output.

Then we make the first draft. We read through it and in the next draft we correct the errors, if there are any, and modify the presentation if it has deviated from the intended plan. Or even modify the intended output if the deviation is more acceptable. What is really required for the performance of a task is a state of equilibrium between the intended plan and the actual output. The process of drafting and re-drafting is repeated until the gap between the intended plan and actual output is sufficiently reduced to convince the person concerned that the letter will have the desired effect.

"Perfection" in presentation is only a concept. It is not possible to achieve what is ultimate in our present state of life because we are always in a state of change all the time. When we experience something our system also changes simultaneously to a new state of physical conditions. This change invariably invalidates the earlier concepts as the ideal standard.

Surgery in medical practice is another good example to illustrate the values of controlled experiences. Here again we have to go through the four states of behaviour, namely:

1. Conception.
2. Translation.
3. Conversion.
4. Construction.

Firstly, we formulate a plan of action. This is dependent on past experiences. Certainly a newly passed out medical graduate will not find it easy to plan out the task even though he would have had some experience in such work during his medical course.

Secondly, this plan is translated into perceivable codes such as: description and listing of duties, distribution of sub-tasks, arrangements in the theatre, etc.

Thirdly, the task force is brought into the theatre and the duties are assigned in order of priority.

Lastly, we arrive at the final performance of the act—the actual operation.

This is true even in playing games. The learner has to go through these four stages before he can acquire the necessary

knowledge to perform the task as desired. Once the knowledge is acquired the functions are carried out automatically through a feed-back net-work.

In concluding this lesson it is useful to note that the two-party system of government is also based on the principle of feed-back control.

The function of the ruling group is to formulate the policies and the duty of the opposition is to stabilize them with reference to what can be accomplished within the means available.

Unfortunately this is not so in actual practice. The government group tries to destroy the opposition and the latter in turn becomes equally enthusiastic about unseating the government. There are some who believe that the duty of the opposition is, "to oppose". This is a misconception.

In terms of the above observations it becomes patently clear that coding alone does not ensure the desired output in communication. As the bees have shown the coded message has to be directed towards the intended objective, *i.e.* it must be "controlled". The two processes "coding" and "control" are interdependent in their functions and they constitute the net-work on which communication rests as a science. These three related phenomena "coding", "control" and "communication" are fundamental to any learning activity, acquisition, utilisation or transmission of knowledge.

If this assumption is correct it must also hold good for the behaviour of the ultimate structure of life—DNA. Let us see if this is true.

In 1953 two young scientists James D. Watson and Francis Crick, working in the Cavendish Laboratory at Cambridge made a spectacular discovery in the field of biological sciences. They found that the molecule of Life, DNA (deoxyribonucleic acid) was made up of two strands wound around each other in the form of a coil (helix). For convenience we shall refer to them as DNA (a) and DNA (b).

One of the strands, say DNA (a) is certainly the genetic code which in fact is the blue print of life. The other one, DNA (b), was explained away as a template and its function, as pointed out by Watson and Crick, was to serve as a mould for the duplication of the genetic code during cell division.

This interpretation seems to be rather weak and the reasons are as follows:—

1. In "Of molecules and men" Dr. Francis Crick says: "In addition some viruses have DNA, the largest ones often being double stranded and the smaller ones single-stranded." If this is so, how do the single-stranded ones duplicate? Very likely there is a built-in mechanism to perform the task. We can therefore say the same thing about the double-stranded ones too.

2. "Life", probably, is the greatest phenomenon the world has ever seen and Nature is its architect. If she can create such a near-miracle, does she require a mould to produce a second one?

The most plausible explanation is that in the single-stranded organisms the tasks are prescribed because there are not many to be executed. But in higher organisms, the tasks, as reported earlier, are many and complex. Therefore a variable feed-back control mechanism is essential to bring about the desired results.

As an illustration let us take the behaviour of say, a bean plant, growing inside a closed box with an opening on one side. Naturally, it will turn towards the opening—to reach out for sunlight. The same thing will happen even when the box is turned round: the plant will again turn towards the opening, for the same reason. Now, what determines this behaviour? There are two possibilities:

1. Mutation.
2. Action of a feed-back Control mechanism.

Mutation means a change which can be transmitted through heredity. This particular behaviour of the bean plant cannot be transmitted to the off-spring. It (the off-spring) will grow up in the normal way unless of course it is also given the same treatment as the parent. Therefore mutation cannot be the cause of this behaviour. We are thus left with only one possibility, *i.e.* action of a feed-back control mechanism, which in our opinion is vested in the second strand of the DNA.

Our theory becomes more formidable if we examine the nature and development of cancer.

We have for a long time, been conditioned to think that virus is the cause of many of our ills. Naturally, people including medical scientists, are led to believe that there is possibly a virus for cancer and the race goes on to trap the marauder. Any unidenti-

fied particle found in the blood-stream of a cancer patient becomes a strong suspect and promptly a report is circularised with the caption: "New evidence to support a virus Cancer theory".

One is at a loss to understand why the virus is being made a scapegoat.

If virus is actually the cause of cancer, then what about smoking, X-rays, and betel-chewing? These are also believed to be responsible for this dreaded disease which in all probability is a creation of man himself.

The word "cause" when used in this context means: "an agent that brings something about" (Webster). Judging by the number of "agents" which have been identified so far, it will not be long before the human race becomes extinct.

Many people in the Orient indulge in betel-chewing and this goes on morning noon and night. If this pastime is in fact an agent for cancer, none of these people will be living today. On the contrary they are well and in good health too.

As things appear to be it is very likely that these "agents" may be acting in an indirect manner to bring about the disease. Recalling once again Sir Cyril Hinshelwood's observations on the behaviour of the living cell referred to earlier it would be instructive to take note of the following remarks:— "...The activity of the enzyme is sometimes inhibited by the products of their own action....."

Suppose there is no such inhibition would it not be possible for the system to increase its output and in the process gets geared to positive feed-back? If this takes place it would lead to an erratic behaviour, culminating in the death and destruction of the organism.

We shall illustrate our point of view with reference to an automatic machine which produces sheet aluminium. The arrangement of the system can be studied from the diagram given in Fig. 4.

As explained by Ferranti, the author,

"This may be described in two different ways: either with regard to "behaviour" or to its "operation" Firstly, if the system were that of an animal it would behave as follows: The strip emerging from the rollers is watched by the photo-electric "eyes", which tell the Control circuit "brain" what thickness is actually

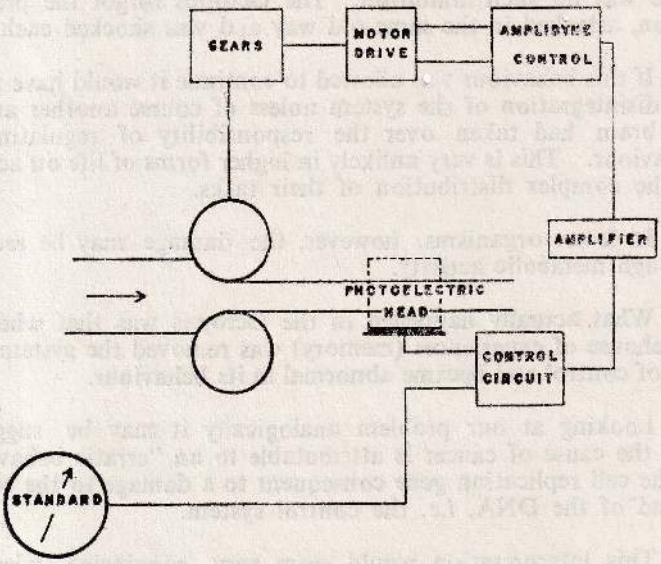

Fig. 4. (*"Machines, Animals and Information" - Ferranti*)

being rolled. At the same time the brain looks at the standard thickness makes a comparison to adjust the height of the top roller accordingly....." [17].

Let us now consider a damage to the control circuit, *i.e.* the "brain". The chances are that the machine may develop an erratic behaviour and in the process produce sheets of wrong thickness.

The concept of "erratic behaviour" in a living system is well illustrated in an experiment carried out by Prof. J. Z. Young on the nervous system of the Octopus. His findings are as follows:

> "The Octopus was presented with a crab and a white disc, so that when it shot out to claim its meal, it received an electric shock. Then instead of attacking in the "guided missile" way the second time the crab and the disc appeared, a more cautious attitude was adopted; but when the crab was finally touched, another shock was received. The third time, the Octopus took fright and reacted as if his most dangerous enemy was near. Thus, the information about the first and second experiences must have been stored in some form of memory, and inhibited the third instinctive attempt to obtain food...". [18]

It was later found that if two lobes of the brain were removed there was no such inhibition. The Octopus forgot the previous lesson, attacked in the same old way and was shocked each time.

If this behaviour was allowed to continue it would have meant the disintegration of the system unless of course another area of the brain had taken over the responsibility of regulating the behaviour. This is very unlikely in higher forms of life on account of the complex distribution of their tasks.

In lower organisms, however, the damage may be rectified through metabolic activity.

What actually happened in the Octopus was that when the storehouse of experiences (memory) was removed the system went out of control and became abnormal in its behaviour.

Looking at our problem analogically it may be suggested that the cause of cancer is attributable to an "erratic behaviour" of the cell replication gene consequent to a damage to the second strand of the DNA, *i.e.* the control system.

This interpretation would seem very convincing when we compare it with another erratic behaviour which takes place in the cell itself.

It has been an accepted practice to induce poly-ploidy (doubling the normal number of chromosomes) in the cells in order to produce giant fruits. This is brought about by injecting certain chemical substances (colchicine) into the plant.

These substances destroy the fibrils which control the movement of the chromosomes from the centre of the mother cell to the respective poles during cell division. As a result of this interruption, the cell, instead of producing two identical daughter cells with the normal diploid number of chromosomes, resolves itself into a giant cell with twice that number.

Technically speaking this too falls under the category of "erratic behaviour". Most important of all is that this condition is brought about by the rupture of the "Controls", and not by any genetic disorder.

The rupture of the control system alone may not lead to a serious condition in cancer. It probably takes a bad turn when the behaviour gets geared to positive feed-back, *i.e.* output increasing in direct proportion to power-supply (metabolic activity) and the power-supply increasing in direct proportion to the output.

We shall now examine our problem from the point of view of a Pathologist, Prof. D.F. Cappel. He says:

> ".....Whilst forming a part of the body, a tumour and its cells seemed to have escaped from the controlling influences of the body, so that it grows independently....." [19]

Precisely, this is what we have said about the cause of cancer. But our presentation, however, is somewhat different. We have said that cancer (tumour) is caused by the rupture of the control system and this view is strongly supported by the following observations on "Disturbances of the pituitary feed-back mechanism:"

"(a) F.S.H. induced ovarian granulosa-cell tumours.

The ovary is stimulated to various activities including the secretion of oestrogens by the follicle stimulating hormone of the pituitary. A rise of oestrogen level in blood reaching the pituitary reduces the output of F.S.H. so the system stabilises. Biskind removed the ovaries of rats and implanted pieces in the spleen. Oestrogen secreted by grafts in this position passes into the portal blood and so all of it is carried direct to the liver and is there inactivated by the normal hydroxylation process. Thus very little reaches the pituitary in active form and the F.S.H. rises. This stimulates the grafts both to grow and to secrete oestrogen, but even the excessive oestrogen so produced is prevented from reaching the pituitary. Prolonged over-stimulation of the grafts leads finally to the appearance of granulosa-cell tumours".

"(b) Thyroidectomy Tumours of the Pituitary.

The similar thyroid pituitary feed-back with thyroid-stimulating hormone increasing the secretion of thyroid hormone, and a rise of thyroid hormone lowering the secretion of T.S.H., can lead experimentally to tumours of either organ. If the thyroid is surgically excised or obliterated with radio-iodine, secretion of T.S.H. is raised. In some strains of mice the T.S.H. secreting cells proliferate so actively under the stimulus that they give rise to malignant tumours of the pituitary....."

"(c) T.S.H. — induced Thyroid Carcinoma.

If the normal output of thyroid hormones is blocked by thiouracil or other goitrogenic drugs, T.S.H. rises and stimulates

thyroid proliferation. In rats, if this is continued for long enough, metastasising tumours may arise". [20]

In concluding his observations on T.S.H. — induced thyroid carcinoma the author says:

"This type of experimental tumour is less irrelevant to human cancer than the two preceding....." [21]

As a matter of fact this experiment.....(c) virtually confirms our proposition that the rupture (or obstruction) of the control system is responsible for the development of cancer.

Sir Karl Popper, the well known philosopher and mathematician once said: "a theory becomes more scientific when faced with an alternative". The truth of this statement can be studied very clearly from the two rival theories of the origin of the Universe which we have quoted earlier to illustrate an aspect of feed-back control.

Under these conditions it may prove valuable for us to re-examine our conclusions about cancer with reference to an "alternative". To meet this requirement we shall select the virus theory, for statistically speaking, it is the most formidable of all known rivals.

Whatever views we may hold about the cause of cancer we cannot get behind the fact that the reaction is positive in character because the activity is only an exaggeration of a specific task of the genetic code namely: "cell-replication".

Cappell's views on this question are not much different from what we have said. He says:

> "..... Malignancy in particular at first sight seems a positive character, a new acquisition by the cell of the ability to do things (multiply rapidly, invade, metastasise, transplant out of its own pure line) that it could not do before...." [22]

Now, in this context, if we say that a virus is responsible for this disease, it can only mean that the virus concerned is imitating the conditions of an enzyme, for, cell-replication is preceded by metabolic activity which as Sir Cyril Hinshelwood says: is "mediated by catalysts of protein-like character called enzymes".

If this is an acceptable proposition, then again in terms of Sir Cyril Hinshelwood's observations, the activity of these imitations of the enzymes as that of the actual enzymes "may be inhibited by the products of their own action". In which case any unnecessary growth will be checked automatically.

But if there is no such inhibition, what purpose does it serve, practically, for the virus to perform this task? If cancer cells can serve as a medium for the proliferation of the virus concerned then there is some purpose behind the performance of this task namely: promoting the rapid multiplication of cells. There does not seem to be any evidence to this effect.

Here again we have no support for this theory.

Lastly, if cancer is in fact a virus disease — like small pox or measles, then the disease must necessarily be communicable. So far it has not been proved to be so.

Our next "alternative" is mutation. This is equally formidable as the virus theory, for, "informed opinion nowadays would probably favour the view that a cancer cell is one with a modification which one can call a somatic mutation....." [23]

What is particularly notable in this concept is that it is believed that "such a mutation might be and probably most often is a classical gene mutation involving one base on the DNA chain". [24]

This is encouraging because we are in common ground.

Now, what exactly is meant by "involving one base on the DNA chain"?

Let us assume that it is mutation. According to this theory the cell can multiply in three different speeds and as observed by Cappell:

> "(i) If it multiplies less rapidly than the cells around it, or its survival time is shortened, it may be replaced by normal cells and never be recognized, or only a local tissue defect may result.
>
> (ii) If it multiplies at the normal rate, it will survive as a single cell, but will not ordinarily be recognised as a significant lesion.
>
> (iii) If it multiplies faster than normal, or survive longer, it will overgrow and replace in time a tumour....." [25]

If we were to accept these propositions we automatically contribute to the view that different genes control different rates of cell-multiplication. As the rates are not definitely determined they may vary very widely and this will involve either a frequent change in the genetic constitution or the manufacturing of a large variety of genes.

Both tasks are uneconomical and unnecessary. Nature would not embark on such an expensive programme, especially when there are much more simpler means of solving the problem.

Suppose we consider the "one base on the DNA chain" as a reservoir which supplies cells, would it not be economical to carry out the desired functions through one sluice gate with a variable control rather than to employ different gates for different quantities? What is really needed is a control system to regulate the production of cells.

Secondly, mutation is a naturally occurring phenomenon and its primary function is to direct the system towards its own survival for, in the words of Pavlov, "The animal responds to modifications of the environment in such a way that its reaction is directed towards its own survival".

The mimicking behaviour of the peppered moth Biston betularia illustrates this point of view very effectively.

Prior to the Industrial Revolution the most common variety of the peppered moth found in England had light coloured spotted wings which blended well with the background. On account of this protective colouration they were not easily spotted by their enemies. Later on, with the growth and development of industries, the tree trunks became darker in colour due to deposits of soot, dust, etc. As a result, the light coloured moths became easy targets for the predatory birds. This led to a decline in their numbers and a black variety of the same species began to spread. Within a few years the black mutant heavily outnumbered the white.

With the introduction of smoke control laws, the trees became cleaner and lighter in colour. This brought about a remarkable change in the behaviour of the peppered moth. It was found that the insect was reverting to its original colour.

In effect this change is a backward step. Yet Nature does not mind it, as long as the net result is favourable for the preservation of life.

We cannot say the same thing about tumour. The final outcome there is disintegration and death of the system. Furthermore, even the cells produced under those conditions are mostly abnormal. Certainly, Nature would not employ such a sophisticated method as mutation to obstruct her own progress. Judging from what has been said above, it is quite clear that the statement

"involving one base on the DNA chain" does not mean mutation and in consequence the "one base" referred to there is not the genetic code DNA(a).

The following extract from "The Possible cause of Cancer — our present knowledge" by Sir Alexander Haddow, reinforces our conceptions of the cause of cancer to the point of irrefutability:

"The alkylating carcinogens were early recognized to be powerfully mutagenic and to exert effects on the mitotic mechanisms largely indistinguishable from those effects due to ionizing radiations. This circumstance fully justified their description as radiomimetic and it was indeed because of the potential carcinogenicity of the ionizing radiations that the sulphur and nitrogen mustards were later tested for their capacity to evoke tumours. The results were immediately positive. Of course, the mustards, on their way to the cells interact with many chemical receptors, but it was not until the classical work of Peter Brookes and Philip Lawley in England, first of all involving reactions with guanylic acid and later with nucleic acids, that the importance of a specific reaction —alkylation of guanine at position 7 (seven) became evident. In turn, this led to the conception of extremely delicate alterations in the purine and pyrimidine bases, and to the notion that the action of these agents might well be to introduce alterations in base sequences — with all the profound changes in protein synthesis and cell that might then ensue". [26]

Cappell also shares this opinion and his interpretations are more relevant to our views on the subject. He says: "Another line of speculation is attributable especially to H. N. Green, who has suggested that carcinogens unite with special cellular components to form antigenic complexes and that the resulting immunological reaction, by damaging those cells which contain the antigen, favours the emergence and proliferation of cells which lack it..." [27]

The concluding remarks "by damaging those cells which contain the antigen" may very well be interpreted as "by damaging the control system".

It must however be noted that Sir Alexander Haddow certainly favours mutation as the cause of the disease, for, in the opening sentence he says: "The alkylating carcinogens were early recognised to be powerfully mutagenic....." But the "delicate alterations in the purine and pyrimidine bases" referred to by him in his final remarks need not be construed as mutation. Such "alterations" can also occur when the DNA is damaged. The following report by R. F. Gomez and A. J. Sinskey on DNA breaks in Rifampin treated salmonella typhimurium....." explains this possibility:

"We have reported the phenomenon of "minimal medium recovery" of heated salmonella typhimurium LT2 (ref. 1) and how this phenomenon could be explained in terms of DNA damage caused by sequential exposure to heat and nutritionally complex medium. We now show that treatment of salmonella typhimurium with rifampin also results in decreased viability on rich relative to minimal medium and that the DNA from these rifampin treated bacteria exhibits breaks after exposure to a rich or complex medium". [28]

The "decreased viability" referred to above implies a change or an "alteration" in the structure of the DNA. Can we use the term "mutation" to explain such abnormalities?

Certainly, it is more appropriate to explain disorders such as cancer, tumour, etc. in terms of "damage to DNA" rather than to describe them as products of mutation. Furthermore, Gomez and Sinskey also say ".....It seems to us that both heat and rifampin cause a change in the cell such that, when exposed to nutritionally rich media lethal DNA breaks ensue".

In other words it means that if the "alteration" is carried too far DNA will cease to function. We cannot associate this behaviour with mutation, for, as stated earlier, the primary aim of mutation is to direct the system "towards its own survival".

In summing up our observations on the "cause of cancer" it is important to note that the subject in question was only a means to an end and not an end in itself.

Our main objective there was to show the essentiality of a regulatory (control) mechanism in a living system. Whether it is located in the second strand of the DNA or not is another matter. The following remarks made by Nobel Laureate Professor Renato Dulbecco, also on the same subject (cause of cancer), contributes to our point of view in no small measure.

"Biologists agree that cancer originates in a cell, which becomes altered and multiplies overcoming the normal cells forming a large cellular mass. This ability to grow without restraints differentiates the cancer cells from normal cells. It represents an alteration of a basic cellular property, called growth regulation, which allow multiplication only when it is needed. Growth regulation is a necessary characteristic of all cells of a large organism, and allows the organism to develop harmoniously, attaining its regular shape and functions". [29]

In this context, it is also interesting to note that the "Operon Concept" of Monod and Jacob favours our arguments equally

well. The text as published in the 1971 edition of Harper's Medical Review is as follows:—

"An explanation of the mechanism of genetic control of the synthesis of enzyme proteins or of that of virus proteins has been formulated by Monod and Jacob (1961:1962). It is postulated that the Chromosomes actually carry 2 types—*structural genes* and operator genes. The structural gene DNA directs the synthesis of specific enzyme and other proteins through the DNA template as described above. The operator gene, however, exerts control over the adjacent structural genes located on the same chromosome since formation of the DNA can be effected only at a point on DNA where the operator occurs. This, structural gene, even though present in a given cell cannot initiate protein synthesis except when appropriate conditions prevail within the cell. One or more structural genes together with their operator gene constitute the genetic structure which is designated an operon....."

Repression and De-repression

A third factor in the genetic control of protein synthesis relates the operon to metabolic events within the cell. This factor is the *regulator gene* which controls the activity of the operator gene. The regulator gene does so by its ability to induce the synthesis of protein macromolecules (probably RNA proteins) called *repressors*. The operator gene, when combined with a repressor is unable to induce activity in the structural gene, in which circumstance the operon is said to be "repressed". When the operon is active because the repressor system is itself inactivated the operon is said to be "de-repressed". [30]

Now, if the reader is still not satisfied with our arguments, we shall revert to the original explanation provided by the discoverers of the DNA, Watson and Crick. They said that the second strand is a template or a mould and its function is to help the genetic code to double itself. In other words the second strand directs the system (life) towards the performance of an intended task (cell-replication). As we have said earlier, when a system is directed to meet a given target, it (the system) is said to be "Controlled". Under these circumstances the "template" becomes a control system. In the early stages of evolution the two strands must have been identical and each would have served as a control for the other. Watson himself in making the following observations, contributes to this view quite positively.

> "It would strongly suggest that one chain in each molecule had at some earlier stage served as a template for the synthesis of the other." [31]

Lastly, let us look at what Prof. Klambt had said about the structure of the DNA:

> "Genetic information is linear-coded information on only one DNA strand. Therefore, in double-stranded DNA this information is present not only in positive form, but also as a negative (in an anti-parallel, complementary manner).
>
> The DNA double strand possesses the highest possible degree of stability. It is resistant to degrading enzymes. Furthermore, all cells contain repair enzymes, which recognise any changes in a strand of the DNA double helix which have been caused by ultra-violet or X-rays or by chemical agents under experimental or natural conditions; these repair enzymes excise such areas and polymerize new nucleotides as replacements, complementary to one intact strand. DNA's particular structure insures that it remain stable". [32]

The word "stability" mentioned above implies "control" and we have already made reference to it earlier.

What probably happens, *i.e.* in terms of our line of thinking, is that the second strand (control system) receives the information from the environment and then instructs the genetic code as to what it should do to keep the organism in a "constant state of equilibrium with the forces external to it".

In concluding our findings it seems hardly necessary to say that the three phenomena, Coding, Control and Communication are fundamental, not only for learning but also for its extension —Organic Evolution.

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CHAPTER III

COMMUNICATION

The word "communication" arises from the Latin term "communis" which means "common". It thus follows, naturally, that when we communicate, our intention is to establish a "commonness" or a state of equilibrium between the learner and the source from which the knowledge originates. This is exactly what is meant by "sharing" knowledge and this is what is most important for us because all learning activities emanate from this basic concept. Education is the art by which this is achieved. Our immediate task now is to explain the need for "sharing" knowledge and we shall carry this out with reference to a particular problem namely: learning to drive a car.

The first step in the performance of this task is to conceive a plan of action. This is the intended output and it is a product of brain-function. Next this plan is translated into a system of perceivable codes. It includes, among other things, oral instructions, written description of the various aspects of the task, demonstrations, etc.

Thirdly, the perceivable codes are converted into constructional codes. This is confined to imitative actions of the practical aspects of the desired task.

Lastly, we arrive at the actual operation. It does not however follow that the actual output meets the requirements of the intended plan automatically.

To begin with the learner will find that there is a wide gap between the intended plan and the actual output. But as he proceeds further the gap gets reduced gradually and with more trials or "experiences" he (the learner) will acquire the necessary "knowledge" to perform the task as desired.

Let us now look at the technical and psychological aspects of this man-machine association. The following illustration (Fig. 5.) will serve as a reference.

At the commencement of the task, the learner observes the environment in all its aspects and then makes the first practical move. The eyes then observe the direction of the vehicle in rela-

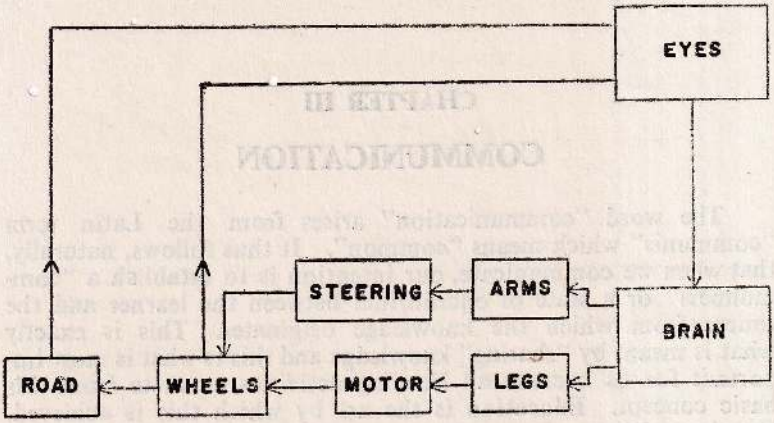

Fig. 5. *Learning to drive a car*
("*Machines, Animals and Information*" — *Ferranti*)

tion to the environment and reports the information to the brain. There a comparison is made between the intended plan and the actual act. Any discrepancy is noted and the brain gives fresh instructions to rectify the error. This information is transmitted to the muscles and limbs via the nerves in the form of pulse-train codes. On receiving the fresh set of instructions the system makes the next move, and so on the cyclic activity is continued until the learner is convinced that he can perform the task as intended. [1] This is true of any task whether carried out by man or animals. What has to be noted here is the bi-way process of transmission of "knowledge". In technical language this bi-way process is called a feed-back control system and we have discussed it at length in Chapter II for the learner to know what it is and what it does. As far as our problems were concerned it was responsible for the establishment of a "commonness" or "a state of equilibrium" between the mind and the body. In other words the two (mind and body) were made to "share" the knowledge in order to fulfil the given mission. If on the other hand the mind and the body had failed to "share" the message the chances are that the system may have failed in its mission, and may have even become erratic in its behaviour as seen in the case of the octopus in Young's experiment (*vide* Chapter II). When the two lobes of the brain were removed the octopus probably lost its feed-back control loop. Consequently the communication system between the "mind" and the "body" failed to function.

Judging by what is happening throughout the world today it is possible to believe that our hardships in life are directly attributable to our inability to "share" our knowledge.

We shall now examine the problems related to this process (communication). We shall carry this out with reference to the chart shown in Fig. 6.

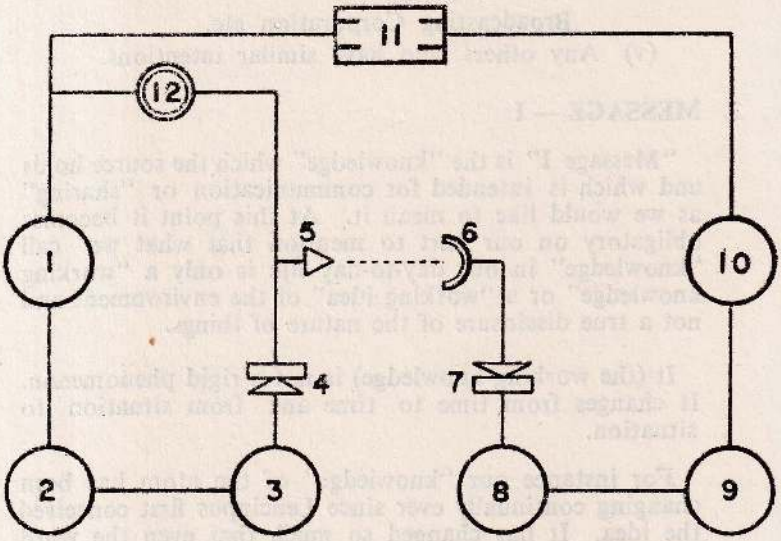

Fig. 6. *The Communication Process*

Key

1. Source
2. Message—I
3. Medium
4. Encoding
5. Transmission
6. Reception
7. Decoding
8. Interpretation
9. Message—II
10. Destination
11. Inferential Feed-back
12. Auxiliary Feed-back

Looking at the net-work we can identify twelve separate components and they are:

1. **SOURCE**

Source refers to the party which intends to "share" its knowledge with another. It can be:

(i) A Teacher
(ii) An Author

(iii) A Producer of a film or a play
(iv) An Establishment such as:
A University, school,
Political party,
Broadcasting Corporation etc.
(v) Any others who have similar intentions.

2. MESSAGE — I

"Message I" is the "knowledge" which the source holds and which is intended for communication or "sharing" as we would like to mean it. At this point it becomes obligatory on our part to mention that what we call "knowledge" in our day-to-day life is only a "working knowledge" or a "working idea" of the environment and not a true disclosure of the nature of things.

It (the working knowledge) is not a rigid phenomenon. It changes from time to time and from situation to situation.

For instance our "knowledge" of the atom has been changing continually ever since Leucippus first conceived the idea. It has changed so much that even the word "atom" which means "indivisible" has now become inapplicable as a title to the subject!

What is most notable in this particular topic is that the old idea—that the atom is the ultimate particle of an element, has not been abandoned even though this theory does not hold good any more. This is because the old idea brings about a better understanding of the subject at primary levels.

We can thus see how important "sharing" of knowledge is. In order to ensure this educationists have even gone to the extent of using imprecisely formulated theories as their "working tools".

Again, let us take the study of Mathematics. The "knowledge", or the "working knowledge" as we would like to say, possessed by a pavement hawker is not the same as that of a University lecturer. But still he (the pavement hawker) shows equal skill as the University lecturer in the application of "Mathematics" for the performance of his task—of course with reference to his own knowledge of the subject.

Furthermore, it is also interesting to note that even our ideas about the subject (Mathematics) seem to be changing. The concept in schools now is "New Maths". Similarly, in other fields of study too the "working knowledge" changes from circumstance to circumstance, depending on what the task is and how it has to be performed.

3. THE MEDIUM

"Knowledge" whether working or otherwise, is an intangible entity and on account of its abstract nature it cannot be communicated from one to another in the state in which it exists as such. If we wish to "share" our knowledge with the others we must first reduce it to a physical process because the pathways of learning are found only in our sense organs and the sense organs in consequence of their pre-determined conditions will not function unless they are physically disturbed. The technical aspects of this process by which we make our knowledge communicable are referred to as "Coding". The form which the "Message" takes is called the "Code" and this is exactly what is meant by "Medium".

Coding may be classified into three categories and they are:

(i) Behavioural
(ii) Digital
(iii) Analogic

(i) Behavioural Coding

This method, in all probability, is the oldest form of communication and it is generally confined to the animal kingdom. The "dance" of the bee mentioned earlier is a typical example. Wagging of the tail by the dog on meeting its master, ruffling of the feathers by birds at the approach of an enemy are also good examples of this system. Certain insects and some animals too, have developed a chemical process to exchange information. We have seen, very often, a dog urinating in several spots in order to cover a specified area. The purpose behind it is to inform the other dogs, through the olfactory channel, that the area covered by the urinated spots is "his" and that others must keep out of it. This process, also falls under the above category.

It is very likely that man too in his primitive life would have utilized this method to communicate his ideas to others. Sometimes even in his present "civilized" state of life he finds this age-old method very convenient. Whistling at ladies, making faces at a fellow motorist while overtaking him, shouting at meetings, though not very desirable, are some of the ways by which our "modern" man conveys his "thoughts" and "feelings" to others. Not to be outdone women also have developed their own system to communicate their "ideas" to others. This can be seen in their mode of dress, make-up and in their general approach towards the performance of their day-to-day tasks.

(ii) Digital Coding

Digital Coding is based on a series of "units" or "symbols". These "symbols" do not carry any meaning by themselves. Information is transmitted through a combination of these units. These meaningful combinations are called "words" and they do not bear any relationship to ideas or things which they represent. They are, as we might say, "name-tags" to things and events. This system has certain shortcomings. Firstly, they lack the impelling immediacy of actuality. Secondly, because of their step characteristics they 'lack the property of efficiently representing continua or changes over time'. [2]

The main advantage in this system is speed. The phonetic alphabet and the Arabic numerals are examples of this method.

(iii) Analogic Coding

In this system the medium of Communication bears a resemblance to the object or idea it represents. From time immemorial Nature has applied this method for the performance of some of her tasks. For example, the seed of Castor resembles a beetle. On account of its deceptive colouration the seed is picked up and carried away by a predatory bird. Later, on realising its mistake the bird discards the seed, thereby assisting the plant in the distribution of its species.

Analogic Coding can be sub-divided into three types:

(*a*) *Actuality*

Actuality means true or real experiences. Here we use actual materials to communicate our "knowledge" to others. For example, if we wish to show an ocean liner to the learner we take him to the harbour and show him the liner if there is one. If we wish to provide him with further experiences about the liner we take him on board the ship.

(*b*) *Imitation*

The term "imitation" is used when the medium of communication is a true representation of the actual phenomenon. The best example of such a medium can be found in Thailand. On the outskirts of Bangkok there is what is called "The Ancient City". It is actually a field museum. It contains true life-size replicas of the various "ruined cities" of Thailand.

In this place the learner can have a glimpse into the early History of Thailand by taking a leisurely walk around the place. In moving around in the area the writer was able to "experience" to some extent the various cultures, DVARAVATI (5th-12th Century A.D.), SRIVIJAYA (7th-12th Century A.D.), SUKHOTHAI (12th-14th Century A.D.) .....etc. which were responsible for the growth and progress of the Thai race. It was indeed a unique experience. It was so real that the writer did not find it necessary to visit the actual areas.

From the point of view of learning the "Ancient City" makes the finest contribution towards the establishment of "imitation" as a medium of Communication.

(*c*) *Simulation*

Simulation, basically means "imitation". It however, differs from the latter in that it (simulation) is a perceivable representation of an abstract phenomenon. For instance, the images of Gods and Goddesses are not imitations of what they actually are but simulations of our ideas about them. In technical language these images are called "simulachra".

If there is no religious connotation the medium is referred to as a "simulant". For example, the petaloid stamen of Canna. This structure is not an "imitation" of the actual petal but a simulation of what should have been a petal.

The actual petals of Canna are highly reduced and in consequence remain unattractive. Hence the modification.

In this context it also becomes necessary for us to point out to the reader that even a reduced or an enlarged model of a thing or an event has to be classified under the category of simulation because it (the model) is not a true representation of the subject.

Sometimes, a learner may need a training in a multisensory activity to perform a given task. If the training process required the use of an aid, such an aid is referred to as a "Simulator". Its purpose is to "imitate" the conditions peculiar to the desired activity. These three groups of material products, simulants, simulators and simulachra are popularly called "Audio-Visual Aids".

4. ENCODING

"Encoding" in contrast to "decoding", is that aspect of coding which deals with the construction of the message. This is a very important stage in the cycle of learning activity, for, a mistake in the process can distort the message and thereby draw the learner towards something other than what is desired.

We shall explain this with reference to that great Hindu epic "Ramayana". The primary aim of this story is to highlight the qualities of a virtuous woman and this is portrayed by Sita, the heroine. Rama, her husband, was heir to the throne of Ayodya. Due to some domestic displeasure caused by Rama's step-mother, both Rama and Sita decided to leave the Palace and live in a jungle hermitage for a while.

Rama's brother, Lakshmana, ignoring the popular belief that three is a crowd, keeps them company.

Ravana, the then reigning monarch of Sri Lanka (Ceylon) found it a suitable occasion to abduct Sita. His first step in the process was to send one of his aides, Mareeson, to

lure away from Sita both Rama and his brother Lakshmana. To fulfil this mission Mareeson transformed himself into a beautiful deer and approached the hermitage. Sita saw the deer and falling in love with it wanted Rama to capture it for her. Rama set himself to the task and went after the deer. Knowing its intentions the deer kept ahead of Rama all the time and in the process lured him (Rama) further and further away into the jungle.

Finally, having lost his patience, Rama shot the deer. The deer, which of course was Mareeson — Ravana's handyman, shouted out "Lakshmana I am in danger".

On hearing this distress call, Sita, fearing that Rama was in difficulties, asked Lakshmana to go to Rama's assistance. Whereupon Lakshmana pointed out to her that Rama had instructed him that under no circumstances should he leave her (Sita) to remain alone.

Sita, then, according to the Sanskrit version by Valmiki had said:

> "You traitor, it looks as if you have been waiting for such an opportunity. I am now inclined to believe that you accompanied us to the forest with a sinister motive: that if by chance Rama meets with his death you can have me for yourself". [3]

The rest is common knowledge and it is not relevant to our work. But Sita's statement is. What she had said destroys the very essence of the epic. No woman of any noble standing will entertain such thoughts in the first place, leave alone giving expression to them. Valmiki had failed in his mission. Because of this failure some scholars are of opinion that Sita may have eloped with Ravana.

Kambar, in his Tamil version of the epic brings the story back into its pristine glory. He says that Sita had threatened to destroy herself if Lakshmana did not leave immediately to rescue Rama. The beauty of it is that she did not say it in so many words. When Lakshmana refused to go she built a fire and with great solemnity started walking round it.[4] Lakshmana knew what she had in mind. He fell at her feet and said that he will leave at once to rescue Rama.

Kambar's excellence in presenting the desired ideals can be best seen in another incident.

When Sita was being carried away by Ravana she removed her anklets and necklace and threw them out to serve as signs to indicate the path by which she was being taken away. When the jewellery were shown to Lakshmana, he identified the anklets as Sita's but he was not sure if the necklace also was hers because he had never looked at her figure in full anytime. According to strict Hindu Code, it is improper for a man to look at a woman who is not his own wife.

To make matters worse Valmiki also says that Ravana carried Sita away bodily and had her seated on his lap. Here again, Kambar comes to the rescue. According to him (Kambar) Ravana did not even touch her. He (Ravana) carried her away by lifting the earth on which she was standing.

Valmiki's failure to code the message correctly has left many serious gaps in the story. So much so one is inclined to believe that Valmiki's Sanskrit version may not be the original.

Here is an interesting story which shows how a message should be coded.

During the 7th Century A. D. there lived in South India two well known saints — Thirunavukkarasar and Thirugnanasambandar. One day they both visited a temple and sang in praise of the Lord, Siva. The story behind it was that if the singing was of any good the door would open automatically. Thirunavukkarasar was the first to sing. To his great disappointment the door did not open. Thirugnanasambandar sang next and when he finished the door opened. Thirunavukkarasar was heart-broken. Thirugnanasambandar felt it and in order to bring his friend's system back to equilibrium, said: "Sir, Lord Siva did not mean to insult you. He was so taken up by your singing that he completely forgot about opening the door. But when I sang he opened the door to find out who the mischief-maker was!"

Coding is an art and one must learn how to do it. This is possible only when one really understands the meaning of the word "communication". The story related above explains this point of view beautifully.

Sometimes people engage others to code the message for them. There is nothing wrong with such practices because what is important is the transmission of the message and not the process of coding. As an illustration let us take the story of the Taj Mahal. When Shah Jehan wanted to communicate to the world the love he had for his wife he had the Mausoleum constructed.

Had he built it himself the "message" would not have been much different from what King Henry VIII had for Anne of Cleves.

5. TRANSMISSION

The coded message is now transmitted through the appropriate apparatus.

For example, if the message is coded in the form of a film-strip the transmitting apparatus is either a film-strip projector or a film-strip-viewer. If the message is presented in the form of an opaque picture, the transmitting apparatus is the opaque projector or the bulletin board.

6. RECEPTION

The message which is thus transmitted is received by the appropriate sense organs first because those are the pathways of learning. The message is then converted into pulse-train signals and transmitted to the brain.

7. DECODING

The pulse-train signals are now "decoded". The correct interpretation of the message depends on the accurate decyphering of the code. The following text is a good illustration of what is meant by "decoding".

"In 1821 Champolin made a capital discovery counting the hieroglyphic signs on the Rosetta stone and the words of the corresponding Greek text, he found the hieroglyphics outnumbered the Greek words three to one; thus it took several hieroglyphics to form a single word. Using a demolic script written on papyrus he confirmed the hieroglyphic name of Ptolemy and in 1822, succeeded in deducing and writing with almost perfect accuracy the name of "Cleopatra". [5]

8. INTERPRETATION

The decoded material must now go through a process of interpretation to know exactly what the message is. The names "Ptolemy" and "Cleopatra" referred to above are only name-tags. The "message" is more than that and this is arrived at by interpreting the context in which they are used.

Let us take a simple example. Suppose someone tells a little child that his daddy is tied up in his office, the child is likely to misconstrue the "message" and may become alarmed. Interpretation is equally important as decoding for good communication.

9. MESSAGE—II

Interpretation leads to the identification of the message and this shall be known as "Message II" because as Poincare says "the causes which have produced a particular effect cannot be reproduced except approximately". [6]

10. DESTINATION

"Destination" refers to the party with which the "source" has attempted to share its "knowledge". As stated above, the message that arrives at the destination is at its best only an approximation of what was intended. This causes an error in the actual output and it is rectified by the action of a psychological process called "Prediction" or "Anticipation".

"Prediction" (or "Anticipation") can be defined as a calculated guess the intention of which is to accomplish a mission which is only partially coded. We shall explain this phenomenon as follows:—

Given below are the names of certain countries and their respective capitals. They are arranged in a parallel sequence and there is a gap across England.

Australia	—	Canberra
Sri Lanka	—	Colombo
France	—	Paris
England	—	
Thailand	—	Bangkok
Malaysia	—	Kuala Lumpur

If the learner, who is acquainted with world geography, is asked to fill the gap, he will automatically write down "London" even though we have not asked him to name the capital of England.

This behaviour on the part of the learner is referred to as "prediction", and it plays a very important role in our day to day activities.

Sometimes we forget the exact location of a place which we visit occasionally. But when we reach the neighbourhood we recognise it at once. This is prediction too.

In music and also in playing games the task is accomplished, mainly, through predictive action. Surely, the members of an orchestra do not look at one another while playing their instruments.

Though this principle can be noticed virtually everywhere nobody ever recognized it as such for a long time. In 1899, the psychologist Bryan and an engineer Harter found that their subjects who were learning Morse Code began with a regular sequence of behaviour first by listening to the individual dots and dashes before tapping them out. But as they progressed they studied the "patterns" or the structures of the dots and dashes and then constructed the words and phrases directly as a whole instead of constructing them letter by letter.

As an illustration let us take the phrase "as far as". If this phrase occurs frequently, the brain will predict exactly what it is as a whole when the phrase appears as a familiar Morse Code. Then instead of transplating it letter by letter from each dot and dash the system moves directly to the construction of the phrase as a whole.

As pointed out by Bryan and Harter, "Transmission from smaller to a larger unit was accomplished by a marked speeding up of performances and today we can see why this is so. The subject no longer has to make a separate decision about each individual item or data or action; instead one decision can cover several." [7]

Perhaps, the following account will tell the reader how important "prediction" is in the process of learning.

On the 27th of June 1976 an Air France plane (Flight No. 139) was hijacked by some terrorists when it was on

its way to Paris from Athens. It was first taken to Benghazi in Libya and from there it was flown to Entebbe in Uganda. Most of the passengers were Jews and they were held as hostages. The conditions laid down by the terrorists for the return of the hostages was the release of fifty three detainees of whom forty were in Israel. The deadline was Thursday 1.7.76.

The Israelis viewed the problem from two angles, referred to as Track A and Track B. Track A was confined to negotiations with the hijackers while Track B dealt with the possibility of a semi-military raid on Entebbe.

If as determined by the terrorists Thursday 1.7.76 was to be the deadline, Track B was out of the question for, military intervention semi or otherwise, demands many things such as information about enemy movements, location of military installations, dress-rehearsals in commando attacks etc. and there was hardly any time for it. Under these conditions the Israeli government had no choice except to come to terms with the hijackers. *This was Prediction No. 1.*

The judgement was well made because shortly after they took this decision the relatives of the hostages broke into the Prime Minister's compound and demanded the release of the detainees—which of course was the condition laid down by the terrorists for the return of the hostages.

The military officers in Israel, however, were on full-time employment in Track B. The possibility of the deadline being postponed was there because President Amin was due to fly to Mauritius for the OAU (Organisation for African Unity) Summit conference and the terrorists may not attempt on anything drastic while the Dictator of Uganda was away. We shall mark this as *Prediction II.*

Fate, the mysterious controller of destinies, played her part well to make the terrorists postpone the deadline to 11 a.m. Sunday 4.7.76. And probably to gain time the Israeli cabinet agreed to meet the demands of the terrorists. When the news of the agreement was broadcast there was great rejoicing among the hostages and the soldiers guarding them remained with their minds unbuttoned.

The operation for the release of the hostages now swung round completely to Track B. *i.e.* military raid on Entebbe. The task was code-named "Thunderbolt".

Information on various matters such as the behaviour pattern of the terrorists, location of buildings in Entebbe, security arrangements etc. were collected by an underground network which evolved into an entity out of sheer necessity. From the data collected with the operation —"Thunderbolt", the officers concerned came to the following conclusions:

1. President Amin the "dangerous buffoon" as they called him—was very fond of publicity. The terrorists have given him the opportunity of being in the limelight of world news and the dictator naturally, would want the drama to continue. This would give the Israelis sufficient time to go through their dress-rehearsals for the task in question (*Prediction III*).

2. The man behind the hijacking was Dr. Wadi Hadad and he was greatly devoted to the cause of P.F.L.P. (Popular Front for the Liberation of Palestine). If this was so he would not order the execution of hostages in a hurry and so there was the possibility of further postponement of the deadline (*Prediction IV*).

These four 'predictions' filled in the necessary gaps to give the Israelis sufficient courage to launch the rescue operation and by Friday 2.7.76 "Operation Thunderbolt" was under way. The task force was put through its rehearsals — mock-combat assaults, first aid practices, airborne surgery etc. For transport the officers chose the C. 130 Hercules. It was a versatile plane and it was duly tested for her behaviour under adverse conditions— landing on invisible desert, minimum use of runways etc. These tests were necessary because the operation demanded a near silent arrival and a swift, steep take-off. The Chief of Staff, General Mordechai Gur, supervised the trial runs personally and he was convinced that if everything worked well the whole operation can be carried out under an hour—55 minutes as he predicted. He was almost on the dot in his calculations. The task was accomplished in 53 minutes !

When everybody concerned was satisfied that the mission would be a success the air armada took off at 3.30 p.m. Saturday 3.7.76 with the necessary 'cargo'.

One of the items included in the 'cargo' was a black Mercedes Benz, exactly like the one used by President Amin. The commandos were painted black and were

dressed as Ugandan soldiers. The first plane arrived exactly at the estimated time of arrival and taxied along to the old terminal building where the hostages were being held and kept guarded. Everything was still and silent. The ramp at the rear of the plane opened and the commandos spread out to take care of the terrorists. The black mercedes with its complement of "Ugandan soldiers" headed towards the airport guard posted near the control tower. When the door of the car opened the soldiers at the post saluted thinking that the President for life (Amin) was in it. Pistols fitted with silencers did the needful and the guards went on a long sleep—with their boots on.

The other commandos completed the rest and in the process two were killed by accident. There was no further mishap and the planes took off with the rest of the hostages.[8]

It is very surprising that America which churns out tons of material on audio-visual aids, Instructional Technology, Programmed Learning, etc. did not seem to have been aware of this valuable 'aid' (Prediction) in learning. Had they known it there would not have been any diplomats in the U.S. Embassy in Teheran for the Iranians to hold as hostages!

The rescue mission was a success because the guesses were well made *i.e.* calculated. If they were wild the mission would have ended in disastrous consequences.

Sometimes people who have vested interests distort the "message" by making wrong predictions *i.e.* wild guesses. One typical example is the theory about Indian civilization.

Most historians, particularly those from the West refer to Indian civilization as "Aryan Civilization". This is because an average Westerner thinks that all good things such as Education, Culture, Civilization, etc. must come from the West. *This is wild guess No. I.*

So in order to make this idea look good to the learner the historians invented a bogey called the split-migration theory. According to this ridiculous fantasy all the "greats", races and people except probably Mohamed Ali, arose out of a common stock called the "Aryans"—*Wild guess No. II.*

In due course these Aryans whose original homeland is still not known started migrating. This is a good story because if they had stayed in one place people would have known whether they existed or not. So the historians "set them on the move"—to avoid people asking embarrassing questions about who they were, what they were, whether they were running around naked with their faces painted pink, etc. After wandering about for a while these "Aryans" split up into two groups. One went West and became Europeans and the other came into India and became the Indians. The entry of this group into India is fixed at 1,500 B.C., by the historians of course. These people, a sort of half-brothers of those who became Europeans, are supposed to have been the ones who brought culture and civilization into India. Therefore Indian civilization became "Aryan civilization". *This is not only a wild guess but also a stupid one.* Can any one in his right senses believe such a theory? Even Fairy-tales do not carry such ridiculous ideas.

Shamelessly some Indians endorse this blatant distortion of truth for the simple reason that they want to be "one" with the Europeans. Amusingly enough it is this one thing which the Europeans are not prepared to accept from their erstwhile "half-brothers". Hitler made it unmistakably clear when he said:

> "All races other than the German Aryans are predestined to irremediable biological degeneration and hence to live under the rule of the pure Aryan German race." [9]

Others went even further. They wanted the non-German Aryans to be sterilized "so as to safeguard the state and the future of Civilization."

Reader, if you are of Indian extract and if you think that you are of Aryan stock consider yourself lucky that Hitler didn't win the war. Had it been otherwise you would have by now, lost some of your most valuable belongings!

It was you whom Hitler had in mind when he said "all races other than German Aryans".

Let us now look at this story —"Aryanization of India" from the point of view of academic values.

1. The Aryans were supposed to have come into India through the Kabul valley. Knowing the Pathans (Afgans) as we do it would not have been an easy matter for the Aryans even to enter the area, unless of course all the Pathans were killed in the process. This cannot be true because the Pathans are still there and the Russians are learning it the hard way.

2. Even if the Aryans had come through they would have been thoroughly exhausted to subjugate the Indians who at that time, according to the Aryan theory, must have been only savages. One must remember that it is not easy for anyone to fight and subdue a savage. He would rather be killed than be subdued.

3. Did the Aryans have any kind of architecture worthy of their name? The answer is no. There is nothing called "Aryan Architecture".

John Bowle in his book "Man through the ages" says: "Nothing survives of Aryan architecture which was mainly in wood and bamboo. The urban and court culture had a background of mud and thatched villages spread out over great plains....." [10]

4. John Bowle, this time paying tribute to the Aryans says:

"Aryan literature was elaborate and its unbroken tradition is the oldest in the world, the hymns of Rig Veda (1,500-1,000 B.C.) still form the core of Hindu sacred books". [11] Hinduism began with the worship of Siva and in one of the seals found in Mohenjo Daro there is an image of Lord Siva. Mohenjo Daro's period is well beyond 1,500 B.C. Therefore the Aryan Rig Veda cannot form the core of Hindu sacred books.

Further, John Bowle also says that the Aryans had a "pastoral nomadic background". One is at a loss to understand how a nomadic tribe can produce "elaborate literature".

5. Where did the Aryans come from? Some say they came from Southern Russia. Others are of opinion that they probably came from a region now called Czechoslovakia. An Indian educationist has now claimed that their ancestors — the "Aryans" came from the Arctic circle! Some education that is: and no wonder India has a few problems! Whatever it is no one seems to be aware of the place of origin of these "pastoral nomads".

6. Lastly, what was the religion of the Aryans? Those who came to India were Hindus because they brought with them the Vedic hymns — "the core of Hindu sacred books"! What about those who went to Germany? And what about those who went to Iran? Did they take their Vedic hymns to those countries too? If so, what happened to them? Were they rejected in favour of Christianity and Islam? If that was so it only means that either:

(i) The "Aryans" were opportunists.

or (ii) They (the Aryans) simply did not exist.

In all probability the latter is correct for, Max Muller who started the myth about the existence of an "Aryan race" later said:

> "I have declared again and again that if I say Aryans I mean neither blood nor bones nor hair nor skull. I mean simply those who speak Aryan language". [12]

In all likelihood, the concept of "Aryanism" may have originated quite harmlessly to set the guide lines for the refinement of man's life. But unfortunately it took a diabolical form in the hands of the Nazi dictator Adolf Hitler. Hitler used the term "Aryan" to denote White supremacy and he applied this idea to good advantage in his political meetings. This theory — of White supremacy — however, was demolished by Jesse Owens when he outclassed the Whites in the 1936 Olympic Games held in Berlin. Hitler was furious. But it was too late for him to do anything about it. Only thing he could do was to refuse to congratulate the champion. That was his idea of Aryan culture!

Aryanism, as it is understood now, is nothing but a fashionable nonsense which secretly fosters the illusion that leaders are born and not made. It is surprising to note that India which claims to be the largest democracy in the world is still entertaining it and there seems to be no sign of her abandoning it.

May be, the following observations by Swami Vivekananda might bring her to her senses:

"What your European Pandits say about Aryans sweeping down from some foreign lands snatching away the land of the aboriginals and settling in India by exterminating them are all pure nonsense, foolish talk. Strange that our Indian scholars, too, say "Amen" to them and all their monstrous lies are being taught to our boys. This is very bad indeed". [13]

Coming now to the actual facts about Indian Civilization the following report provides some useful answers:

"Investigations made by anthropologists, including minute examination of fossil remains found in the Tirunelveli district, reveal that South India was once the passage ground of many ancient races of the Mediterranean countries. Adverting to the Tamil people inhabiting South India, Swami Vivekananda has made the following remark. "The Madras presidency is the habitat of the Tamil race, whose civilization was the most ancient and a branch of whom called the Summerians spread a vast civilization on the banks of the Euphrates, in very ancient times, whose astrology, religious lore, morals and rites, etc. furnished the foundation for the Assyrian and Babylonian civilization and whose mythology was the source of the Christian Bible. Another branch of these Tamilians spread from the Malabar coast and gave rise to the wonderful Egyptian civilization, and the Aryans also are indebted to the race in many respects."

The antiquity of the Tamilians and their rich heritage of literature is computed to be more than 20,000 years old. Historians, archaeologists and geologists are of the opinion that Tamilakam (the ancient home of the Tamil speaking people) was actually the continent of Lemuria which is now submerged beneath the Indian Ocean.

Many scholars have written about the existence of a great mass extending beyond the present Kanyakumari in the Indian Ocean. An examination of these views corroborate the literature of Tamil-speaking people.

Sir Walter Raleigh, in his authoritative work, "History of the World" stated that "India was the planted and peopled country after flood". The December 1900 issue of the "Science of Man" mentioned "the locality of the origin of the earliest race from the most recent researches appears to have been on lands now submerged beneath

the Indian ocean". Sir John Evans, in 1897, in his presidential address to the British Association, mentioned Southern India as the cradle of the human race. The same view is held by Dr. Maclean, author of the book, "Manual of the Madras Presidency." Scott Elliot, in his treatise, held the view that the original abode of man was in the Indian Ocean.

Sir T. V. Holdemess, in his scholarly work, "Peoples and Problems of India" stated that "Peninsular India or the Deccan (literally the country of the south) is geologically distinct from the Indo-Gangetic plain and Himalaya. It is the remains of a former continent, which stretched continuously to Africa in the space now occupied by the Indian Ocean. Its rocks show no traces of having ever been submerged. In many parts they are overlaid by sheets of trap rock or basalt which once flowed over them as molten lava. The Deccan land is almost same as it existed before the beginnings of life. The Indo-Gangetic plain stretched without a break from the Indus on the west to the delta of the Ganges on the east, a distance of 1,200 miles. Before the elevation of the Himalayas, the space now occupied by this plain was a sea. The southern shore of this sea was what is now peninsular India. With the rise of the Himalayas, the sea disappeared."

The historical information available from Ceylon also provides evidence to the occurrence of cataclysmic land-shifts. E. I. Tambimuthu, a great scholar from Jaffna, referred in his book, "Dravida" thus: "Marine biologists are actually of the opinion that an onrush of the sea had arisen in pre-historic times and separated India from Ceylon and if the tradition of the Tamils — the very people who inhabited the submerged country and who alone could have witnessed the event be given credence, this must have happened about 5,400 B.C." J. E. Tennent, an English scholar, in his book, "Ceylon" referred to a cataclysmic landshift in B.C. 504 during the reign of the king Banduvasa when India was completely separated from Ceylon.

LINGUISTIC AFFINITY

There is evidence to prove that Tamilakam was a large continent — vast in area bordering Africa in the west, Australia in the south and extending to Kamaschatka in the east. W. W. Hunter, in his "History of India" mentioned that the language

spoken of the north-east corner of Asia (Kamaschatka) bears resemblance to ancient Tamil and appears to be a dialect of it. The language spoken by the Maoris of New Zealand is also similar to Tamil. Historians are of the opinion that the people who migrated to distant lands after the successive cataclysmic land-shifts in Lemuria or Tamilakam had actually established colonies in the Americas, especially Mexico and Peru. It is pointed out that the language spoken in Tuscany in Italy is a dialect of Tamil. Linguists and scholars also have found a major similarity with the Scots, especially in language, manners and customs. Hebrew and Greek abound in Tamil words which could be recognized. Research scholars and linguists thus indicate that the great classical languages of the world are actually Sanskrit and Tamil.*

The existence of the Tamil Academy or Tamil Sangham is mentioned in the ancient history of the Tamils, "Silappadhikaram", one of the celebrated of the five Tamil epics written in the second century A.D. by Ilango Adigal, frequently referenced a vast tract of country called Kumari Nadu (identified as Lemuria by European scholars) extending far beyond the present Kanyakumari, lying submerged in the Indian Ocean. It is said that ancient Madurai was the seat of the Tamil Sangham (Academy) and Kavatapuraum (or Muthoor) was the capital of the Pandyan Kingdom. The Tamil commentators, Atiyarkkunallar, Nachi Nark-Kiniar and Ilampuranar, mention the submersion of two rivers, Kumari and Pahroli in Tamilakam. The region was interspersed with hills and mountains with a bewildering variety of flora and fauna. The Tamil Academy (Sangham) was patronized by the ruling Pandian kings. It was reported that in "Silappadikaram", between the rivers Pahroli and Kumari, a vast tract of land extended 700 kavathams. It was divided into 7 Thanga Nadu, 7 Madurai Nadu, 7 Munpalai Nadu, 7 Pinpalai Nadu, 7 Kunra Nadu, 7 Kunakkarai Nadu and 7 Kurumporai Nadu or 49 Nadus in all.

FIRST DYNASTY

Among the most prominent mountains was the Mani Malai, where precious stones including rubies were mined. The Meru mountain also produced gold and caused an ancient proverb "Meruvai cherntha kakamum Ponnam". It is also said that Chinese labourers, employed by the Pandian king, appeared like a huge army of small ants when they descended into the mines. They were called "Pon thondi Erumbukal". The above data is also confirmed by ancient Chinese chronicles. The Meru mountain, with 49 peaks and by its side flowed the Peru Aru. The topography of this land is described in poetry of the "Tamil vidu thoothu". It is said that the river, Pahroli was excavated to

irrigate the mountain valley by the Pandian king, Nediyon —first Nilamtharu Neduvirapandian (otherwise called Azhivadivampalam, Pandian Jayamakirty). After establishing his capital, the Pandian king ruled over the adjoining lands called Oilnadu, Peruvala Nadu, Kumari Nadu and Pandya Nadu. The Pandian king established the Tamil Academy (Sangham) and patronized the Tamil Language. The Pandian kings, who established these sanghams on the banks of the rivers Kumari and Pahroli, lasted from 30,000 B.C. to 16,500 B.C. (for about 13,500 years)."[14]

What gave currency to this so called Aryan theory was that "Sanskrit", in which most of the Indian literary and scientific works were recorded was claimed by Westerners as one of their "Aryan" languages because there was some "commonness" between Sanskrit and the Western languages. This can be due to mutual borrowing and because of this one need not run away with the idea that Sanskrit came from the West.

Indian Civilization is built around the concepts embodied in the two great epics "Ramayana" and "Mahabaratha". The events connected with them are believed to have taken place long before the arrival of the so-called Aryans. The beginning of Mahabaratha war is dated as 3,067 B.C. and Sri Rama's departure to the Forest as 4,414 B.C. [15] Sanskrit was in usage during both periods. Then how can one say that "Sanskrit" was brought into India by the Aryans in 1,500 B.C.?

Sanskrit is a product of pure Indian thought and it was developed as a language to keep records of all the great works of Art, Culture, Science, Education, etc. of all the various linguistic groups of India. The purpose was to enable all the people of India to have access to them.

This, probably, was man's first attempt at understanding the concept of "conservation of energy". Indian civilization was built on it and not on any fancy notion of the West.

Let us take another example — The origin of the Fijian race. Here again the "Truth" seems to be somewhat distorted. People in general are of opinion that the Fijians are cannibals whose ancestry lies in a primitive savage society. This is because almost all the books written about them say so. In all probability those who wrote these books have neither visited Fiji nor met any Fijians. All what they had, to work with, were some wierd accounts of tribal warfare where the winners ate the losers or some such rubbish. These 'accounts' were well spiced, and supplied by such characters

whom James Michener had immortalized in his most engaging masterpiece, "Rascals in Paradise". The reader can now understand what kind of stories people would have written about Fiji.

If one wishes to study about a particular race one must live amongst its people and understand their ways. This is what the writer did. While he was on the staff of the South Pacific Commission he had the opportunity of living in Fiji. During his stay there he came to know the Fijians well. Contrary to popular belief he found the Fijians to be a highly cultured race. They were pleasant and honourable in their ways. They had no use for such games as tennis, badminton, bridge, etc. They consider it below their dignity to play such games, which, they say, are meant only for women. Rugger is their favourite game. These characteristics are the hallmarks of a civilized community and not those of a savage tribe. Encyclopaedias say that Fiji is the last outpost of Melanesian culture. This again is not correct. Fijians are quite different from the Melanesians. Fijians have more in common with the Maoris than with any other race in the Pacific. These facts made the writer wonder whether people said the right things about the Fijians.

One day, quite by accident, the writer came across a booklet called "The Fijian Wanderers". While going through the pages he found, to his astonishment, some fascinating information about the origin of the Fijian race.

According to the author Ann Tyson-Harvey, the original home of the ancestors of the present Fijians was in "Turania" in Asia Minor. For some reason or other they left their homeland and migrated to Egypt under the leadership of a chief named Tura. These people mixed freely with the local population and some of them married the Egyptians. After some time Tura, their chief died and his son, Lutanasobasoba took over the leadership of the clan. He decided to move on further to the south and the tribe followed him. When they reached Lake Tanganyika they decided to settle down there. Later, not being satisfied with the place they moved again, now eastwards. On reaching the coast they found that the area was already occupied by other tribes. It was then that they decided to sail away.

They built large canoes and putting all their belongings in them started on their long journey into the unknown. The young Chief Lutanasobasoba had all the valuables, ornaments, documents, relics, etc. put into a large trunk and this trunk was safely stored

away in the canoe in which he sailed. After a long and adventurous voyage they arrived in what is now known as the Fiji islands. One may wonder whether such things are possible. The answer is yes. William Bligh, Captain of the battleship "Bounty", along with eighteen other people was put into a 23-foot life-boat and set adrift in mid-Pacific by his mutinous crew. He (Bligh) covered 3,600 miles in this tiny craft and reached Timor, in Java safely. Coming back to the story, the ancestors of the Fijians ran into many storms during their epic voyage and they came through most of them without much mishap. But in one they lost all their belongings including the trunk containing their valuables. This happened shortly after the party had left what is now called "Solomon Islands". Since they lost all their materials the Fijians passed on their story orally to each new generation, like the "Vedic hymns"— of the Aryans. Here are some facts from the "Vedic hymns" of the Fijians:

1. The early Egyptians worshipped the spirits of the dead and the Fijians did likewise.

2. The Egyptians looked upon birds and animals as "Gods". This is so in Fiji. Snakes, Turtles, Sharks, etc. are regarded as "Gods" of the tribes.

3. The Egyptians filled the Tombs of their Kings with many things for the use of the spirit in "after life". The Fijians also filled the Tombs of their chiefs with valuables — 'so that the spirit would have its own possessions when it arrived in the world hereafter or as it is known — Eternity'.

4. The Egyptians built Temples to honour their chiefs. The Fijians also built Temples to honour their chiefs.

5. The Fijians made masai cloth from the mulberry tree. The Nile valley dwellers have been practising this for centuries.

6. There is a coastal settlement near Bau in Fiji called "Kiuva". In Africa there is a lake by the name "Kivu". It is connected to lake Tanganyika by the river Rizizi.

7. In the main island of Fiji (Viti Levu) there is a place called "Magodra". This sounds similar to "Morogoro" in East Africa.

8. Besides, there is "viria" in the upper Rewa river (Fiji). This name could have been a modification of the African name "Uvira".

9. Lastly, take the word "Fiji" and compare it with the following African names:—

Fizi, Ujiji, Rufiji and Rizizi.[16]

Most probably it (Fiji) is derived from them.

As the author says: Could all these names be alike by coincidence? What we have reported above shows that the ancestors of the present Fijians may have come through Africa. Now we must ascertain their origin. According to what we have said earlier the ancestors of the Fijians came from "Turania" in Asia Minor. Curiously enough this was also the home of the Early Etruscans but the name was slightly different. It was called "Tyrrhenia"—*vide* Fig. 7. Again, one of the early settlements of the Etruscans was called "Vetulonia". This sounds very much like "Vitu Levu", the island on which Suva, the capital of Fiji is situated. Historical records say that the Etruscans were a gay people, fond of good food and dancing. So are the Fijians.

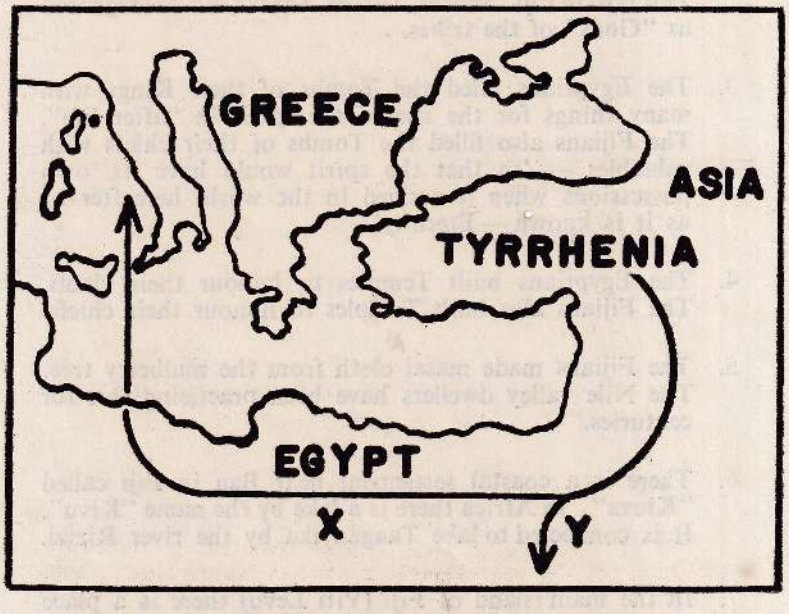

Fig. 7. X — *Migration of the Etruscans.* **
Y — *Migration of the Ancestors of the Fijians.*

Could it be that the "mysterious" Etruscans and the early ancestors of the Fijians had a common origin? If what Ann Tyson-Harvey had said in the "Fijian Wanderers" is true then there is every reason for us to give the answer in the affirmative. The following evidence makes it doubly convincing:—

> In the life of mankind the matter that holds fast to a community is its religion and the customs associated with it. Nobody seems to know exactly what the original religion of the Fijians was. But everybody is agreed that they worshipped the spirits of the Dead and they built Temples to keep the remains of the dead. These shrines were called Bure-Kalous (House of God). There is a model of a Bure-Kalou in the National museum of Fiji and its shape is very much similar to the Etruscan Funerary urn where the ashes of the dead are kept—*vide* Fig. 8.

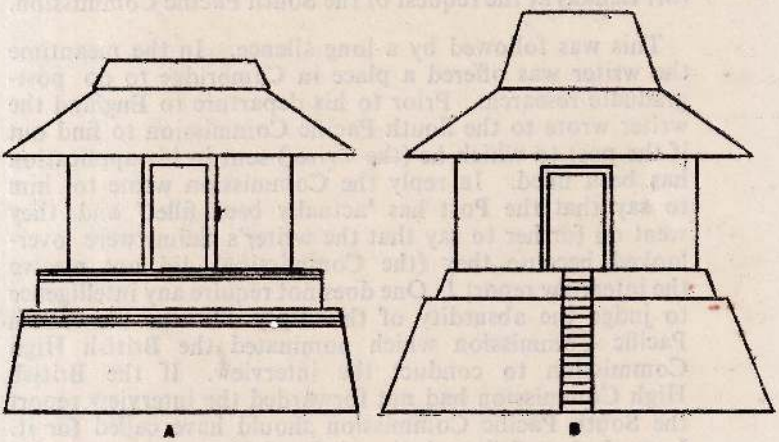

Fig. 8. A. — *Funerary Urn of the Etruscans.*+
B. — *Bure-Kalou* (*House of God*) *of the Fijians.*

11. INFERENTIAL FEED-BACK

Inferential feed-back constitutes the sum of what the learner does after completing his course of study. His performance in the examination, behaviour in social life, ability to predict future events etc. are all part of this component of the communication net-work.

Its function as explained earlier in Chapter II, is to "regulate" or "stabilise" the system with reference to the task that has to be performed. If the feed-back does not correspond to what was expected, then the learning programme must be reorganized to bring about the desired results.

12. AUXILIARY FEED-BACK

More often than not the coded message is transmitted without a final check on the objectives. This can be disastrous. The following incident in the writer's life is a good example to show how valuable the Auxiliary feed-back is in the performance of a task:

Sometime ago, during the early part of 1967, the writer, in response to an advertisement calling candidates for the post of Teaching Aids officer in the South Pacific Commission sent his application to the agency concerned. He was later interviewed by the British High Commission in Ceylon (Sri Lanka) at the request of the South Pacific Commission.

This was followed by a long silence. In the meantime the writer was offered a place in Cambridge to do post-graduate research. Prior to his departure to England the writer wrote to the South Pacific Commission to find out if the post to which he (the writer) sent in his application has been filled. In reply the Commission wrote to him to say that the Post has 'actually been filled' and they went on further to say that the writer's claims were over-looked because they (the Commission) did not receive the interview report ! One does not require any intelligence to judge the absurdity of this reply. It was the South Pacific Commission which nominated the British High Commission to conduct the interview. If the British High Commission had not forwarded the interview report the South Pacific Commission should have called for it. Instead they followed the path of least resistance and penalised the writer.

The writer's immediate reaction was to write back to the South Pacific Commission asking them to fold up their contraption and follow a course in administrative studies.

Then he cautioned himself to check on the objectives: What was the purpose of the letter? Was it to have some fun at the expense of the Commission or was it intended to make them reconsider the writer's claims for another post there if and when a vacancy occurred?

Most certainly, the latter was the intended objective. If this was so the message has to be coded accordingly and the reply he sent was as follows:-

"Thank you very much for your letter of.....I am sorry to note that you did not receive the interview report. Probably it must have been lost in the post. Nevertheless it is just as well it happened the way it did for had I been appointed to the Post I would have found it a difficult task to make the choice between the two offers, yours and that of Cambridge. I shall however be interested in the Commission.

....."

After sending the letter the writer left for Cambridge. A few months later another vacancy occurred in the South Pacific Commission and they wrote to the writer asking him if he would be interested in joining their staff. It did not take much time for the writer to say "Yes". Shortly after he found himself in their midst. This became possible because the writer selected the most appropriate codes to establish a communication linkage between the South Pacific Commission and himself.

Had he (the writer) on the other hand sent out the reply as originally planned *i.e.* asking the Commission to fold up their contraption etc., etc., he would have had cause to regret.

What the writer did was, he imagined himself as the Secretary-General of the South Pacific Commission and viewed the "letter". He was amused. But if he was the Secretary-General of the South Pacific Commission he was not going to "share" that knowledge.

Imagining oneself as another is called "make-believe" and the "knowledge" that one acquires through such a process constitutes what is called an "auxiliary feed-back". Its function is to pre-control a system.

Auxiliary feed-back includes such things as: staff discussions about lessons, pre-views of films, micro teaching etc.

It is actually a safety measure and the teachers will be well advised to pay attention to this principle when they plan their lessons.

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* In the published article it says—"the great classical languages of the World are actually Sanskrit". In terms of the context it should be "Sanskrit and Tamil". Hence the addition (Tamil).

This is a good example to show what exactly is meant by "Prediction".

** Source
\+ Source } : *Knowledge*
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U. K.

CHAPTER IV

SIMULATION AS A MEDIUM OF COMMUNICATION

The conception of simulation as a medium of communication arises from the age-old principle "like causes produce like effects". This principle was known to man for a very long time and its application for the performance of a task can be traced back to primitive times. The following text bears evidence to this fact:

"Perhaps the most familiar application of the principle like begets like is the attempt which has been made by many people in many ages to injure or destroy an enemy by injuring or destroying an image of him, in the belief that just as the image suffers, so does the man that when it perishes he must die. A few instances out of many may be given to prove at once the wide diffusion of the practice over the world and its remarkable persistence through the ages. For thousands of years ago it was known to the sorcerers of ancient India, Babylon, and Egypt as well as of Greece and Rome and to this day it is still resorted to by cunning and malignant savages in Australia, Africa and Scotland".[1]

In the same way as how this method (imitative or Homeopathic magic) is used for spiritual purposes of putting 'obnoxious people out of the world', it has also been applied to help people who are in distress.

Among the Bataks of Sumatra a childless woman who desires to have a child makes a wooden image of a child and holds it in her lap, believing that her "make-believe" behaviour will lead to the fulfilment of her wish.

In another territory this process is carried out in another way. The woman who wishes to have a child invites a man who has a large family "to pray on her behalf to Upulero, the spirit of the sun. A doll is made of red cotton, which the woman clasps in her arms, as if she would suckle it. Then the father of the many children takes a fowl and holds it by the legs to the woman's head saying "O Upulero, make use of the fowl; let fall, let descend a child. I beseech you, I entreat you, let a child fall and descend into my hands and on my lap". Then he asks the woman "Has the child come"? And she answers "Yes, it is sucking already". After that the man holds the fowl on the husband's head and mumbles some form of words. Lastly, the bird is killed and laid, together with some betel, on the domestic place of sacrifice".[2]

At the conclusion of the rituals a rumour spreads around the village that the woman is "expecting" and her friends come round to congratulate her. If anything ever happened it was just coincidence. There is no real proof to show that these rituals brought about the desired effects. All we can say is that these rituals may bring about certain mental relief to the woman concerned. In this context it is interesting to note that Nature also performs a similar function through the medium of false-pregnancy. When a barren woman develops symptoms of pregnancy she is relieved (temporarily) of the sorrow of being childless.

The Dyaks of Borneo have developed an interesting technique to facilitate child-birth. In the maternity ward a witch-doctor stands outside the labour room with a stone tied to his abdomen. When the woman develops labour pains the "wizard" standing outside the room pretends that he is also having such pains and he imitates the actions of the woman who is in pains. These false "imitations" are supposed to make child-birth less painful.

What has been said above refers more to witch-craft than to religion. In primitive societies witch-craft and religious practices were closely related to each other. It is therefore not surprising to find people applying this method for religious practices as well. Here again the origin can be traced back to ancient times.

Almost all Hindu rituals are based on simulation. The metaphysical phenomena are reduced to tangible representations (simulachra). In other societies too, where image-worship is practised the religious activities follow simulation methods. In certain primitive societies even death is simulated.

What effect these images have on the minds of the people is an open question. The only satisfactory explanation we can provide is that these images function as "controls" to regulate the behaviour of the human system.

Let us now examine this problem, *i.e.* controlling the behaviour of the human system, as a task to be performed. The first step in the performance of this task is to formulate an operational plan which becomes the "intended output". This "intended output" is then reduced to a tangible form and that is the Image. We then prepare a list of desired ideals such as, speaking the truth, avoiding gossip, treating the beggar with kindness, etc. These "ideals" are then associated with this "Image" which of course is our representation of "God".

It must however, be borne in mind that in our present physical state of life it is difficult for us to know exactly the nature and quality of Gods and Goddesses because as Protogoras says 'we are not in a position to experience their phenomenal existence or otherwise, nor their nature with regard to their external manifestation: not only the impossibility of having a sense-experience of the Gods but also the brevity of human life'.[3]

Conditions being such it became necessary for man to create his own idea of God. Later he reduced it to a tangible form (Image) for purposes of communication. These "Images", as we have mentioned earlier, are called "simulachra".

Our next step is to "imitate" this idea—of God, *i.e.* speaking the truth, avoiding gossip, etc. With the first practical move we establish a closed-loop control circuit. From then onwards we proceed to reduce the gap between the intended and the actual output as in the case of learning to drive a car.

If the gap does not get reduced, as we find in most cases, the whole purpose of the task is lost with a considerable waste of energy.

But on the other hand if one can reduce the gap to the required standard so that his actions (the actual output) superimposes on his concept of God then he becomes "one with God". This should make him sufficiently happy "in his present state of life". This "happiness", which is necessary for one to keep oneself "in a constant state of equilibrium with the forces external to it", is attained through a process of simulation. Concerning simulation in Hindu rituals nothing is more interesting and more effective than the following practice in Tamil weddings.

On the ceremonial platform are included, among other things, two items of great significance. They are (*a*) a twig of spiny Erithrina indica and (*b*) a grinding stone. The story behind it is that, Indran, the Chief High Priest and Lord of the so-called "Aryans" took a fancy for the wife of a Rishi called Gauthamar. One day, shortly after midnight, this Lord of the "Aryans" descended to our mother Earth and made his way to Gauthamar's hermitage. On reaching his destination our heavenly visitor hid behind the Rishi's cottage and crowed like a cock. On hearing the crowing, Gauthamar, misinterpreting the "code " as a signal for the breaking of dawn went down to the river for his usual bath. After finishing his morning ablutions the Rishi prepared to leave for home for his "bacon and eggs". It was then that he realised that something had gone wrong somewhere: the sun was missing! Utterly confused, he used his spiritual powers to check on the movement of the sun. As usual the sun was on his normal course. It was he who had made a mistake. Suspecting something sinister he focussed his "powers" on to his own home.

He was confronted with a sight—a sight which would have put Marlon Brando's "Last Tango in Paris" in the category of children's films.

It was Aryan culture in its "Sunday best". In a fury like the proverbial "woman scorned" Gauthamar raced back to his abode like a super-sonic jet. Taking Indran by surprise he threw a curse on him—to the effect that his (Indran's) body should be covered with ugly scars, each of which to take the shape of what brought Indran to this sad predicament. He tnen turned his wrath on his wife Ahalihai. Not being satisfied with her explanations he transformed her into a grinding stone.

Badly mauled, Indran went back to his heavenly home, sadder, but not wiser by any means. For, on a later occasion he upset the applecart of another Rishi, Visvamithra. Here is the story: Visvamithra was sitting in meditation to invoke the blessings of the Gods and thereby to obtain from them as a boon certain "supernatural powers". What these "powers" were to be, nobody knew. But Indran was alarmed because Viswamithra was a formidable Rishi and too difficult to handle even under normal circumstances. With "supernatural powers" he could be far worse. than Gauthamar. So Indran sent one of his Court dancers, Menaka, to distract Viswamithra. She went a little too far and ended up with "Sakuntala" the heroine of Kalidasa's famous play by that name. Anyway that is beside the point. She (Menaka) however, fulfilled her duties. Indran was pleased. Visvamithra had to start his business all over again. Fortunately, he did not know who was at the bottom of it all. Had he known it, the story wouldn't have ended with "ugly scars".

Now, getting back to our subject, the two symbolic items (*a*) twig of Erithrina indica and (*b*) grinding stone are placed on the ceremonial platform to serve as "sign-boards" of warning to the bride and the bride-groom. The spiny twig of Erithrina indica symbolises Indran under the curse. The spines are the "ugly scars". The twig is there to remind the bride-groom of the fate that befell Indran when the latter deviated from the path of righteousness. Likewise the grinding stone symbolises the fate of Ahalihai, the erring wife of Gauthamar. It is a warning to the bride.

Technically speaking, the two items (Erithrina indica and the grinding stone) function as "controls" to direct the behaviour of the bridal couple towards the desired social norms.

Though man claims to have applied these methods (simulation) for Communication from primitive times it was Nature who first

employed these techniques for the performance of some of her tasks. For example, the dispersal of seeds in Castor—described eariler.

The same technique, popularly referred to as mimicry, have also been employed equally well for the preservation of species. The stick-insect imitates the foliage on which it rests to escape its enemies. The grass-hoppers do likewise for the same reason.

The ingenuity of Nature in using simulation as a technique can be best studied in the obliterative design she has provided for the zebra. In his observations on "Adaptive Colouration in Animals" Cott says that these stripes of the zebra, besides helping the animal to conceal itself, may also cause the predator to misjudge its leap. Because the stripes make the zebra appear bigger than what it is.[4]

Certain animals have adopted this method for purposes of defence. The Indian hornworm pretends ferocity to drive away its enemies. At the approach of an enemy the hornworm retracts its real head to reveal a set of frightening "eyes". Later when the danger is over the head moves out to take its normal position and the "warning" eyes disappear into a skinfold.

In this context it is interesting to note that some people, particularly in Sri Lanka (Ceylon) have the habit of prominently displaying the letters G.B. (Great Britain) at the back of their cars. The implied meaning of this "advertisement" is that the owner of the "G. B." vehicle has been overseas and thereby he is entitled to a certain amount of attention from the public at large. Such "displays" arise out of a fear of "insecurity" which is inherent in all living organisms. They (the displays) may therefore be classified under 'defence mechanisms' just as in the case of the Indian hornworm.

On the question of defence it may also be said that certain insects acquired 'the external appearance' of another species that is armed with venoms or other undesirable qualities which are advertised by a suitable warning colouration.[5]

Using the same principle of 'protective similarity'—presenting the appearance of one species of insect to another the edible Papilio dardanus escapes its enemies by successfully mimicking the distasteful butterfly Amauris albimaculata.

In recent years, scientists have successfully applied the principles of simulation to evolve a complete plant out of a single cell. In an article under the caption "The control of growth in plant cells",

F. C. Steward makes the following observations with reference to an experiment he has carried out to cause the development of a carrot plant from a single cell: "Experiment begins when, as shown at left, a thin metal tube is used to cut small carrot segments or explants, which are then placed in a tube containing a growth medium that includes coconut milk. The medium thus *imitates* the nutritive functions of the endorsperm". [6]

The word "imitates" *italicised* by the writer connotes "simulation".

In this technique we see a possible solution to the food problem affecting the whole world. The difficulty in this technique lies in identifying the exact material which will simulate the environmental conditions necessary for the growth and development of the species concerned.

Although there are many fields in which simulation has been applied successfully to bring about the desired results, it was only in the field of engineering that it received academic recognition. The following report confirms what we have just said:

"A model is the only means of solving some of the more complex problems of fluid motion. Channels through natural topography, for example, do not permit of mathematical definition. Nor is the influence of untried combinations of artificial shapes easily expressed without danger of presumption. But an unfailing law, called the "Law of Similitude", connects the model with its prototype. Briefly this Law states that like configuration of causes produces like configuration of results.

The ability of a small scale model to reproduce in miniature any occurrence that takes place in or near its larger counterpart depends upon a few simple laws of mechanics. These major laws are often undisturbed by any imperfection of the fluid, and the derived features are then open to exact comparison. In the interest of simplicity when evaluating the performance of a model, any secondary influence may well be held in the background until found to be of numerical importance by the test of accepted criteria. Experiments can be tried out without much cost.

Models help to instil confidence even in examples that accurately follow the fundamental laws.

The Weisbach experiments on short tubes, for example, were model experiments substantiating the theory, both quantitatively and qualitatively.

Models correctly indicate such features as water profiles, mean velocity, local wave patterns, periodic vortices, and forces on obstruction such as bridge piers.

The theory of models deals with the quantitative relation of results in regard to length, time and force. All physical phenomena may be described in these three fundamentals. All that is known is expressed in these terms and all that is sought may be similarly expressed. The specific purpose of a given model determines the necessary refinement of measurement and the degree of tolerance for such influence as viscosity or surface tension.

The art of predicting the performance in hydraulic structures by means of data collected from small models is the result of more than a century of refining influence.

In a model that is geometrically similar to its prototype, all homologous distances are proportional to those of the prototype regardless of the plane in which these distances are measured, whether horizontal, vertical or inclined at an angle.....

In conclusion may it be said that much valuable information can be gained from a model even though the observer be familiar only with the simple scale relationships herein derived". [7]

Simulation techniques can be applied in games too. Here is an illustration:

In the 1959 Tennis Tournament conducted by the Kandy Garden Club, the writer met Dr. V. C. de Silva in the semi-finals of the Men's Open Singles event. They were evenly matched. Both had played for the University (Ceylon) at the same time and both had won their Tennis colours there. As one would say, it was anybody's game. And it proved to be so when the score was set all and two all. At this stage the writer (K) broke through his opponent's service and led 3-2. But on his own service he was down 15-30. It was a dangerous situation and he knew it. One more mistake could be fatal. At 15-40 the writer's chances of winning that point were very little. Then at three all and the service going over to his opponent the writer's chances of winning the match were also little. Therefore the score had to be brought to 30 -30 at least.

The play at this point started on a sober note and in due course led to a long rally. Both parties played cautiously watching for an opening for the "kill". Then due to some miscalculation the writer played a weak back-hand shot which fell short on the fore-hand court of the opponent and the latter seized the opportunity

to drive the ball cross-court. The ball bounced at I and headed towards X (*vide* dotted line — Figure 9). The writer ran across to retrieve the ball. The situation was hopeless but the writer ignored it. As he ran, he, through a process of simulation, worked out the possibilities and took the decision accordingly as follows:—

1. The normal return would have been a fore-hand drive along the sidelines to the opponent's back-hand. He decided against it because his opponent, anticipating this possibility, had moved back (towards T) for a volley.

2. The next shot was a deep lob. Here again it was risky because his opponent (S) was in a commanding position in mid-court and his over-head play was notoriously formidable.

3. Thirdly, there was the fore-hand cross-court drive, sending the ball back almost in the same direction (X I S). For this it was too late. Such shots have to be taken as the ball rises—immediately after the bounce. In any case not from outside the base line.

4. Under these circumstances there was only one possibility, *i.e.* a side-spin scoop and the writer had no choice except to play it. The ball flew across (*vide* Fig. 9—dark line) and fell at Y. His opponent moved towards it from his mid-Court position at T. As he swung the racquet for a fore-hand drive the ball broke off at an angle and moved in the direction of Z. He missed the shot and the score became 30-30.

Encouraged by this success the writer went on to win the match and eventually the championship. In this context it is fitting to recall what Clerk Maxwell had said in his inaugural address as Professor of Experimental Physics at Cambridge:

> "Science appears to us with a very different aspect after we have found out that it is not in lecture rooms only, and by means of electric light projected on a screen, that we may witness physical phenomena, but that we may find illustrations of the highest doctrines of science in games and gymnastics....."[8]

As we can see from what we have said so far "simulation" is not a new innovation. Its application as a method of learning, communication or otherwise, 'probably precedes recorded history'.

Its universal popularity, however, came in with the space programme where frequent references were made to this subject.

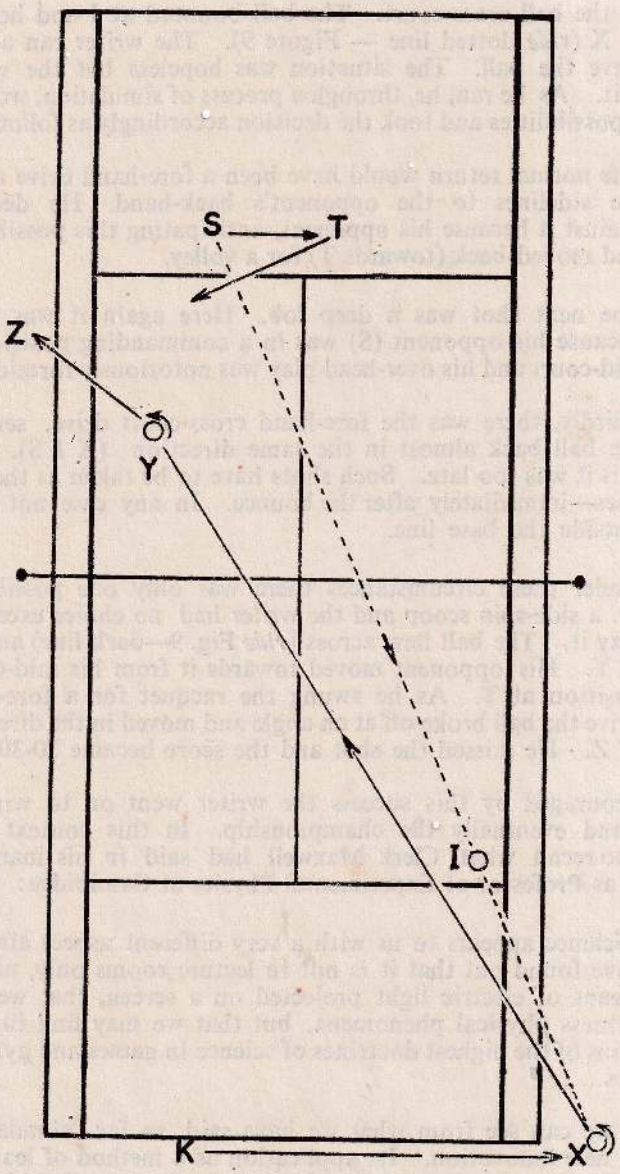

Fig. 9

In the field of social sciences and education very little attention was paid to this method for a long time. Even now many educationists use the technique under different titles: Micro-teaching is a typical example. Again, the well known Montessori system is based on simulation although it is not referred to as such. A casual glance into "Simulation in social sciences: readings" edited by Professor Harold Guetzkow will enlighten the reader of the variety of topics where this method (simulation) can be applied to bring about better results in communication output. The applicable areas range from inter-nation relations to operations in bus terminals.

In introducing the subject to the readers Richard Dawson says: "Simulation is of increasing importance to social and behavioural scientists. The term appears frequently in a wide variety of social science literature and in reports of social science experiments. Earlier, the term was used almost exclusively in the discourse of various branches of engineering. In recent years, however, the use of the term and a more explicit use of the method it designates have spread into military science, industrial engineering, business and management training and research, economics, psychology, political science and sociology".[9]

The most formidable claim, however, concerning the values of simulation techniques, comes to us from Sydney Fox. In his paper on "Simulated Natural Experiments on Spontaneous Organization of Morphological Units from Protenoid", he makes some thought-provoking statements with regard to the origin of life. He begins the subject with the following riddle: "How when no life existed, did substances come into being which today are absolutely essential to living systems, yet which can only be formed by those systems".[10]

What it really means is: there are certain compounds which are necessary for life to function. And these compounds can be manufactured only by a living system. If this is so how did the first life function?

The only answer to this question is that Nature must have created a "simulant" of the desired substance to activate "life" and when once "life" came into being the process must have gone on automatically like the internal combustion engine.

Fox's arguments are not much different from what we have just said. He says:

"The Thermal experiments have demonstrated how a "non-living" system could give rise to polymers which are sufficiently protein-like that they could form a proto-cellular or pre-cellular system (Fox 1964) with which natural experiments could continue".[11]

Equally important as the "Origin of life" is the process of Evolution. Here too simulation comes into play. In expressing his views on the theory of Evolution, Dodson says: "Ontogeny does recapitulate phylogeny in a significant way, but it is ancestral embryonic, not adult, stages which are repeated....."[12]

Further he also adds that during the embryological development certain stages are condensed while others are completely eliminated. The only conclusion we can arrive at to explain the course of action by Nature is that she too finds it more profitable to study the problems in models (embryonic stages) rather than in actuality (adults). Perhaps the following story from Mahabaratha, will give the reader an idea of the extent to which man had thought of applying simulation techniques for purposes of Communication.

Dronar, a brahmin, was tutor in archery to the Pandavas, the heroes of Mahabaratha war. As a policy he refused to take non-brahmins as his pupils. Arjuna, the warrior prince of the Pandavas soon became his favourite and Dronar taught him many techniques one of which was the dispatch of several arrows at the same time. This particular technique known as "Panchamasthram" was kept as a secret between the two, Dronar and Arjuna.

On hearing about this novel technique a hunter called Erhalaivan, went up to Dronar and asked him to teach him (Erhalaivan) also that special "art" — sending several arrows at the same time. Dronar turned him down on the grounds that Erhalaivan was a non-brahmin.

One day, while out hunting, Arjuna saw a dog running past him with several arrows sticking to its body. He knew what that meant; there is also someone else who had acquired the knowledge of sending several arrows at the same time. Suspecting Dronar of treachery Arjuna went up to him and asked for an explanation. Dronar denied ever having taught anybody else that particular "art". They were both puzzled and they decided to investigate the whole matter. They located the place where the dog had finally fallen and then by following up its blood stains came to the place where the dog was first shot at. On making inquiries in the neighbourhood, Dronar and Arjuna discovered that the person responsible for the act was none other than Erhalaivan, the hunter, whose application to Dronar's school of archery was turned down by the Guru on the grounds that he (Erhalaivan) was a non-brahmin!

Dronar and Arjuna then went up to him and asked him how he acquired that knowledge—sending several arrows at the same time. Erhalaivan's reply unnerved them both. He said that when Dronar turned him down he (Erhalaivan) returned home more determined than ever. He then made an Image (Simulachrum) of Dronar and prayed to it day after day. One day while he was seated in deep meditation in front of the Image, it (the Image) came alive and asked him what he (Erhalaivan) wanted. When he told the "Image" what he had in mind, it divulged the secret of "Panchamasthram" and faded away. The story does not end here. Dronar was greatly disturbed, for, he belonged to a self-opinionated group which thrived on the theory that the "Brahmins", or "Aryans" as they call themselves when occasion demands, are the custodians of not only all knowledge but also of God's morals on earth. Erhalaivan had by-passed all this.

Concealing his thoughts and feelings, Dronar, cunningly, reminding Erhalaivan that the hunter had used him (Dronar) as his Guru, asked him (Erhalaivan) for the Guru-dakshina (fee). When Erhalaivan asked him (Dronar) what he wanted, the latter said: "Your two thumps".

Erhalaivan, living up to Hindu traditions complied with his (Dronar's) request, thereby losing the power to use that "knowledge".

The story sounds vulgar and barbaric. But from the point of view of our work it has a meaning of great significance. That is: No knowledge is of any value unless it has some practical consequence. This is the foundation on which was based Dr. Premadasa Uda-ama's most enlightening Educational Concept: "Pre-vocational studies".

The examples cited so far to study the values of simulation as a medium of communication are so varied and so far-reaching that there seems to be no room for the existence of any other methods. As a matter of fact it is true and this is how we explain it:

One of the factors which determines the nature and quality of a given event is the environment in which it occurs. If the environment changes it constitutes in the reproduction of the event concerned a circumstance which no longer remains the same. To say that the environment remains constant is to say that our celestial system is at a standstill.

What is meant in the above statement is that "actuality" because of its constantly changing environment changes its character from moment to moment. In other words "actuality" as such does not exist.

Peter Handke says the same thing differently as follows:

"What scientists give out as reality is a model of reality expressed in formulae, a system of abstraction by which they communicate with one another. There is consequently no single reality, but models of reality. It interests me as writer, to discover the model of reality which renders humanity and communication possible to the greatest extent. What reality is I do not presume to say".[13]

What appears as "actuality" (or "reality") is only a simulation of what has just happened and a simulation of what is due to happen in the next moment.

As an illustration let us take a star which is ten light years away from us. What we see as the star is only a simulation of the star because by the time light reaches us from the star, the star would have moved to another position. When we look at the star a second time we again see another simulation and not the actual star.

Let us take another example: Movie films. Movie films are shot at the rate of twenty four frames per second (sound). Then when the film is run through the projector at the same speed (24 f.p.s.) we "experience" the action recorded in the film. It is only an illusion because the pictures do not move. They are all stills. Each frame is a simulant of the one next to it. Here again the experiential effects are brought to us through false pretences or simulations.

This is true of all things. What appears as "reality" is only a series of simulations. Sometimes the changes are too slow to be recorded by the sense organs. For example the growth of a plant. That does not mean that things are at a standstill.

If "actuality" as such does not exist the question of it being a medium of communication does not arise. From this it follows that "Imitation" also fails to be a medium of communication because according to our definition it (Imitation) is a true representation of the actual phenomenon.

According to historical records digital coding is only a modification of analogic coding because the origin of the alphabet lies in picture-writing. Furthermore, when we describe something in words our intention is to create in the mind of the learner an "image"or a "simulant" of the subject concerned.

From the point of view of evolution these two methods, digital and analogic are the two branches arising out of that one common trunk, Behavioural coding. The origin of this system (Behavioural Coding) can be traced back to mimicry and mimicry is also a form of simulation.

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CHAPTER V

SIMULATION AS APPLIED TO EDUCATION

As we can see from what we have said in the foregoing Chapters, Simulation includes a variety of techniques, Mimicry, Make-believe, False pretences etc. But when it is applied to Education it strictly means "imitation".

When we imitate something our motive is to provide for the learner a sense-experience peculiar to our ideas about the subject in question.

Precisely, the same thing can be said of simulation too. What arises from such a process is called a "simulated experience". It is essentially partial, for, as stated in Chapter III, 'the causes which have produced a particular effect cannot be reproduced except approximately'.

The question before us is: Can these partial experiences meet the requirements of a task? The answer is, yes. We have a multi-million dollar experiment to provide the data.

Neil Armstrong when he landed on the moon, performed his task (moon-walk) with such ease that he was prompted to make the following remarks:

> "There seems to be no difficulty in walking about as we suspected. It's even perhaps easier than simulations" .[1]

It must be noted that the Astronaut (Neil Armstrong) had no actual experience in moon-walk, weighted or otherwise, prior to his landing on the moon. The necessary "knowledge" or "experience" was acquired only through a process of simulation, weighted of course. The effect of simulation was so rich in providing the necessary requirements that the actual task became "easier than simulations". Let us now look at the problem from the standpoint of theoretical considerations.

A simulated experience on account of its own circumstances falls within the principle "like causes produce like effects". As far as our work is concerned this is what it really means:

If the effects of a given event can be simulated to bear a point to point correspondence with the actual effects of the event in question, the sensory cells, on account of their pre-determined behaviour will react exactly in the same way as they will for the normal event.

From this it may also be pointed out that if the simulated effects vary from the effects of the actual event by a degree so small that it falls just below the threshold of the senses, the desired sensory reactions will still take place because the error will be corrected by the psychological process of "perceptual closure" (prediction).

In terms of what we have said above it can be shown that total as well as partial imitations of "experiences" can meet the requirements of a given task.

Validity alone does not qualify a method to be referred to as such. Reliability is equally important. Here again the answer comes from the NASA (National Aeronautics and Space Administration). All moon-landing missions undertaken so far have proved to be a success.

We thus see that "simulated experiences" are both valid and reliable in their applications.

Our next question is: Are they economical? The answer again is, yes. If partial experiences can fulfil a mission it will certainly be less expensive to use them rather than to apply actual or total experiences.

For the benefit of the reader, we shall explain the process.

Given below are the various branches of psychology arranged in two ways: A; B.

A.	B.	
	(i)	(ii)
Individual psychology	Individual psychology	Group
Child psychology	Child psychology	Adult
Human psychology	Human psychology	Animal
Group psychology	Normal psychology	Abnormal
Pure psychology	Pure psychology	Applied
Applied psychology		
Normal psychology		
Adult psychology		
Abnormal psychology		
Animal psychology		

The task in question is to learn the various branches of the subject and then recall them if and when necessary. If we follow the arrangement in A, the learning of each item becomes a task in itself. But if we follow the arrangement in B only half the effort is required to perform the task.

If the learner can remember the list given under (B) (i) he will be able to recall in addition to what is given under (i) also those under (ii)—(B). This is because of the "Continuity of Correspondence" that exists between (B) (i) and (B) (ii).

This "continuity of correspondence" facilitates prediction and this is exactly the principle which links up simulated experience with actuality or what is believed to be "actuality".

Coming now to the question of applicable possibilities of this medium (simulated experience) it becomes necessary for us to study the values of experience first because by nature and consequences a simulated experience is an experience first and foremost.

During the course of the history of education many statements have been made by philosophers and educationists about experience and its importance in education. We shall study the values of experience firstly in terms of some of the views which have already been expressed.

John Amos Comenius (1592—1670) an educationist of great repute and acclaimed as the father of Audio-Visual Methods wrote in the preface of his book "*Orbis Sensualium Pictus*" :—

> ".....there is nothing in the intellect which has not first been in the senses....."[2]

This is an oft-quoted phrase and its Latin equivalent: "*Nihil est in intellectu quod non in prius in sensu*" is attributed to Aristotle. Although Manuals and text-books use it, it is not found as such in any of Aristotle's writings. According to Hick's translation of "*De Anima*" the text is as follows:—

> ".....As without sensation a man would not learn or understand anything, so at the very time when he is actually thinking he must have an image before him".[3]

Similar views have been expressed by Thomas Aquinas too:—

> "For Augustine says (soliloq: 4) that bodies cannot be understood by the intellect: nor anything corporeal unless it can be perceived by the senses".[4]

These observations quoted above come to us from three well-known and greatly renowned philosopher-educationists. The implied meaning of their views is that the intellect is built up, primarily of sensory experiences. The acceptance or the attempt to establish the facts of these propositions invariably increases the refutability of the old classical view that the mind (intellect) is independent of the sensory processes. This makes our task more formidable since the old concept that the mind is a separate entity still prevails and in some quarters well entrenched and deep-seated. But at the same time this mutual rivalry of the two schools of thought provides us with an ideal medium to conduct our investigations for, as Sir Karl Popper says, "a theory becomes more scientific when faced with an alternative" (*vide* Chapter II).

Speech is acclaimed as the greatest achievement man has made in the course of his evolution. Besides on account of its sophistication it becomes associated with culture, progress, civilisation, etc. It is often equated with other media of communication with preconceived values. To an educationist, particularly for one who is engaged in the study of methodology speech must remain only as a medium of communication just as "life" means any life to a biologist. Unfortunately it is not so in actual practice. The emphasis placed on speech as a measure of the intellect is still high in many countries. Therefore, it is this area—*the development of* speech in man—that we shall first mark out for our investigations as it presents us with "a formidable alternative".

We shall begin our study by analysing the process involved in the learning of a single word.

Webster defines a word as:

> "An articulate sound or series of sounds which symbolises and communicates an idea; the smallest unit of speech that has meaning when taken by itself."

To this may be added the following:

> "A word is not a crystal transparent and unchanged, it is the skin of a living thought and may vary in colour and content according to the circumstances and the time in which it is used".[5]

From these two definitions alone it becomes evidently clear that to learn a word means more than merely to produce a sound as it is generally imagined. On the contrary, it is not exclusively a function of the intellect either. Sensory experiences and intellectual activity are both necessary to learn a word in its entirety. As

we are engaged mainly in the study of experiences, let us see the extent to which experiences are involved in the process of learning a word. We shall do this with reference to the following chart (Fig. 10). Looking at the chart, we can mark out seven distinct "experiences" and they are :—

1. Visual experience of observing the 'object' denoted by the word.
2. Visual experience of observing the written word.
3. Visual experience of observing the teacher writing the word.
4. Aural experience of hearing the sound of the spoken word.
5. Audio-Visual experience of the teacher pronouncing the word.
6. Kinesthetic (muscular) experience of writing the word.
7. Kinesthetic (muscular) experience of producing the sound of the spoken word.[6]

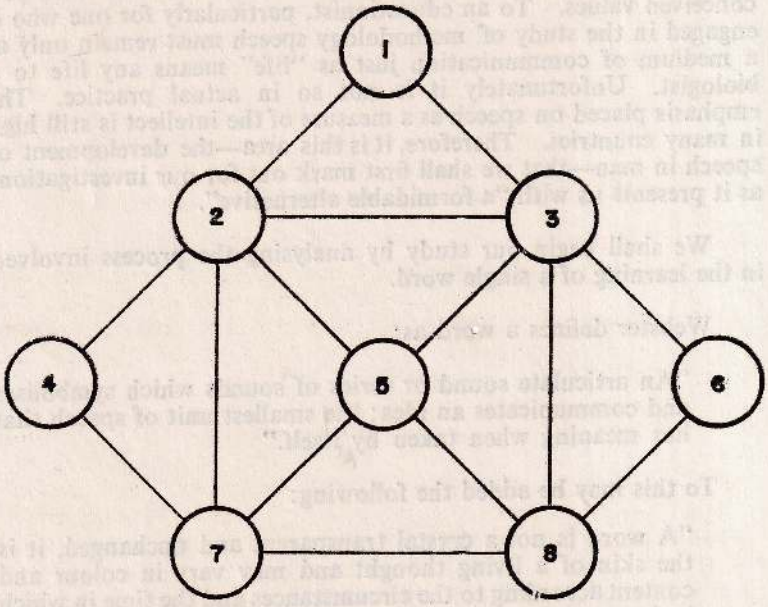

Fig. 10. *Communication net-work for the development of speech in man.*

Key

1. Equivalent native word
2. Sound of word

3. Vocal act seen
4. Vocal act performed
5. Object, action etc.
6. Appearance of word
7. Graphic act seen
8. Graphic act performed

(Ref. Visual Methods in Teaching. P. 67)

If the "object" could be handled there will be another addition to this list of experiences namely, "tactual". These experiences listed above are all necessary to enable the learner to acquire the "knowledge" of a given word in its entirety. Not any one of them can be omitted or even ignored in the process of learning to speak.

This is only an opinion but not an experimental determination. The reader can very well say that a child may learn to speak through heredity and not necessarily by "experience". It is not easy for us to reject his views or even justify our claims because it is difficult to carry out the desired experiments.

There is, however, a unique experiment carried out by Emperor Akbar which throws some light on this controversial question.

The text is as follows :—

> "Akbar's enquiring turn of mind led to many novel experiments. In order to ascertain the origin of language, he had twenty children isolated at birth and brought up by dumb nurses. Needless to say the experiment was not a success, the survivors were unable to utter a sound and they talked by signs!"[7]

This is an invaluable piece of evidence to prove what is obvious even to primitive societies. One can well imagine the seriousness of an experiment of this nature. The consequences are too dangerous to consider a second attempt to confirm what Akbar had found out.

Mastery of the utterance of words does not mean the mastery of speech. The words have to be understood and coined into functional sentences. Here again we have to seek recourse in experience, for, as Gorgias says:

> "Speech consisting of a product of sounds, 'does not coincide' with the things which are endowed with a real existence, since we present to others not the things which exist but speech, which is other than that which is real" (S., 84):

"Certainly he who speaks speaks, but he does not speak a colour or an experience" (980b 2-3), consequently: "Just as what is visible cannot become audible and *vice versa*, so that which exists, since it is based on a reality outside us, could not coincide with speech....."[8]

Finally, we must also accept the fact that "exact correspondence between the knowledge possessed by the speaker and that of the hearer, does not necessarily exist and is even rare; speech does not mean strictly the same thing for both of them because they differ in their mutuality, their culture, etc.".[9]

In the circumstances it becomes very necessary for us to relate our speech with "experiences" relevant to the message. This does not mean that we can bring about an exact correspondence between the knowledge possessed by the speaker and that of the hearer but the gap between the two "knowledges" can be greatly reduced. This leads to better understanding and more rigid standardisation of ideas about things and events. We must not for a moment forget the fact that what is meant by "Knowledge" in our present state of life is only a "working knowledge" of the environment, but not a true disclosure of the nature of things (*vide* Chapter III).

We have thus brought out many facts concerning the values of experience, in the development of speech in man. Enumeration is not really necessary to show its extent.

We shall now move on to another area, namely, the learning of practical skills. This subject includes among other things, playing games, driving a car, construction of models, designing of an apparatus etc. These skills are learnt mainly through practical experiences. The purpose of our study is not really to establish the fact that it is so but to examine the role played by the intellect in the acquisition of such "knowledge".

It is very unfortunate that the term "skill' is often associated with manual and mechanical work. Consequently it does not find a proper place "in the scale of intellectual and aesthetic values". As Professor Grieg says, 'skill in the execution of established techniques is not in the intellectual scale, as particularly meritorious'.[10] Our task shall be to dispel such mistaken notions, for any learning must be free from stress, psychological or otherwise.

The term 'skill' should be used in a wider sense "than that customary in industry, including any 'expert' quality in performance, however, produced, and not confined to technique and knowledge acquired in the course of an apprenticeship training".[11] Techniques

such as the development of radio communication by Marconi cannot be regarded as something which is not "particularly meritorious". On the contrary such work may require more than a normal share of intellectual output. In the words of Professor Grieg, "the devising of a new technique may demand high qualities of intellect or of imagination". But the validity and reliability of a new technique depends entirely on practical consequences. If there are no practical values, a technique however well-conceived, may not exist as such. Therefore, it is incorrect for any one to place more emphasis on one and relegate the other to an inferior position. Besides, as Whitehead says, 'Education is the acquisition of the art of utilization of knowledge'.[12] If this is an acceptable interpretation of the term "Education" the emphasis then is on the practical application of knowledge. In effect, practical work is really the feed-back control for theoretical decisions.

The term "skill" can be classified into two categories:

(*a*) conceptual skill
(*b*) constructional skill

The former is applicable to the behaviour of the intellect while the latter to that of the physical system. But in the performance of a task both forms are necessary.

A given task includes the following functions:

(1) Conception of the idea—It is the intended plan of action.

(2) Translation of the conceptual output into perceivable codes.

It includes, among other things, verbal descriptions, pictorial representations, models, charts, etc., of the intended output.

(3) Conversion of the perceivable codes into constructional codes.

This includes the following:—

(i) Raw materials
(ii) Labour
(iii) Plans, outlines, scale models, etc.

(4) Construction *i.e.* the actual performance of the intended task. It is at this stage that work becomes a physical process and this is what is mistakenly called "skill" by many.

These four stages namely, Conception, Translation, Conversion and Construction are necessary to carry out any programme of work. We have already made mention of them in Chapter II.

Coming now to the question of what "experience" does in the accomplishment of a mission we have already provided the answer in Chapter II and confirmed it in Chapter III. When we examine the process involved in the designing of the cut-out model of the Temple of the Tooth referred to in Chapter II, it does not take much time to note that the function of "experience" in the performance of a task is to direct the system towards the acquisition of the objective. In other words, it serves as a regulatory mechanism. Then again in "learning to drive a car" referred to in Chapter III we see the same results.

Let us take another example, say, a child picking up a fruit. It first looks at the object curiously and then reaches out for it. More often than not it misses it. The "message" is then transmitted to the brain. There the failure is noted and the brain gives fresh instructions to the limbs to make another attempt. Finally, after several "experiences" or sensory activities the child achieves the desired objective—picking up the fruit.

Similarly, in all practical tasks, whether it is model-building, playing games or even learning to speak, the principle is the same and "experience" plays a specific role in the accomplishment of the mission.

When we take all what we have said into consideration we can list the values of experience as follows:—

(1) "Experience" serves as a medium for the growth and development of the intellect.

(2) It functions as a regulatory or "control" mechanism to direct the system towards the acquisition of the intended objective.

In (1) "Experience" acts as a catalyst. Under those circumstances a simulated experience as pointed out earlier is an "experience" in itself, and unique in its values. For example, playing with toy motor boats provides an experience which is quite different from that of driving an actual one. Each has its own contribution to make towards the growth and development of the intellect. Hence the question of imitating an experience or acquiring an "experience" through a process of imitation does not arise.

We are thus left with only one problem to deal with and our task is to find out how well or how far can simulated experiences perform the desired functions in a similar capacity, *i.e.* as a

regulatory or control mechanism. We shall discuss the problem with reference to a simple task such as completing a given number of round trips between two points X and Y shown on the road map illustrated in Fig. 11. There are two ways by which this mission can be accomplished:

(1) unskilled operation

(2) skilled execution

In the first *i.e.* in unskilled operation the route is selected at random and the task is carried out without paying any attention to conservation of time or energy. In consequence this process is regarded as unscientific.

Skilled execution on the other hand is carried out with reference to "conservation of energy". Hence this method qualifies itself to be called "scientific". It must be borne in mind that the use of scientific knowledge alone does not qualify a method to be regarded as "scientific". To be considered "Scientific" a method must tend towards "conservation of energy".

From this it follows that "skill" means the execution of a task with the minimum expenditure of energy. The reader will know what is implied in the above definition when we examine this method. Skilled execution involves the employment of "regulatory" of "control" mechanisms and this falls under two categories:

(1) using actual experiences

(2) using simulated experiences

Let us take the first method. Our main concern is to select the most advantageous route among the four possible combinations listed as follows :

	Forward	Return
1.	X A B U D Y	Y D U B A X
2.	X A B U D Y	Y D C T A X
3.	X A T C D Y	Y D C T A X
4.	X A T C D Y	Y D U B A X

Theoretically speaking, it is not possible to determine the best combination because there are many unknown problems which may come up from time to time while the task is being performed. For example, the traffic on the highway. Buildings, vegetation, terrain, etc., may present additional problems. Under these conditions, the course available for us is to conduct a few trial

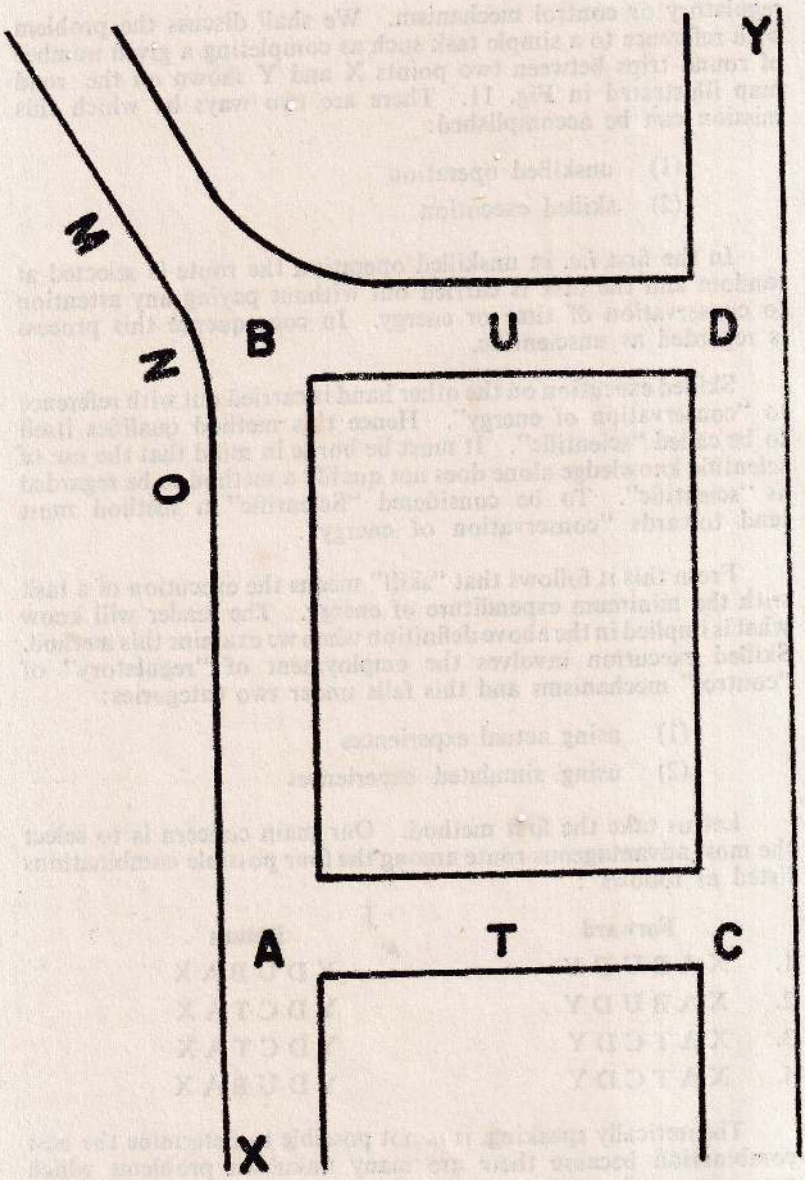

Fig. 11

runs on each of the combinations and then take the average. The one which gives us the shortest time for each round trip shall be chosen as the route to be followed.

As for the second method the desired data are obtained through the use of a miniature car. The procedure is as follows :—

At first we make a larger version of the given road map so that the miniature car could be accommodated on the road. Then we move it along the pathway pretending that we are driving it. In the process we must take note of the spots which are convenient for making the turns at the intersections. For instance, let us take the two intersections at A and B. Turning right at A is more advantageous than at B because the driver can see the on-coming traffic from a long distance and he can regulate his driving, either speeding up or slowing down, before taking the turn. This is not possible at B because the road ahead turns left in a curve and the motorist has to come right up to the intersection to see the on-coming traffic. This will result in a slowing down of the car, change of gears or even complete stoppage. This operation costs more time and more energy.

Then on the return run, however, the situation is of a reverse order. Turning left at B is more advantageous. The driver can see the on-coming traffic on the right before he gets to the intersection at B because of the curvature (MNO). But if the driver wishes to take the turn at the intersection at A he will have to move right up to the point of turning to see the traffic on the right.

Similarly we can also study the economic values of other combinations. The "experience" we acquire through such a process is called a "simulated experience". This is not the end of the process. Now we must test our findings under actual conditions, *i.e.* drive the car along the four combinations and then pick out the route which takes less time for making the round trip. If it tallies with what we have found out through simulation we can dispense with all other trial runs and confine our attention to that particular combination. What we have to note in the above illustration is that simulated experience reduces the employment of actual experience. Under certain circumstances the use of actual experiences can even be eliminated completely as in space-flight training. But it must be pointed out that a higher degree of prediction is required to accomplish a mission with the use of simulated experience than with direct experience. In actual fact simulated experience "pre-controls" or "pre-conditions" the organism for employment of actual experiences later. And the feed-back that is established through such a process is called an "auxiliary feed-back". We have already made reference to it in Chapter III.

The principle in the two forms of experiences, however, is the same.

Before we proceed further we shall "stabilize" our newly acquired "working knowledge" of what we have called "pre-control". The construction of a "buttress" on a book shelf (Fig. 12) out of

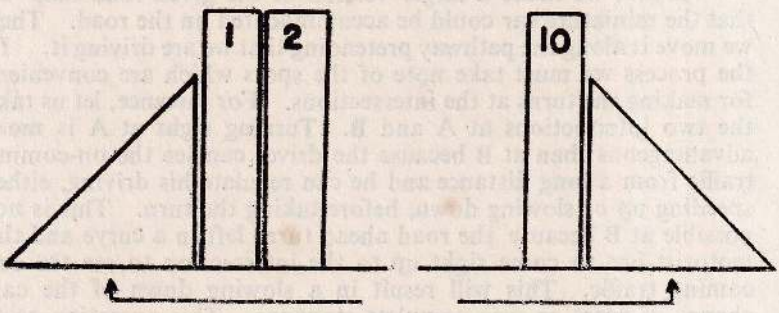

Fig. 12

tin-foil shall serve as an illustration for our study. If the students were to do it by themselves they will carry out their assignment by trial and error and the outcome will leave much to be desired. Besides, there will be several "trials" or "experiences" before the objective is finally achieved. This will undoubtedly result in a large wastage of raw material. But if we pre-control the operation the task can be carried out without much difficulty. The procedure is as follows :—

The main problem in this task is to determine the distance DE_1 where E_1 coincides with B. (Fig. 13 IV). This distance can be deduced by applying Pythagoras theorem which says: "The square on the hypotenuse is equal to the sum of the squares on the other two sides".

Suppose we fix the height of the "buttress" at 3" and the hypotenuse (CD) at 5" the distance DE_1 can be calculated as follows :—

$$(DE_1)^2 + (BC)^2 = (CD)^2$$

$$(DE_1)^2 + 9 = 25$$

$$(DE_1)^2 = 25 - 9 = 16$$

$$DE_1 = 4"$$

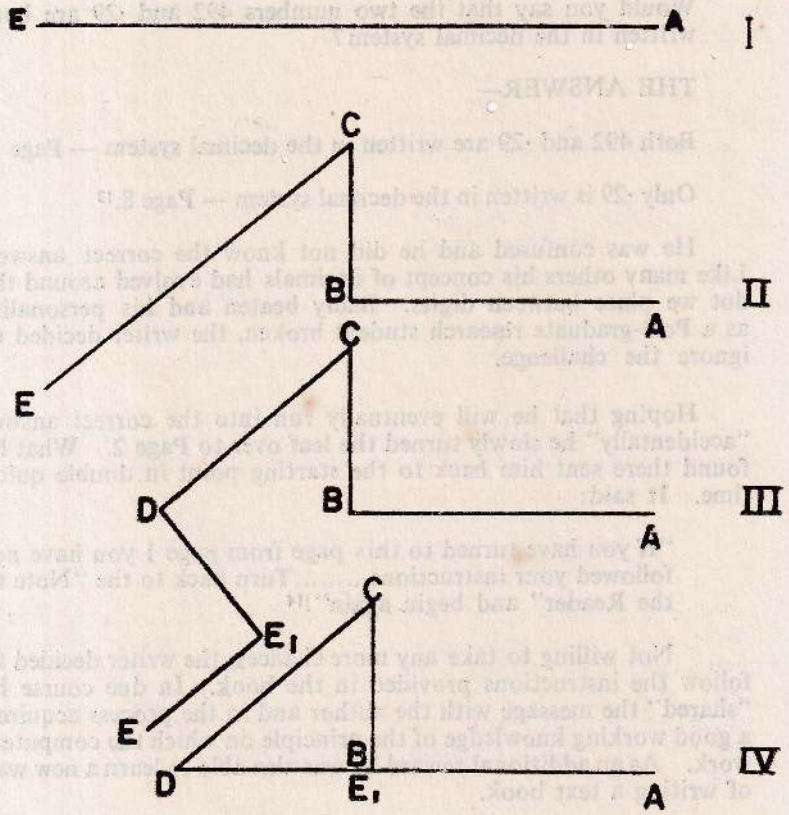

Fig. 13

In this illustration we can easily see some tangible evidence of the economic values of a pre-control system.

Norman Crowder's book on "Arithemtic of Computers" gives an excellent illustration of this principle. One day while walking around in a book-shop in London, the writer came across this book — "Arithmetic of Computers". Taking a fancy to it he bought the book — no doubt with good intentions. On reaching home the first thing he did was to see whether the book contained what he wanted. When he opened it he found that the first page carried an elementary lesson on decimals! A little disappointed, he, however, went through the lesson. At the bottom of the page he found the following :—

Would you say that the two numbers 492 and ·29 are both written in the decimal system?

THE ANSWER—

Both 492 and ·29 are written in the decimal system — Page 4.

Only ·29 is written in the decimal system — Page 8.[13]

He was confused and he did not know the correct answer. Like many others his concept of decimals had evolved around the dot we place between digits. Badly beaten and his personality as a Post-graduate research student broken, the writer decided to ignore the challenge.

Hoping that he will eventually run into the correct answer "accidentally" he slowly turned the leaf over to Page 2. What he found there sent him back to the starting point in double quick time. It said:

> "If you have turned to this page from page 1 you have not followed your instructions.....Turn back to the "Note to the Reader" and begin again"!![14]

Not willing to take any more chances, the writer decided to follow the instructions provided in the book. In due course he "shared" the message with the author and in the process acquired a good working knowledge of the principle on which the computers work. As an additional reward he was also able to learn a new way of writing a text book.

In this new system the lessons are presented in the form of short discussions. And at the end of each lesson there is a multiple choice question. The possible answers, wrong and right, are given in different pages with an explanation to say why each one has to be so determined. In the language of an educationist such a technique is called "Programmed Learning". But in the language of an educational technologist it is called a pre-controlled system.

Whatever the title may be the intention of this technique, which is to conserve energy, is unmistakably clear.

Let us now see how the lessons are prepared for such a technique. We shall examine the problem with reference to the advice—

> "You have not followed your instructions.....etc. given to the reader in the "Arithmetic of Computers".

To begin with we must find out how the author arrived at the conclusion that the reader will turn to Page 2 without paying attention to what he was asked to do. The only explanation possible is that the author had first imagined himself as an intended reader and then studied his own reactions as to what he would do under such cirrcumstances. The 'Knowledge' thus acquired helped the author to control the behaviour of the reader retroactively.

As pointed out earlier imagining oneself as something else means "make-believe". The "experience" acquired thereof is also called a "simulated experience".

"Make-believe" can also mean the theoretical establishment of certain situations for making appropriate decisions.

Here is an illustration to show the values of this technique under such conditions.

On the map shown in Fig. 14 there are four people using the highway and they are :—

1. Motorist ... ... A
2. Cyclist ... ... B
3. Pedestrian with a parcel on his head C
4. Motorist ... ... D

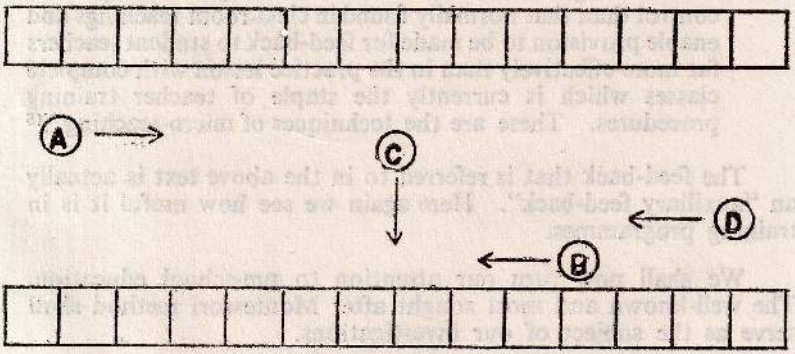

Fig. 14

The arrows in front of them show the direction in which the participants are moving.

As it stands the pedestrian is moving across the road in the direction shown by the arrow and he is well past the middle of the road. As he crosses, the cyclist moves up and the pedestrian will naturally stop to let the cyclist pass. In the meantime the motorist D would have moved up. The pedestrian will now move back further to let the motorist pass. Then when he (the pedestrian) is suddenly disturbed by the unexpected arrival of A he, in all probability, will jump forward to take his chances with the known rather than with the unknown at the rear.

If D is not alert to this possibility he may knock the pedestrian down. To be alert one must know the art of simulation and if motorists wish to be on the safe side of the law it will be wise for them to pay some attention to this principle of "make-believe" and take their decisions accordingly.

Micro-teaching, acclaimed as a method of great consequence in Teacher Education is also based on the principles of simulated experience.

Stones and Morris in their observations on this subject, "Micro-teaching", confirm our views. They say:—

> "Simulation techniques provide a means of student teacher induction through the medium of experience demanding skills that closely approximate to real situations. In this section we consider techniques that involve the use of real teaching situations, but situations that are not normally found in a teacher's day to day activities. They are simplified teaching situations which allow of a greater degree of control than that normally found in class-room teachings and enable provision to be made for feed-back to student teachers far more effectively than in the practice lesson with complete classes which is currently the staple of teacher training procedures. These are the techniques of micro-teaching".[15]

The feed-back that is referred to in the above text is actually an "auxiliary feed-back". Here again we see how useful it is in training programmes.

We shall now turn our attention to pre-school education. The well-known and most sought after Montessori method shall serve as the subject of our investigations.

This method of Instruction derives its name from its founder Dr. Maria Montessori, an Italian doctor of Medicine. She developed her ideas after observing the behaviour of some retarded children in an Italian school and then she applied these methods to normal children.

We shall examine this system with reference to Standing's book on "Maria Montessori: Her life and works" since Madame Montessori herself has endorsed Standing's interpretations of her ideas with the following words:

> "What you have written on my life is a wonder and beautiful as a piece of writing".[16]

According to the author, a Montessori class-room "should be part of a building specially constructed in every detail to form a 'Children's Home'."

This must include miniature furniture and "cupboards containing all the domestic appliances for the exercises of practical life .....etc".

An establishment of this nature falls under the category of "imitation of adult life" and this has already been referred to as "simulated experiences" which is a derivative of analogic coding.

What is most noteworthy in the Motessori system is the emphasis placed on the "principle of Control" or "Conservation of energy". Standing, using the very words of Madame Montessori, makes the following observations:—

> "We arrive at abstractions", says Montessori "by the law of least resistance and least effort".[19]

Again on Page 152, Standing says, with reference to this principle, "Just as there are these times when the child works like an adult towards an external end, with a minimum expenditure of effort so there are times when the adult expends a vast amount of energy which appears to have no quantitative relationship to the outward end".[17]

The above observations illustrate clearly the importance of the principle of control in the performance of a task.

In fact Montessori firmly believes in this principle. She does not approve of the child running wild. To meet this objective she sets up a "prepared environment" in order to direct the child to perform its task with the minimum expenditure of energy.

As an example we shall take the lesson on "Geometric Insets". The text is as follows:—

> "The child first meets them in the form of solid wooden insets which can be taken out and fitted into corres-

ponding wooden sockets. Such a triangle (1) is a very material, tangible, movable object, so is the corresponding socket which acts as "Control of error". Later (2) the child is given the corresponding forms printed on cards with the shape wholly filled in. Next (3) comes a series of the same forms not filled in now, but drawn with thick outlines; and finally (4) the forms are shown in this outline only. Nothing remains to be done now but the last stage (which of course comes a good deal later) which is to arrive at (5) the Euclidean definition of a triangle, *i.e.* a plane figure enclosed by three straight lines".[18]

The above observations correspond exactly with what we have already said about the function of "Controls", namely: To direct the system towards the intended destination.

Lastly, Standing says: "What distinguishes Montessori method from many other "activity methods" in vogue today is her emphasis on precision, order and discipline".[19]

When there is precision, order and discipline, the performance of a task becomes easier by virtue of the fact that the alternatives are reduced in decision-making. When problems are reduced the task is performed "by the law of least resistance and least effort".

Perhaps, the field where simulated experiences have proved to be very useful as a medium of learning is navigational studies, air, sea, space, etc. As a matter of fact it was in flight-training that simulated experiences were first conceived as a method for the accomplishment of a mission. The necessary "experiences" were communicated to the learner through a device called the "Link-trainer".

The following text tells us what it is and what it does:

"The 'Link-trainer' used to train R.A.F. pilots in the second world war was one of the earliest devices to be consciously described as a "simulator"; it was a dummy cock-pit set up in a hangar or an office-block with a canvas hood over it. Once inside, the learner pilot was alone with the controls and dials outside it, watched by senior and more experienced performers. The Link-trainer allowed the pilot to experience a "model" of the actual flying situation; it also allowed him to see what mistakes he might make, and to escape from them punishment free. The simulator was giving experience and acting as an instrument of self-teaching".[20]

Under certain circumstances simulators can be unique in their values. Adams, in his observations on "Some considerations in the design and use of dynamic simulators" gives us a classic example of such a situation. He says :

"Another problem is that aspects of a pilot's prior flying experience can transfer negatively to a new aircraft. There are numerous recorded accidents where negative transfer was the basis of death-producing errors. Intellectualizing a negative transfer problem in the class-room possibly may reduce errors, but most learning psychologists probably would agree that a flight simulator permitting actual practice of the new response to highly similar stimuli would be most effective in extinguishing the old, inappropriate response and establishing the new. One of the newest jet aircraft contains an excellent example of a negative transfer paradigm and illustrates the type of difficulty which could be minimized with adequate simulator training. The problem arises when this aircraft, either at subsonic or supersonic speeds, sometimes undergoes a longitudinal pitch-up. The normal technique to recover from the pitch-up conditions is to apply nose-down stick. Sometimes, however, the aircraft will start to roll off during recovery, and the correction at this point is to move the stick *in the direction of the roll-off*. This response to correct the roll-off condition is precisely contrary to that for most other aircrafts which require stick movement in the direction opposite to the roll-off. A flight simulator for this aircraft can save millions of dollars in equipment and many lives by permitting thorough training in such new response requirements".[21]

This process, *i.e.* training through simulators is now being applied to many other areas such as car-driving, horse-riding, water-skiing etc. It is time for school-teachers and others in similar positions to take note of this "rapidly advancing technology".

Apart from being useful as a medium for the communication of ideas, simulators also have a high motivational value. Incidentally, motivation too falls within the category of feed-back systems. But unlike the ones we have described earlier, which are negative in nature, the feed-back here is positive *i.e.* power increases with power. The word "control" is not added on to positive feed-back for, control is negative. Positive feed-back is applied only in such situations where the behaviour of the system is not governed by the law of diminishing returns.

What we have said so far about simulated experience and its values in educational practice is sufficient to convince any learner that this technique is a method of consequence and it can be applied with great success practically in any field of study.

For the benefit of the reader we shall sum up our findings as follows :—

Simulated experience, like any other similar process—such as a real experience, acts as a medium for the growth and development of the Intellect.

In the performance of a task it (simulated experience) functions as a regulatory (control) mechanism to direct the system towards the intended objective.

In its capacity as a regulatory mechanism it (simulated experience) is found to be valid, reliable and economical.

Under certain circumstances such as space-flight training simulated experience has proved itself to be unique in its uses.

Lastly in bringing this Chapter to a close we may even mention that in terms of what has been stated above the use of actual experience is not really important for the execution of a given mission. The necessary requirements can be met by simulated experience.

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CHAPTER VI

AUDIO-VISUAL AIDS

As pointed out in Chapter III, "Audio-Visual Aids" is the popular title for the three groups of material products, simulants, simulators and simulachra. The function of these aids is to provide for the learner a sense-experience peculiar to the subject they represent. We have already explained the values of such "experiences" in the last Chapter and there is no need for us to go through them over again. We shall therefore confine our study to the technical aspects of the subject.

The idea of "Audio-Visual Aids" is of great antiquity and its origin can be traced back to pre-historic times. When archaeological excavations were carried out in the Middle East and the Mediterranean regions, certain miniature articles or "simulants" as we shall call them were brought to light. They included replicas of animals, wheeled toys, household utensils, human figurines and many others. Some of these materials were 4000 years old and they can be seen in the National Museum of Cairo, Egypt. Other museums, too, have such collections. The variety of pre-historic models in the Berlin Museum is particularly noteworthy. Similar articles were discovered in Mohenjo-Daro in Northern India (now Pakistan) and Pompei in Italy. The early Indians of America, too, made use of such miniatures in their cultural life. A few of them can be seen in the Ohio State Museum and in the Natural History Museum of New York. Whether they were used for instructional purposes or not we cannot say. But from what Paul Monroe had said in his book "A Brief Course in the History of Education" we are inclined to believe that these miniature articles were used by children for role-play.[1]

Anita Klein in "Child life in Greek Art" probably thinks that these miniatures may have been used as toys, for she says:

> "For the entertainment of the younger member of the family, who had just reached the walking stage, toys made to be moved about were undoubtedly most satisfying. One plaything of this type was an animal—a horse, surely, with arched neck and curved tail, and with four wheels instead of legs. Further, the nose was pierced, so the only thing needed was to insert the string and the horse (*a*) was ready to go.

Somewhat similar are the horses with long cylindrical bodies, carrying panniers on their backs, with two large (*b*) or six small jars (*c*). There are also very small two wheeled carts, some of them with an opening apparently made for the insertion of a little pole (*d*). The box is sometimes open at the back or front, and when this is the case the floor projects somewhat beyond the sides (*e*)."[2]

Aids in Religious practices

The ancient Egyptians, as we understand, had a superstitious belief that the human spirit led a "normal" life and was capable of travelling about. But it was not capable of crossing the waters of the Nile without assistance. Therefore, in order to help the spirit to cross the river, a model boat called the "spirit-ship" was buried in the tombs. Other kinds of models of objects or representing various types of activities were also placed in the tombs. There is a model in the Cairo Museum which illustrates the methods of spinning and weaving of the early Egyptians. It is of the eleventh dynasty (2160—2000) and was found in Thebes.[3] There is another model, showing people making bricks, in the Berlin Museum. Very likely these models were also placed in the tombs for the use of the "spirit".

Aids in Architecture

Some of the Engineering feats accomplished in the past by the ancient Egyptians and Greeks leave us wondering how they could have carried out such work without adequate machinery. Further, one also wonders whether the Architects would have trusted themselves to trial and error processes. Sarton believes that these people may have experimented with scale models before starting work on such projects. He says:

> "The sophistication of the Egyptian architect is proved by the existence of a definite entasis in the Paris Obelisk. The final erection of an obelisk was an extremely delicate job, on which the architect risked his reputation and possibly his life..... The task was complex and so full of hidden difficulties that one cannot help wondering whether the Egyptians did not experiment with scale models in order to determine the weight and balancing points of obelisks, rehearse the erection process and thus escape fatal disappointments".[4]

There is no real evidence to show that aids were used in architectural studies. There are, however, some models of houses in the Deutsches Museum. They may have been used in Town-planning.

Aids in the Study of Medicine

The following account speaks for itself:

> "Babylonian hepatoscopy is represented by a large number of texts (some 640 were already published in 1938) and what is more remarkable, by many clay models. Two such are in the British Museum, one of which is particularly clear and covered with inscriptions. Other models, found in Boghaz-koy, include inscriptions in Hitite as well as Accadian. Finally, a bronze model (136 m.m. long) was discovered in the Etruscan site of Piacenza. It is possible that the mysterious Etruscans brought Babylonian hepatoscopy with them from Western Asia, and later transmitted to the Romans. These three liver models are good symbols of the transmission of science to distant places....."[5]

The author, Sarton, also says that there were about fifteen objects of this kind excavated in Mari (Tell Hariri) in 1936. They date back to the second millenium. These models are in the Louvre in Paris.

The Etruscan liver model was found in 1877 in a field near Settina and is kept in the Civico Museuo of Piacenza.

Aids in the Study of Geography

Margaret Irene Fead in the Geographical Review of July 1933 confirms this possibility. She says:

> "The first known city maps are those from Mesopotamia. A crude and simple plan of Babylon, done on a clay tablet is an attempt to show the aerial spread of a city and is of great antiquity. Eckert dates it from about the middle of the 7th Century B.C. The Euphrates, represented by wavy lines, is mapped as flowing past the walls of the town. A plan of the city of Modakha of 650 B.C., (not Susa or Shushin, as the city is called by Daly and Laftus), appearing on a slab of baked brick, is probably contemporaneous with the map of Babylon. The bas-relief was made to adorn the walls of the Palace of Ashurbanipal, King of Assyria, who reigned in 668 - 626 B.C. at Nineveh. Unfortunately a part of the slab showing the city has been destroyed. The part remaining is bordered by two rivers and the ground plan of the city is distinct".[6]

These relief maps were not confined to the old world only. Pedro Sarmiento de Gamboa in his "History of the Incas" says that relief-maps were in use among the Incas of Peru. He further

adds that the 9th Inca (beginning of Twelfth Century) ordered the preparation of relief maps of certain localities in a district which he had recently conquered and intended to colonize.[7]

The Abacus

The earliest known "aid" used exclusively for instructional purposes is the abacus. Here again we are not sure when and where it was first used. Some believe that it is semitic in origin while others think that it was first developed in India and later the idea was carried to other parts of the world including China and Japan. A few believe that it first originated in China because it is there that the abacus is being used widely even now.

The abacus existed in different parts of the world. Like many modern machines it has also gone through a process of "evolution". The first known abacus consisted of a board covered with sand. It was called the dust-board. Later, bones were added to the board to make counting easier. The bones were subsequently replaced by pebbles or "calculi". From this pebble board arose the modern abacus.

The dust-board is probably the simplest type of teaching aid. Many schools in India consider it religious to begin the three R's for a child with a dust-board. In India the sand is generally spread on the floor and the teacher gets hold of the child's forefinger and writes the alphabet or numbers on it. Sometimes, but not always, the sand is spread on a small plank. The dust-board is not an elaborate mechanism for one nation to copy from another. Anyone with a mechanical bent could have conceived the idea. The Romans had three forms of the abacus. At first there was the inevitable dust-board. Then came the marked table with counters and finally the grooved table with beads. The Salamis had marbles instead of beads. The Japanese used bamboo rods and the ancient Peruvians employed knotted chords. Likewise other races also would have developed their own designs of the abacus. The following account tells us of such possibilities:

> "One may see in the National Museum, Washington D.C. five bundles of reeds which constituted a census made by Comanche Indians (originally from Western Wyoming and later ranging widely between Kansas and Northern Mexico). These bundles indicate respectively the number of women in the village, the number of young men, the number of warriors, the number of children and the number of lodges".[8]

These bundles which were made up of tule reeds, also served as a form of calendar. If the Indians agreed to perform a task on a particular day a single reed was removed from the bundle each

day or each night. Then when all the pieces were removed from the bundle, they (the Indians) will know that the time had come for them to act.

Dr. Auzoux Anatomical models

During the beginning of the 19th Century, Dr. Auzoux of St. Aubin de Ecroville, France, made some anatomical models for instructional purposes. These models became so popular that a firm under the name of Auzoux was established in 1822. Since then the firm has been supplying botanical, zoological and anatomical models to schools, colleges, universities and other institutions. The models have become famous all over the world. The Auzoux models are life-like and durable. In recognition of the invaluable work done by Dr. Auzoux a monument has been erected in his honour at the village square in St. Aubin de Ecroville.

The Glass models of Blaschka

Some years ago Rudolph and Leopold Blaschka (father and son) of Dresden, Germany, made some unusual models of plant-life. These models were made of coloured glass and they are exact replicas of live specimens. Some of the models were magnified to enable the student to see the structures with the naked eye.

These models are now in the Botanical Museum of Harvard University. They were made in Germany and shipped over to the United States. They are so delicate and they are likely to break at the slightest jerk of the show-case. As a matter of fact some are already damaged. Yet not one of them was broken during the long voyage.

Although we have shown that the origin of Audio-Visual Aids can be traced back to pre-historic times it was only in the 17th Century A. D. that it came to be recognized as such and the person responsible for advocating the subject as a discipline in Teacher-Training was a Moravian Bishop-Philosopher called John Amos Comenius. We have already made reference to him in the last Chapter. He felt that there was something radically wrong with the school system of his time. This prompted him to think of new methods of communication and in due course brought forth his first history-making book on Audio-Visual Aids. It was a children's pictorial Encyclopaedia called "Orbis Sensualium Pictus". In the preface of this book he wrote:

> "I say and repeat with loud voice.....that we can neither put into effect nor discuss reasonably unless we have at first understood properly all that has to be done or has to

be discussed.....
.....If the senses are thoroughly trained to understand the differences of the things well, it is practically the same as to lay the foundation to all wisdom, wise, eloquence and all clever acts of life.....So you see a new aid for schools namely the picture and the catalogue for all the fundamental things in the world and acts of life .....Prepared in this way this book will serve, I hope firstly to attract the mind, so that it conceives the school not as a crucifixion but as 'sheer delight'.....Secondly, the book serves to arouse attention, to direct it to things and to sharpen it more and more which is something great in itself.....From that the third will follow namely that pupils attracted thus far and thus around to attention will absorb knowledge of the fundamental things of the world by pastime and pleasure."[9]

All his pleas fell on deaf ears and not much progress was made for many years. During the last thirty years, however, we have seen a marked advancement in the growth and development of Audio Visual Aids. Now we have a variety of materials, some of them highly sophisticated.

Audio-Visual Aids can be classified into four main categories:—

A. Audio aids

B. Visual aids

C. Audio-Visual aids

D. Multi-sensory aids

A. Audio Aids

"Audio Aids" as the title implies are materials which deal with the sense of hearing. They include such things as Tape-recorders, Radio, Gramophones, etc. The main advantage here is that the lessons can be "canned" and the student can choose his own time and place to learn his lessons.

Secondly, "canned" lessons are uniform and can be reproduced in their true form at any time. This favours Communication.

Thirdly, audio aids can reach a wider area. This, we must admit, is their strength.

B. Visual Aids

Visual aids can be classified into two categories:

I. Two dimensional
II. Three dimensional

I. Two Dimensional

Here again the materials can be divided into two types, namely:

(*a*) Opaque pictures
(*b*) Transparencies

(*a*) *Opaque Pictures*

These pictures are so called because they do not permit light to pass through them. They include:

(i) Photographs and printed pictures
(ii) Paintings
(iii) Cartoons
(iv) Comic-strips
(v) Charts, maps and graphs
(vi) Posters

As explained earlier, all these materials provide for the learner "experiences" related to the subjects they represent. As an example let us take the study of the fraction $\frac{1}{4}$. It does not provide for the learner the "experience" associated with the subject it (the fraction) represents. What it really means is: One part out of four. But if we present the subject pictorially as shown in Fig. 15 the learner acquires an "experience" peculiar to the subject in question.

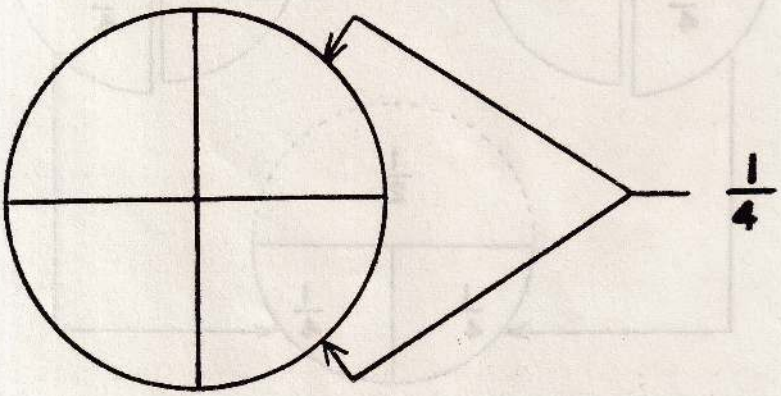

Fig. 15

For the benefit of the reader we shall make this problem a little more meaningful and this we shall do with reference to adding two fractions — $\frac{1}{4} + \frac{1}{4}$. This task can be performed in two ways:

(*a*) Digital

(*b*) Analogic

(*a*) ***Digital:***

The steps are as follows:—

1. $\frac{1}{4} + \frac{1}{4}$
2. $\frac{\frac{1}{4} + \frac{1}{4}}{4}$
3. $\frac{\frac{1}{4} + \frac{1}{4}}{\frac{1+1}{4}}$
4. $\frac{2}{4} = \frac{1}{2}$

(*b*) ***Analogic*** (Pictorial)

Fig. 16 explains the process.

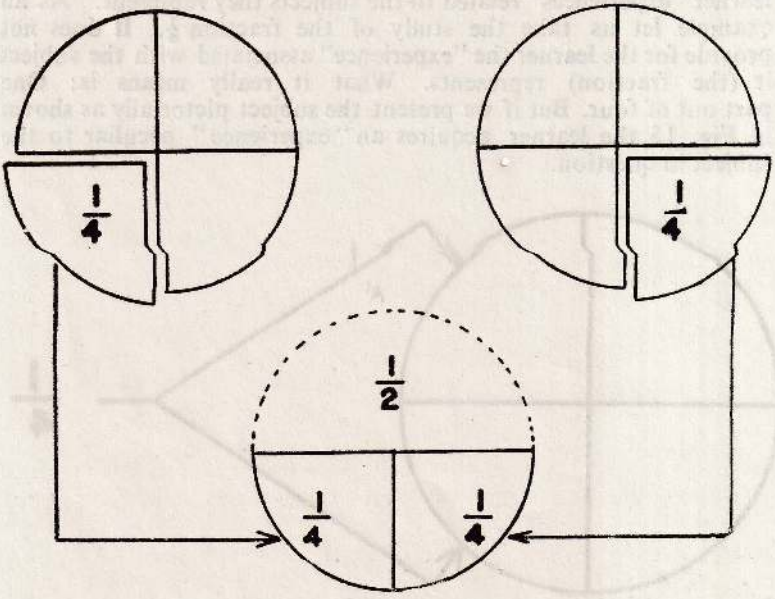

Fig. 16

This method *i.e.* (*b*) provides for the learner an "experience" peculiar to the subject in question.

This is exactly what happens when we use pictures to explain things.

The advantages of such aids can be listed as follows:—

1. They are inexpensive and readily available. There are so many pictorial magazines which one can collect from foreign embassies and travel agencies almost for nothing.
2. They can be handled easily and can be displayed without much difficulty.
3. They can be combined and recombined to build up stories.
4. They can be reproduced photographically and so replacements are easy.
5. If the pictures are not too large they can be projected on to a screen with the help of an episcope—*vide* Fig. 17. It must however be noted that the projection room must be absolutely dark.

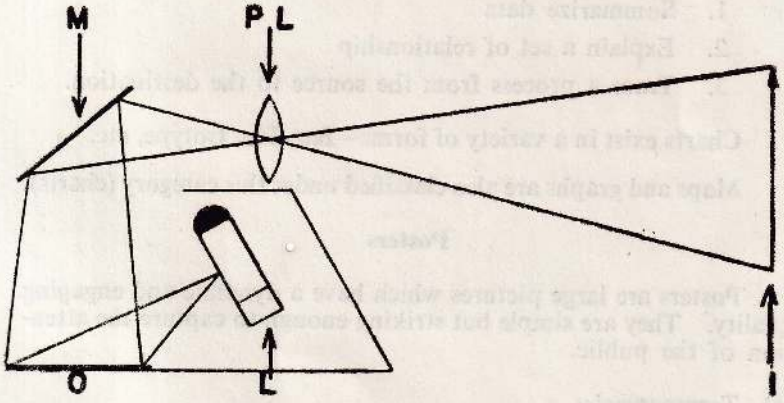

Fig. 17. *M: Mirror, P.L.: Projection Lens, O: Object, L: Lamp, I: Image*

Pictorial aids also have some draw-backs and they are:

1. Most pictures are small and as such they cannot be used in a large class.
2. Being two-dimensional they lack depth.
3. Motion cannot be represented easily.

Cartoons

A cartoon is a humorous exposition of an idea the purpose of which is to influence public opinion towards a pre-determined objective.

Cartoons are widely used in newspapers and periodicals. They usually appear as single pictures and more often than not political in content.

Comic-strips

Comic-strips are actually pictures in which the characters enact a story. They are motivational in value and they are particularly meant for children who are too young to learn from written texts. Very often these materials keep even the adults occupied.

Charts

These are materials which carry summaries of information through digital and analogic codes. Their values are:

1. Summarize data
2. Explain a set of relationship
3. Trace a process from the source to the destination.

Charts exist in a variety of forms—Bar, Pie, Isotype, etc.

Maps and graphs are also classified under this category (charts).

Posters

Posters are large pictures which have a dynamic and engaging quality. They are simple but striking enough to capture the attention of the public.

(*b*) *Transparencies*

Transparencies include:

1. Slides
2. Film-strips

Slides

Slides were first associated with Sunday school teaching and they were then called "lantern slides". The size of these "lantern slides" were $3\frac{1}{4}'' \times 3\frac{1}{4}''$. Now the popular size is $2'' \times 2''$. The slides whether $3\frac{1}{4}'' \times 3\frac{1}{4}''$ or $2'' \times 2''$ have to be projected on to a screen

through a slide project—*vide* Fig. 18. There is a slight difference between this instrument and the episcope. In the former the illumination is at the rear of the picture (slide) while in the latter it (illumination) is in the front of the picture.

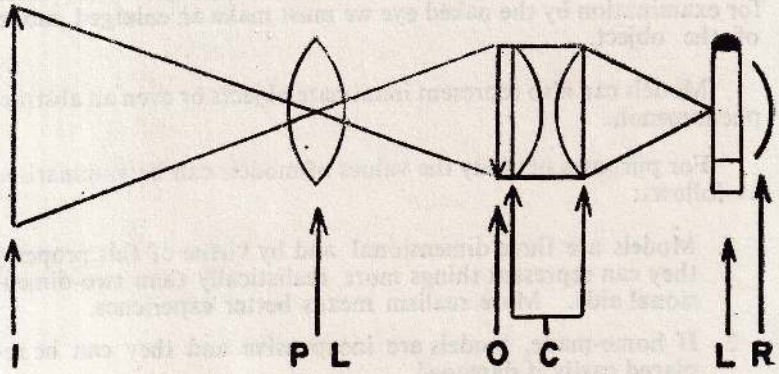

Fig. 18. *I: Image, P.L.: Projection Lens, O: Object, C: Condenser, L: Lamp, R: Reflector*

Slides are convenient to handle and they can be combined and recombined to suit the lessons. Another important advantage is that teachers can make their own slides.

The danger here is that the slides can get out of order.

Film-Strips

A film-strip is a strip of film on which are printed a series of pictures in a sequence. In other words it is a picture story which can be projected on a screen frame by frame.

The only disadvantage here is that the pictures cannot be recombined to suit lessons other than what is recorded on the film-strip.

II. Three Dimensional Aids

1. Models

As a rule models are three dimensional in form. In addition to length and breath they also have real depth. When we say "real" we mean "actual". Some pictures appear to have depth but they are not real.

A model can be smaller or even bigger than the actual object, depending on the size of what it represents. For instance, if we want to explain to the learner something about the solar system a table model is the ideal aid. Certainly we cannot produce a life-size model of the system: Can we? Similarly, if the object is too small for examination by the naked eye we must make an enlarged model of the object.

Models can also represent inanimate objects or even an abstract phenomenon.

For purposes of study the values of models can be summarised as follows:

1. Models are three dimensional and by virtue of this property they can represent things more realistically than two-dimensional aids. More realism means better experience.
2. If home-made, models are inexpensive and they can be replaced easily if damaged.
3. They are durable.
4. They can simplify complex objects.
5. Models can highlight special features.
6. Models, like those of Dr. Auzoux can be "dissected" and re-assembled.
7. Models can be made to show the interior views of objects. Such materials are called cut-away models.
8. Models can also represent a whole system such as a manufacturing plant.

2. Mock-ups

A Mock-up is really an organization chart where the various units are represented by models which can be moved about. For example, a plan of attack in a foot-ball game. These aids are widely used in military exercises. The allied invasion of Normandy during the last war was planned with the help of a large model of the French Coast.

3. Dioramas

A Diorama is really a three dimensional picture. It takes the shape of a box inside which there is a curved screen. In front of the screen we place objects in such a way that the whole assemblage gives a three-dimensional effect. These aids are very common in natural history museums.

C. Audio-Visual Aids

1. Instructional Television
2. Motion Pictures

1. Instructional Television

Television is not merely an aid. It is a medium in itself. In many countries it has become a serious threat to class-room teaching. This is because the programmes can be well controlled, *i.e.* the best of teachers can be invited to record or present the lessons. The only disadvantage is that it is also a one-way process. However, with the advancement in programmed learning this difficulty can be overcome.

2. Motion Pictures

We shall study this subject in terms of what Professor Edgar Dale had said about it:

> "Life is too short to permit us to learn all that we need to know either by first-hand "doing" or first-hand "viewing". We are compelled to get much of our experience at "second-hand". .....
> .....as Twentieth Century citizens we are fortunate in having so useful a means of indirect observation as motion pictures. Through them we are able to see what the camera has recorded on film anywhere and everywhere in the world". [10]

As he says, 'we cannot accompany Admiral Byrd on his expeditions to the South Pole, but we can all see these things by means of motion pictures'. [11] We shall now examine the values of motion pictures.

1. *"Experiencing" motion*

In the last Chapter we have said "speech consisting of a product of sounds, does not coincide with the things which are endowed with a real existence....." Similarly we can say the same thing about still pictures when they try to communicate events which are "endowed" with motion or action. Motion pictures can overcome this problem.

2. *Compels attention*

This is because almost all disturbances are cut off. When the room is darkened the entire attention of the learner is directed towards the screen.

3. *Motivational*

As a rule all normal human beings are attracted towards movie films. We have to accept it as a statement of fact because it is difficult for us to give an exact scientific explanation for such behaviour.

4. *Control of Time*

There are certain events which are too slow to be "experienced", *e.g.* the growth of a plant. This problem can be overcome by a special technique called "Time-lapse photography". In this method the pictures are shot at a rate slower than the normal speed—twenty four frames per second (sound).

Then when the film is run through the projector at the normal speed (24 frames per second) the action is speeded up. This "speeding up" enables us to "see" and "experience" the process in question.

There are also certain events which are too fast to observe, *e.g.* the passage of a bullet. For this there is another technique called "slow motion". In this method the pictures are shot at a rate faster than the normal twenty four frames per second. The speeds can be 48, 72, 96, 120, etc.— frames per second. Then when the film is run at the usual speed — (24 f.p.s.) the action is slowed down for the human eye to see.

5. *Recall of the past*

With the advent of motion pictures, institutions all over the world are keeping records of their activities in movie films so that one could "recall" them if and when necessary.

6. *Projecting the future*

Subjects such as development programmes, population growth, educational expansion, etc. of the future can be brought into the class-room through the medium of motion pictures. The technique which makes this possible is referred to as "animation". Animation is a process where action is given to hand-drawn pictures. The popular "Mickey Mouse" film by Walt Disney is a typical example. The pictures are drawn in sequence and then photographed. Suppose a particular action takes one second, then we break it up into twenty four frames and each frame will carry the picture of a particular stage in the action —sequentially of course. Then when the film is run through

the projector the pictures overlap to give the illusion of movement. Animation can bring the universe itself into the classroom. Most of the space adventure films we see on the screen are all animations.

7. *Magnification*

Films can show us the activities of microscopic organisms. This is done through a process known as "cine-micrography". Through cine-micrography we can see cell-division, blood circulation, fungal growth, etc. In other words, cine-micrography can make an invisible world visible.

8. *Miniaturization*

Certain objects or events are too big or too complex to be observed by the human eye, *e.g.* the solar system. But through the medium of motion pictures, either animated or real, the system can be brought within the normal vision of the learner. Then we can also produce a "close-up" film of a particular celestial body. Here again motion pictures become invaluable in their uses.

9. *Mass-media*

Another important characteristic of the motion pictures is that they can reach a large number of people at relatively low cost.

Suppose a film costs a hundred dollars and if it can be shown to five hundred students then the cost per student is only twenty cents If the film is looked after carefully, it can last for more than ten years. That will further reduce the cost of overhead expenditure.

10. *Communication*

"Communication" as we have defined it earlier, "is the establishment of a state of equilibrium between the learner and the source from which the 'knowledge' originates". Motion pictures can achieve this far better than the conventional classroom method, because the latter varies from time to time and from place to place. This is not so in the case of motion pictures. Every screening is a true representation of the previous one. This is important for "sharing" knowledge.

D. Multi-sensory Aids

These include: 1. Simulators
2. In-plant training
3. Dramatization

1. Simulators

Simulators, as they are now understood, are actually training machines. The simplest example is the three-wheeled cart which a child pushes around to learn the art of walking. Then there is the boat-shaped contraption which the cricketers use to learn the art of fielding. From such simple beginnings the simulators have now become part and parcel of almost all training programmes. We find simulators being applied to games, car driving, aviation, space-flight training, etc. Their values, as explained earlier is to provide the learner with a sensory experience peculiar to the task which the learner is expected to carry out in the future. In other words the function of the simulator is to establish in the body of the learner the necessary feed-back network for the performance of the intended task.

The following illustration will show the reader that simulators can be used even to solve psychological problems:

The writer's son dreaded even getting close to large sheets of water. So it was a problem to bathe him. He rebelled against anyone who attempted to give him a bath. At one stage it was thought that a "forced" bath might lead to dangerous consequences. What the writer did was to build a miniature pool in the lawn outside his house. Then he let his other children sit inside and play. Soon his son joined them. When he was engaged in play the writer let the pool fill very slowly. His son did not notice the water creeping upon him because he was too busy frolicking and splashing water on the other children. By the time he realised what was happening his body had got itself adjusted to the environment. After that it was a problem to stop him from bathing! The reader might think that it is an expensive method. It is not so. The miniature pool cost only one hundred rupees (ten dollars). The outcome was worth more than ten dollars.

2. In-plant Education

To understand what this is we must look at what has come to be known as "Pre-vocational Education".

This subject is the brain-child of the former Secretary to the Ministry of Education, Dr. P. Udagama. We shall therefore examine this subject with the following remarks made by him at a Seminar on "The Present Education System in Sri Lanka and its Relevance to National Development":

"All Asian nations had developed a system of education which served their societies quite effectively in the past. At present the most pervading influence in all our societies is colonialism in some

form or the other. It has affected our country for a period of four centuries, perhaps the longest for any Asian nation. Independence from colonial rule is a political fact, but we realize that it is an equally valid educational fact as well.

Because of our past history and also of the impact of colonialism in our societies education has a social and cultural value on its own merit. Our scholars, whether they were mandarins, Brahmins, Buddhist monks, valued education as a supreme way of developing the ideal man to fit into his culture. In colonial times missionary education added to this high social standing of education. Learning and scholarship were venerated. Colonial education added a further dimension by providing an economic value as well. In almost all the countries after independence, education was thought to serve many purposes. Education was considered essential for the political and the ruling aliens. Education was also considered as a morally up-lifting force for its citizens. Education for literacy of all the people was also considered an ideal that all states should foster for development.

After the end of colonialism in the political sense and in the post-independent era most of our leaders expressed the idea of liberating our people from colonialism for the development of our own societies. At least, in Sri Lanka, people themselves were politically concerned to obtain an education for their children for economic and cultural values. The foundation of this education was based upon the idea of redeeming our people to develop their own values and ideals in culture, morality, science and technology and politics.

After nearly three decades of political independence we are now realizing, in spite of the vast efforts made in education, that the promised land has not been reached through the process of educating our masses in the old style. The youth in our country do not talk the same language as their post-independent leaders. Our youth need employment. They desire decent living standards. They want to modernize our societies and not necessarily westernize them as in colonial times.

We are therefore, approaching historically important cross-roads in our educational system. We note the restrictions that oppress the people from receiving an education needed for economic and social development. The colonial school in our societies was a school for the elite. They were organised on a strictly utilitarian basis with an age specific subject centred academic curriculum. The school allowed no one to join it if they had missed one or two years of schooling. It assisted the selection of professionals and

bureaucrats to dominate our societies. It was aloof from the people and their culture and valued an ideal society not found in the Asian continent.

However, the schools for the masses in the vernacular languages were meant for the peasantry and the working classes to have only a basic literacy. These schools were the poor man's schools that produced law-abiding citizens.

When in 1833 British colonial government took a positive stand to teach in the English medium our people were almost immediately alienated from our educational system. From then onwards began a long process of organizing a cheap but efficient educational system to train the petty officials and bureaucrats and to man successfully the colonial power structure. The curriculum of this school remained British in every respect. The effort of the local people to develop their own school system towards the end of the 19th Century did not alter this situation. The nationalist schools with a Buddhist or Hindu or Muslim religious environment paid glorious tribute to the missionary schools when they organized their schools on the model of the missionary one. The only difference was seen in the religious environment of these schools. For a long time therefore, this upper class colonial school devoted itself to one main purpose providing social mobility for some able children to obtain government employment.

As people valued education for its own sake the granting of Universal Franchise in 1931 ushered in an era of educational expansion in the rural districts. Today our well-distributed school system in the whole country is due to the impetus given by this political act through which the people obtained their schools in location closer to the homes of the children.

Free education was a reality in 1945, three years before Independence. After Independence the school systems expanded phenomenally in Sri Lanka. In the twenty years from 1950 the school-going population increased almost by 500%. The media of instruction became Sinhala and Tamil as an essential step of cultural de-colonization. Later in 1960 all the private schools were taken over by the State in order to run an efficient and economic system of education. With all these progressive movements in education people have realised rather late that this education has not solved the problems of the individuals or of the nation.

However, by then with our progressive movement in education we had to some extent provided equal opportunities of education for nearly all the children. We had reached a high level of

literacy by any standards. Nearly 61% of our people had successfully passed the school final examination and more than 10% had completed a ten year period in school. The regional disparities remained and the really poor had no opportunity to progress far in spite of free education.

Up to this point we had never considered the relevance of this education for a national renaissance. Hence, education created more problems than it solved. Unemployment of youth in large numbers was one significant failure. The orientation of youth to obtain white-collar jobs that were not available left them insecure and dissatisfied. The curricula and the text-books did not portray our national problems; and we know now education for its own sake has become a failure for many and a dead-end for the whole nation." [12]

Nothing can be further from the truth. Millions of rupees were being spent to produce a "dead-end for the whole nation".

It was under these circumstances that the concept of pre-vocational education was born and its main aim was "to provide for the learner a scientific and technical knowledge that was both useful and necessary for the individual and national growth ".

As we can see from what we have said above pre-vocational education was a form of practical education—the purpose of which was to enable the learner to obtain food, clothing and shelter in the event of his becoming a drop-out in academic studies.

Is it realistic? The answer is, yes. Here again we have to fall back on the writer's experience. For a while the writer was unemployed. During this period he earned his living by teaching children to play tennis. Further, he also enhanced his income by designing cut-out models. The writer did not learn these subjects through formal teaching. He acquired the necessary knowledge by his own effort. But in pre-vocational education the learner is directed towards the intended objectives, *i.e.* the process is "controlled".

To begin with there were about eighty subjects and they included Fishing, Brick-making, Flower arrangement, Hair-dressing, Paper-manufacture, etc. Unfortunately, there were no qualified teachers. As a result progress was slow and before the teachers could be trained the sponsors lost their hold on the programme due to change of government. Knowing the values of this system (pre-vocational education) as we do, we will not be surprised if it is re-introduced —may be under a different title. So let us not abandon the plan altogether.

The pre-vocational subjects which were taught in schools were more or less academic in nature. The practical work associated with them were only test-runs. They were not adequate enough to provide the experience necessary for the learner to embark on a technological career. In order to equip the learner with adequate experience he was sent to an industrial establishment. This programme was called "In-plant education" and it was first 'initiated at the Veyangoda Textile Mills in 1973 for the students of Sanghabodhi Maha Vidyalaya, Attanagalla'.

The objectives of In-plant Education can be summed up as follows:-

1. To enable students to participate in the national development programme by actually working in a productive organization and to acquire a sense of self-confidence and self-reliance.
2. To introduce the child to productive labour, foster a sense of dignity of labour and thereby develop favourable attitudes towards it.
3. To serve as an extension of the Pre-vocational programme.
4. To develop the ability to apply school learning to practical situations and at the same time enable the children to adjust to a new environment.
5. To provide an initial familiarity with development projects for the H.N.C.E. level of education.
6. To strengthen values, skills and attitudes learnt in the formal education system in a non-formal sector of education.[13]

3. Dramatization

The term "Dramatization" is self explanatory and so there is no need for us to describe what it is. We shall therefore confine our study to what it does and what it includes. It includes:

1. Participation
2. Observation

Of the two, the former is more effective because the learner is directly experiencing the characteristics of the subject he is portraying.

As for the other, *i.e.* Observation, it is believed that in this process the learner imagines himself as the hero of the play and thereby acquires the "experience" necessary for him to live up to the standards set by the hero. This process is called "make-believe" which, as we have said earlier, is also a form of simulation.

Dramatization can be classified as follows:

1. Plays
2. Pageant
3. Pantomime
4. Tableau
5. Puppetry

Experience will tell us that of these five, only the last, *i.e.* Puppetry, particularly cut-outs, is the one which comes within reach of production by any school, rich or poor. The schools and institutions will be well advised to devote some time to develop this medium.

Puppetry also can be classified into five types:

1. String puppets or marionettes
2. Hand and Rod puppets
3. Hand and finger puppets
4. Shadow puppets
5. Cut-outs

For reasons already given we shall restrict our study to cut-out puppets.

These puppets are so called because they are cut out from the base material which may be either card-board or ply-wood. The 'characters' are then mounted on wooden handles. The operators lift the puppets up by their handles and manipulate them by remote-control. The "theatre" is usually a rectangular frame.

As for the values of Dramatization, we can say they are environmental, and we shall discuss this subject in the next Chapter.

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CHAPTER VII

GENETIC ENGINEERING

Performance of the task and preservation of life are not the only objectives in learning. Acquisition of a socially acceptable behaviour by the learner is equally important as the other two, for, it reduces the "fear of insecurity" inevitably present in the "minds" of all living organisms on account of the fact that they are constantly surrounded by an unpredictably changing environment. How often have people found their neighbour's attitude towards them changing even though they have not done anything to disturb his way of life.

Reduction in the fear of insecurity automatically increases the stability of the learner and this, as the reader himself will agree, is essential for better learning. This can be seen in the behaviour of children in the class-room. Surely a child will make a better effort to learn under a kind teacher rather than under a bully.

Acquisition of a socially acceptable behaviour is a difficult mission to accomplish because we will have to deal with problems in genetics and our knowledge about the subject is still not adequate enough for us to take a positive approach towards the task in question. We shall, however, present the likely possibilities here so that the reader will know exactly what he should do if and when the problem forces itself on his mind and becomes "importunate in its demand for a solution".

As a means of introducing ourselves and the reader to the subject we shall begin our study with the following report by Hirschhorn:

> "The past 20 years, and more particularly, the past 5 years have seen an exponential growth of biological knowledge. The chemical structure of the hereditary material, as well as its language, has essentially been resolved — cells can be routinely grown in test tubes by tissue culture techniques. The exact biochemical mechanism of many hereditary disorders have been classified. Pre-natal diagnosis of many disorders has become possible. Computer programs for genetic analysis are in common use. All of these advances and many others have inevitably led to discussions and suggestions for the modification of human heredity, both in individuals and in population. This has been called genetic engineering."[1]

As an introduction to our intended course of study, nothing can be more appropriate than what has been quoted above. In effect it is refreshing and reassuring — and we are quite sure the reader himself will share our views. What is more, we have a formidable title too.

Genetic engineering, as the subject is called, has its own problems, much more than what we encounter in the traditional fields of engineering, civil, mechanical, electrical, etc. In these areas the problems are confined mainly to applications. Theories have been well established and proved to be valid. This is not so in our field of study. Theories have not been tested satisfactorily and as a result progress has been slow.

What concerns us most, in our mission, is the 'frequency of the disadvantageous genes in the population'. Biologists tell us that 'each of us carries between three and eight genes which if present in double dose in the offspring of two carriers of identical genes would lead to severe genetic abnormality, or even to death'.[2]

Treatment of such disorders following medical advances have undoubtedly led to the spread of the defective genes through reproduction by the affected individuals. Cure of the disease does not mean the "cure" of the gene. If we look at this problem pessimistically we must conclude that the human race will, sooner or later, end up as "cripples" or become extinct.

This is a contradiction of the principle of conservation of energy and therefore we must not renounce ourselves to such a situation because we have already placed our faith in this fundamental law of Nature. We must act on the premise that "the forces of natural evolution will continue to select favourably those individuals who are best adapted to the then current environment".[3]

Our subject — Genetic Engineering, includes four distinct fields of study, namely:

(i) Eugenics

(ii) Euthenics

(iii) Genetic error-correction

(iv) Environmental regulation

We shall now discuss these subjects to see how they can help us to fulfil our mission, *i.e.* to bring about a refinement in the behaviour of the learner.

(i) Eugenics

Eugenics, as applied to human behaviour fails into two categories—

1. Positive Eugenics
2. Negative Eugenics

Positive eugenics refers to the preferential breeding of the so-called upper class of people in order to improve the genetic constitution of the human stock. It involves the establishment of a sperm bank with a "capital" from a selected number of clients who are intellectually "well-do-do".

The sperms are kept there frozen and when the occasion arises the "desired" one is picked out to inseminate the participant concerned. Then we must remain in hope, to achieve the intended objective because that particular sperm may carry other genes which may not be conducive for "progress". This leaves us in a state of uncertainty about the values of this method.

Negative eugenics on the other hand seems to be more practicable. It involves the prevention of reproduction by individuals who carry defective genes, *i.e.* those which are responsible for disease or disability. This can be brought about by:

(*a*) genetic counselling
(*b*) selective abortion
(*c*) sterilization

The problem here is the determination of what traits are to be considered sufficiently disadvantageous to warrant the application of negative eugenics. Here again we face serious opposition for implementation.

(ii) **Euthenics**

Our next field of investigation is euthenics. This method is a process of error-correction by artificial means. For example, the use of braille for blind children. The employment of hearing aids for partly deaf individuals is another example of this method. Though these methods are humanitarian in nature they have not gained favour with the group which believes in the establishment of a super race. This particular group feels that this method will lead to a further spread of the defective genes and thereby contribute towards the decline of the species — Homo sapiens. People should not entertain such fears. As we have said earlier "the forces of natural evolution will continue to select favourably those individuals who are best adapted to the then current environment".

As an illustration let us take the case of a person who carries a "sickle-cell" gene, *i.e.* a gene which causes sickle-cell anaemia. If this gene is present in double dose, *i.e.* in a homozygous state the carrier will develop the disease and it may lead to fatal consequences. But if this particular gene exists in association with a normal gene, *i.e.* in a heterozygous condition, it does not exert its influence. Besides the carrier is better protected, more so than the normal persons, against "the effects of some of the harmful forms of malaria". What is more, women who carry this heterozygous combination have "a higher fertility rate in malarial areas than do normals". This evidence, though favourable enough not to discourage our humanitarian activities, is not sufficiently strong to convince those who oppose the practice of euthenics.

(iii) **Genetic error-correction**

We shall now discuss "genetic error-correction", one of the most formidable of all known areas in the field of applied sciences.

The principle behind this is as follows:— The genetic code is built up of a language of sixty four letters, each of which is a combination of three of the four nucleotide bases, Adenine, Thymine, Cytocine and Guanine. A chain of these bases constitute the genetic material of the chromosomes. Now if the "letter" responsible for producing the defective gene can be located in the zygote (fertilized egg) the necessary corrections can be made to bring the system back to normality, hopefully of course.

There is yet another method which can be applied to bring about the necessary correction in a defective genetic code. This method takes its origin from the way certain viruses have made use of bacteria to achieve their objectives.

Viruses can function only in a cellular environment and it is believed that they make use of the machinery of the host cell to perform their tasks. Most probably they (viruses) lack a regulatory mechanism and in consequence the genetic code is rendered functionless. Here again we have strong support to show the essentiality of such an arrangement in a living cell. Enough has been said about this subject already and it might become an obsession if we make any further attempt to explain it.

There are certain viruses which cause diseases while living in the human cells. But there are also others which while continuing with their functions in the host cell remain harmless. They do not cause any damage either to the cell or to the organism. If such viruses can be made to carry the desired genetic material into the cells of the affected individuals the person concerned can be cured permanently.

Besides these two methods there is also the possibility of transplanting whole nuclei from one cell to another. This suggestion comes from no less a person than Nobel Prize winning Geneticist, Joshua Lederberg. As Hirschhorn says: 'the problem of altering an individual's genes by direct chemical change of his DNA presents a technically very difficult task. Even if it became possible to do this the chance of error will be high, such an error, of course, would have the opposite effect of that desired and would be irreversible, in other words the individual would become even more abnormal'.[4]

Here again, our task becomes hazardous. We are thus left with only one possibility, *i.e.* Environmental regulation.

(iv) **Environmental regulation**

M. J. Berry, in his remarks on "Conservation Aspects of Genetical Constitution of Population" says — "Since the genetical constitution of any species is determined by the sum of past environments experienced by the species it follows inevitably that conservation practices are potentially capable of genetical changes".[5] In other words it means that changes in the genetic code can be brought about by controlling or regulating the environment. The mimicking behaviour of the peppered moth Biston betularia, referred to in Chapter II, illustrates this point of view very effectively.

Though this illustration supports our views satisfactorily it does not permit us to make far-reaching claims such as transforming a bird into a bee or a bee into a fish. The behaviour of Biston betularia is only an example to show the possibility of changing the genetic code by environmental regulation. It is by no means an indication of the nature of change.

This method is a form of "false pretences". The intention here is to "condition" the gene for the purpose of directing it towards the performance of the desired task.

The principle is exactly the same as that found in the immunisation of an individual against small pox. What we do there is to "cheat" the system by "false pretences". Acting on this false alarm the organism builds up the defence against this imaginary enemy.

The value of this method lies in the fact that in it (environmental regulation) we look forward to a permanent change through re-adjustment of the genetic code by the system itself. Why this is necessary is because some of the characteristics of higher organisms are polygenic, *i.e.* they are governed by groups of genes.

In such a situation an artificial process of genetic error-correction is not only difficult but also harmful in that it may lead to the disruption of the genetic complex.

In the case of environmental regulation the system will reject the interference if the process becomes a danger to the constitution of the genetic code.

It is here that we find this method more satisfying than the others described above. Even if the mission fails the organism will not be dangerously affected.

Now, how do we apply this method for the execution of our mission—to make the learner a socially acceptable individual?

We shall discuss this problem with reference to a learner whose conduct becomes anti-social because of his aggressive behaviour. As a rule people have adopted the philosophy of "fire drives out fire" to counteract this evil temperament in man. This cannot be regarded as a permanent cure to be transmitted to the subsequent generations. On the contrary it may worsen it by aggravating the "fear of insecurity" which is already present in the system and which is responsible for most of man's anti-social behaviour.

There are two ways by which this problem can be handled successfully:

(1) Avoid providing opportunities for the person concerned to exercise this characteristic.

(2) Use counteracting arguments in terms of the *individual's* own personal security.

For instance if we wish to regulate the behaviour of a reckless motorist who has no use for other people's lives we must set up a signboard with the following captions:

"DRIVE SLOW: SAVE A LIFE: IT MAY BE YOURS"

It will even be better if we use these slogans separately on three separate signboards placed along the highway one after the other at regular intervals.

Educationally speaking, these two methods must necessarily bring about certain physiological or psychological reactions in the system and these reactions may lead to a favourable output in the process of acquiring a socially acceptable behaviour by the learner.

Once the human "mind" is convinced about the values of this "Social acceptability" it will underplay the defective characteristic.

In due course, *i.e.* in the future generations this anti-social behaviour may get eliminated genetically. Pessimists may look upon this as wishful thinking. But we can explain this possibility with reference to another characteristic — nasal accent in speech. Speaking English with a nasal accent is considered a socially acceptable characteristic in the United States of America. So much so, this behaviour has become a part of her cultural life. The ease with which each new generation picks up this characteristic clearly indicates that it has a genetic bearing. If this is not an acceptable proposition then the entire credit is attributable to environmental regulation.

What we have said above is only a reiteration of Lamarkian theory of evolution. This theory has been an explosive issue among biologists and the battle had gone on for more than a century. As a matter of fact the issue still remains controversial. Therefore, it is necessary for us to settle this matter before we continue further with our task.

This subject, *i.e.* Lamarkianism, became "explosive" when Kammerer, an Austrian Biologist of great repute charged headlong into the Darwinists' camp like a "bull in a chinashop". He refused to give any credit to their theory of evolution, 'based on random mutations — haphazard variations produced by blind chance'. To make matters worse he also strongly supported what Lamark had postulated in 1809, *i.e.* 'useful adaptive changes in the parents were preserved by heredity and transmitted to the offspring'.[6]

This was too much for the Darwinists to take but they could not do anything about it because Darwin himself had praised Lamark in his early note-book entries. He had referred to him (Lamark) as a source of inspiration 'endowed with the prophetic spirit in science, the highest endowment of lofty genius'.[7]

The Darwinians took the onslaught calmly. When they had cooled down they summoned all their resources and started their attack directly on Kammerer, rather cunningly. While praising him for his invaluable contributions to science, they started cutting the earth under his feet. Before he knew what was happening Kammerer was in the grave — dug for him by his enemies. Here is a brief report on the tragic episode:

"On September 23, 1926 an Austrian experimental biologist named Paul Kammerer committed suicide. This formed the climax to a great evolutionary controversy which Kammerer's

experiments had aroused. The battle was between the followers of Lamark, who maintained that acquired characteristics could be inherited, and the neo-Darwinists, who upheld the theory of chance mutations preserved by natural selection. Dr. Kammerer's experiments with various amphibians, including Salamanders and the mid-wife toad (Alytes obstetricans), lent much weight to the Lamarkian argument and drew upon him the full fury of the orthodox neo-Darwinists. Heading the attack on Kammerer was a British scientist, William Bateson, who hinted that his experiments were faked, but failed to examine the evidence, including the so-called nuptial pads of his last remaining specimen of the mid-wife toad. It was a young American Scientist who delivered the coup-de-grace. On a visit to Vienna, he discovered that the discolouration of the nuptial pads was due not to natural causes but to the injection of Indian Ink. When his findings were published, Kammerer shot himself".[8]

By this act Kammerer played into the hands of his opponents who maintained that his (Kammerer's) suicide was a confession of guilt. This is far from the truth. Richard Goldschmidt, a renowned geneticist and one of Kammerer's detractors had this to say about him (Kammerer):

> "He was a high-strung, decadent but brilliant man who spent his nights, after a day in the laboratory, comparing symphonies. He was originally not a scientist, but what the Germans call an "Aquarianer", an amateur (sic) breeder of lower vertebrates. In this field he had acquired immense skill, and I believe that the data that he presented upon the direct action of the environment are largely correct".[9]

A person of such ability will not descend to the level of faking experimental data. Besides, his specimens were exhibited at various places. Nobody challenged him then.

Dr. G. K. Noble, the fellow who carried out the test on the Alytes was described by Gregory Bateson as a "ruffian". He had the same reputation among the other English Zoologists as well. Have we ever heard of ruffians being associated with fairplay?

Again, Kammerer's papers on the experiments he carried out on the midwife-toad (Altyes) "dates from 1906 and occupies ninety-two pages of solid German text-book size; the next, in 1909 occupies ninety-nine pages, the last in 1919 forty-seven pages".[10]

Can anybody in his right senses spend so much time and so many pages (238) over faked experiments?

What had happened was, the actual specimens were replaced by faked ones. The whole thing was manipulated. Kammerer committed suicide in utter disgust. Whatever it is, one thing is clear: *Environment is a force which one could ill-afford to ignore.*

Let us not go further into the controversy by opening up the case of the mid-wife toad (Alytes obstetricans). We shall examine Kammerer's first experiment, *i.e.* with the spotted salamander. Here is the report on the subject:

> "According to circumstances, as we saw, it gives birth in the water or on land, to larvae or to young adult forms. Moreover, the spotted type, will also change its colour, like the chameleon; but—unfortunately for the experimenter—at a much slower rate. The variety which Kammerer collected in the Vienna woods (Salamandra maculosa, forma typica) has yellow spots irregularly distributed on a background. The preliminary stage in the next series of experiments to be described—which ranged over eleven years—was to rear one group of animals on black soil, another group on yellow soil. In the first group, the yellow spots gradually diminished until, at full maturity around the sixth year, they were quite small. In the second group the yellow spots expanded and merged into large stripes. This part of the experiment was repeated by others, and is not contested. It is also established that these colour changes were not caused by the direct chemical or photo-chemical action of the environment on the animal's skin; they were mediated by its central nervous system, reacting to the colour perceived through the animals eyes.....
>
> .....The progeny of black-adapted parents, again reared on black earth, were born with a single row of small yellow spots along the median line on the back, which became smaller and later all but disappeared. The progeny of yellow adapted parents, again brought up on a yellow soil, were born with two symmetrical rows of yellow dots, which later united into two broad yellow stripes; and the third generation brought salamanders whose back became of uniform canary yellow colour".[11]

This change of colour by the salamander is not much different from what happened to the peppered moth Biston betularia during the industrial revolution in England.

This evidence is proof enough to accept what Lamark had postulated.

It is also possible for a chance mutation to take place in an organism. But it cannot be held as the one and only method of evolution. The neo-Darwinians had been rather unfair in their attacks on Lamarkianism and the methods they adopted to disprove it were somewhat flimsy. As an example let us take the experiments of August Weismann who was more Darwinian than Darwin himself. To study the possibility of developing a tailless mouse he cut off the tails of mice for twenty two generations. It was as silly as studying the possibility of inheriting a wooden leg. It was a distortion of Lamark's theory. What he (Lamark) postulated was:

> "Only such characteristics are inherited which an animal develops as a result of its natural, adaptive needs".[12]

Cutting the tail of an animal can hardly be called an adaptive need.

Kammerer did not carry out the experiments for sheer excitement. He had a purpose, *i.e.* to make education meaningful. In a lecture on "The Significance of Inheritance of Acquired Characteristics for Education" this is what he said:

> "Froebel, Pestolozzi (educational reformers much in vogue at the time) and their schools relied on their potential dispositions which the child inherits from its ancestors, hereditary dispositions which the educator hope to enrich; but he could not hope to bestow on the children a permanent heirloom in which their children's children would be able to share—only a gift for the fleeting duration of an individual existence. They could not conclude otherwise but that at the death of an individual his acquired merits would also die with him; his heirs might continue what the ancestor began, but however excellent their hereditary dispositions, they again had to begin at the beginning.
>
> However, on the hypothesis of the inheritability of acquired characters, which seems to be closer to the truth, the individual's efforts are not wasted; they are not limited by his own life span, but enter into the life-sap of generations. It depends on us whether it will produce a benign or destructive effect.
>
> By teaching our children and pupils how to prevail in the struggles of life and attain to ever higher perfection, we give them more than short benefits for their own lifetime—because an extract of it will penetrate that substance which is the truly immortal part of man. Out of the treasure of potentialities contained in the hereditary substance transmitted to us from the past, we form and transform, according to our choice and fancy, a new and better one for the future".[13]

The remarks "seems to be closer to the truth" mentioned in the above passage is an understatement. What Kammerer had said is probably the truth for as a famous scientist once said it is difficult for us to believe that the "Creator plays dice with the world".[14]

Environmental regulation is not a new idea. For centuries the Hindus of Ancient India have applied this principle for the training of the human mind. This process has been well explained through a series of stories in "Hindu Mind Training". Let us examine some of the stories and see how they contribute towards the growth and development of the intellect. We shall begin our study with the story of Savitri.[15]

Savitri was the daughter of King Aswapati. When she came of age her father wanted to get her married. Having made up his mind he called his daughter and told her of his intentions. He then said that he will leave the matter of choosing her husband entirely in her hands and that she should go round in his kingdom and select someone whom she would like to marry. Further he also reminded her that he will give his approval for marriage if he is also satisfied with her choice.

The young Princess Savitri with her father's warm blessings mounted a golden charriot and 'travelled through the woods accompanied by wise men, advisers of her father, full of years and experience'.

One day when King Aswapati was sitting with the Sage Narada, Savitri entered and bowed in respectful greeting to the Rishi and her sire. The king was overjoyed to see his daughter back from her mission. When they had settled down after taking refreshments the King asked his daughter Savitri whether her mission was successful and if so to let him know about it.

Savitri in a voice as sweet as the sound of the Yarl* said "I have seen in the forest one whom I would like to wed..... the son of the blind King Dyumatsena whose kingdom was taken from him by an enemy, and who therefore retired to the woods with his queen and infant son, where they have lived for many years a life of rigid austerities". When she had finished, sage Narada who was listening to what she was saying said "Oh King, this prince's father is a lover of truth, his mother likewise speaketh truth, therefore is their son named Satyavan, "the truthful". But Savitri knoweth not how unwise hath been her choice." The king was greatly disturbed and he asked Narada to let him know why he considered his daughter's choice "unwise". Narada then said that Satyavan has all the qualities of a noble being, but unfor-

tunately he will not live long. 'A year from today this brief life of Satyavan will end and he will abandon his body'. The king turned to Savitri and reminding her of what sage Narada had said asked her whether she would not like to choose someone else as her husband. Her reply was clear and decisive. "My father, only once can the lot be cast; whether life be short or long, full of merit or devoid of it, I have made my choice, I will not choose again. First a thing is thought out and decided in the mind, then the decision is clothed in words; then it is put into execution, so it is with me !".

On hearing these words Narada told the king that Savitri has a strong mind and that there is no likelihood of her changing her decision. He then advised the king to let Savitri marry Satyavan.

"Be it so!" exclaimed the king "for thou art my preceptor and dost ever speak the truth". When the king had finished speaking Narada wished them well and left. In due course, Savitri was married to Satyavan. This was done in a simple ceremony in the forest hermitage where Satyavan's parents lived. After her parents left Savitri put aside her costly ornaments and royal attire and dressed hereself in simple garments to be in harmony (state of equilibrium) with those worn by her ascetic husband.

As days passed Savitri thought more and more of Narada's prediction about her husband's fate. Fear of insecurity began to grip her and she became sorrowful. But she kept her feelings to herself. Three days before her husband was due to lay aside his body she undertook a vow not to eat or drink anything during those three days. This was a very difficult task and she performed it admirably. On the final day, *i.e.* on the day Satyavan was due to end his life on earth, Savitri got up early and having attended to the usual household duties sat in deep meditation.

Meanwhile Satyavan picked up his axe and got ready to go into the forest to cut firewood. Savitri woke up just in time to see him depart. She went up to him and said that she would like to go with him that day. Satyavan objected to her proposal saying that her soft feet might get hurt in the rough terrain. Later he yielded to her request and both went out together. Satyavan's parents were also surprised at her strange request. Jokingly they told her not to distract Satyavan from his task. This shows how well Savitri had contained her sorrow and fear. On reaching the forest Savitri found a convenient spot and sat down while Satyavan went about collecting firewood. Suddenly he felt uncomfortable. He called Savitri and told her that his head was in pain and that a sort of dizziness was coming upon him. Savitri then knew that the fateful moment had arrived. She took him in her arms and

helped him to lie down on her lap. While she was thus engaged in attending to her husband's needs she beheld a dark form approaching them. In its hand was a noose and its eyes were fixed on Satyavan.

As it moved closer to where Satyavan was Savitri laid her burden aside and raising herself from the ground asked this 'dark form' who he was and what his mission was. It then said that he was Yama, the God of Death, and that he had come to take away Satyavan as he had completed his span of life on earth. He further added that he cannot be seen by any ordinary mortals. She (Savitri) was able to see him because of her religious merit acquired as a result of her loyalty and devotion to her husband. After having said this Yama drew forth Satyavan's life and proceeded on his way to his kingdom.

Savitri followed him. Yama turned round and asked her not to follow him but to go back and attend to the final rites of her husband. In reply Savitri said that her husband—Satyavan was in his (Yama's) hands and the duty of a Hindu wife is to remain beside her husband. So saying she kept following Yama. Yama was very pleased at what Savitri had said and he told her so. Then in appreciation of her intelligent answer Yama offered her a "wish" —anything other than the life of her husband. Savitri told Yama that her father-in-law who had lost his eyesight sometime ago should regain it. Yama readily granted this "wish" to her. When he left Savitri again followed him. Yama told her that she must be tired and that she should return home. In reply Savitri said: "How can I be tired when I am with my husband? My husband's fate is mine and wherever thou taketh him I will go....." Yama was again pleased with Savitri's scholarly reply and told her that he was prepared to give her another "wish"—but not the life of her husband. Savitri then asked him to restore to her father-in-law the kingdom which was taken away from him by a neighbouring ruler. Yama granted her the "wish" and proceeded on his way.

Savitri still followed him. Yama again told her that he will give her another "wish" if she would only stop following him. Her third request was that her parents be blessed with a son, so that he might be able to take over the responsibilities of their kingdom when her father was no more. Yama granted this "wish" to her and thought that his troubles were over. But Savitri went on following him as before. Yama lost his patience and yelled out to her that he will grant her one more "wish" and with that she must get back to her home. Savitri then asked Yama that she and Satyavan be blessed with a son. Yama being not in his true senses due to irritation and weariness said "Very well you can

have that "wish" and now get back to your people". Savitri then said "How can we have a son when Satyavan's life is with you?" Beaten badly Yama released the life of Satyavan. When she got back to the forest she saw Satyavan waking up as if he had had an afternoon siesta.

They then collected their belongings and returned to the hermitage. On arrival there they were met by their parents and taken to the palace. In due course when his father died Satyavan became king and ruled his empire with great justice.

We shall now list some of the values embodied in the story:

1. Savitri was a well-disciplined child and she was loyal to her parents.
2. Her father had considerable confidence in her power of choosing her husband wisely.
3. Her father had trust in her because of her loyalty to him.
4. When her father asked her to make another choice because of Satyavan's short life-span Savitri remained firm and said that she had already made her choice. This shows her strength of character and on account of it she must have secretly entertained the thought that no misfortune would ever befall her.
5. Savitri was chaste and god-fearing. By virtue of these honourable qualities she was able to see the God of Death, communicate with him and then win her husband's life back.

Apart from what has been said above there is also a lesson in psychology. When Yama first told Savitri to ask for a "wish" other than the life of her husband she did not ask for a son to be born to her and Satyavan. Yama would have been alert and would have been careful not to fall into a trap. Savitri being an intelligent girl would have known this. She first led Yama into a state of "hopelessness". Under such conditions one's behaviour generally becomes automatic. Then when she asked for a son Yama said "yes" without realising the implications. This is the principle on which cross-examinations are carried out in the Court of Law.

Now let us look at another story namely Chinta,[16] also from the same book "Hindu Mind Training". Chinta was the wife of Srivatsa, one of the greatest kings of Hindustan. Like Savitri she was also chaste and greatly devoted to her husband. During the course of their reign a violent earthquake occurred in their land

and the kingdom was completely paralysed. The king was heart-broken. He told Chinta to return to her parents and live with them for a while—till things returned to normal in their kingdom.

Chinta would not agree to this proposal. She told her Lord that a wife's place is by her husband. Further she added: "Did not Sita follow Rama into exile? and shall I fail in devotion to my Lord?.....The holy Sastras say that the husband is the body and the wife the shadow. I am most glad to prove that scriptural dictum true".

The king was very pleased with what his queen Chinta had said and decided to take her with him wherever he went. The two travelled to various parts of their kingdom to see the damages done to their people by the earthquake. After a long and arduous journey they found a hut in a small village where they could rest for some-time. It was in a neighbouring kingdom and so the villagers did not know who they were.

On the following morning some of the villagers went out to cut firewood and they invited King Srivatsa also to join them. He accepted this invitation and so every morning he would go out to cut firewood, leaving Chinta at home 'with strict instructions not to stir from the hut'. On fullmoon days a merchant came up to the village to buy firewood from the wood-cutters. The village was on the banks of the river and this merchant came there by boat. One day his boat was stuck in the mud and nothing could be done to move it out. As the merchant was wondering what he should do to get the boat out an astrologer approached him and said "that there was a chaste woman in the village who is greatly devoted to her husband. If she comes and touches the boat, the boat will come out of the mud and float again".

The merchant then asked all the women of the village to come and touch the boat and they all did so. But the boat did not come out. The merchant was angry and looked at the astrologer questioningly. The astrologer being sure of his predictions told the merchant that everyone in the village had not touched the boat. Continuing further he said that there was yet another woman living in a hut in the village who had not come out. Soon a search was made and the merchant found Chinta inside a hut. She was in deep meditation. Sensing the presence of people around her she woke up and the merchant explained his problem to her. In reply she said that she would be happy to go and touch the boat but her husband's orders were that she should not leave the hut under any circumstance. The astrologer then said that if she did not go and touch the boat it would go down with all the people in it.

Continuing further he also said that if her husband was there he would have been the first to tell her to go and touch the boat. After a lengthy discussion Chinta decided that circumstances justified her in disobeying her lord's command and she went down to the river bank 'to lay her hand upon the boat'. The moment she touched it the boat left its 'muddy bed and rose upon the incoming tide'. The merchant was greatly impressed by her power. He then said to himself 'If I could kidnap this holy lady and keep her always in my boat it would never meet with an accident again!' Prompted by this evil thought the merchant dragged Chinta aboard and gave orders for the crew to set sail. When her husband Srivatsa returned from the forest the astrologer who was standing near the hut told him the whole story. We need not go into details about the rest of the story. In most mythologies the hero and heroine are always reunited at the end. True to form King Srivatsa and Queen Chinta after going through great hardships were finally reunited.

What we have to note here is that Chinta disobeyed her husband's orders, even though she was convinced that she was doing the right thing. This slip in her life probably destroyed her divine power which she had acquired through a long process of devotion and obedience to her husband. Otherwise, with her power she could have easily destroyed her captors and escaped. Equally interesting as the stories related already is the story of Nalayini. Like Savitri, Nalayini was also expected to lose her husband early in life and she was aware of it. The day before her husband's last day on earth dawned Nalayini went up to the Heavenly Lords and asked them to spare her husband's life. The Lords of Heaven after hearing Nalayini's pleas said that destinies of people are planned ahead and even a minor change can disrupt the whole network of life in the Universe. Therefore, they said, they cannot grant her the "wish" she asked for. Nalayini asked the Lords to reconsider their decision. The Lords then said: "Nalayini, we greatly appreciate your feelings and your devotion to your husband but unfortunately we cannot accede to your request. We have already given you the reasons and so tomorrow morning as the sun rises your husband's life will be taken away". Nalayini was no chicken. she returned home undaunted and using her spiritual powers ordered the sun not to appear on the following morning. When the Lords of Heaven got up on the following morning at their usual hour they found that the world was still in darkness. Soon they found out what had happened. Hurriedly they made a bee-line to where Nalayini was and apologised to her for their heartless behaviour. The matter was finally settled amicably: Nalayini to withdraw her spell over the sun and they to spare the life of her husband.

In all civilizations of mankind, chastity has been one of the most desired characteristics in a woman. The Hindus carried it to extremes. In order to prove its values they wrote stories and we have already related a few. Sometimes these stories reached ridiculous proportions. The story of Anasuya is one of them and the reader must know this, at least to learn the extent to which the author had gone to illustrate the powers of chastity.

Anasuya, like Ahalihai, was also the wife of a Rishi and his name was Aththiri. He had given her standing instructions that she must provide meals to all those who called at their hermitage. Because of her spiritual powers acquired through chastity she saw to it that there was no shortage of food at any time in their household. So everyone who called at their place was sure of a meal always. Her (Anasuya's) reputation spread far and wide in the universe.

Sage Narada, the political adviser to the Heavenly Lords heard about it and came down to earth to see if what he had heard about Anasuya was really true. Calling at her abode he asked her if she could convert some stones into peanuts. To his amazement she said yes and did it.

Narada then returned to Heaven and threw the same challenge to Parvathy (consort of Lord Siva), Lakshmi (consort of Lord Vishnu) and Saraswathy (consort of Lord Bhraman). They failed to perform the task and Narada took the opportunity to ridicule them.

The three Goddesses became angry and jealous. When their husbands returned they complained to them about what had happened. The Triumvirate, Siva, Vishnu and Bhraman took it as an insult to the Kingdom of Heaven and came down to Earth to break the powers of Anasuya.

Disguised as Yogis, they called on her and asked her if she would provide them with food. When she said yes, they laid down a condition, *i.e.* when she served she must be in the nude! Without losing her countenance, she said, yes and with a sweep of her hand converted them into new born babies. She then let her hair down to cover her nude body and fed the "babies" with milk.

When the three Goddesses heard about the fate of their husbands, they came down to Earth and apologised to Anasuya for under-estimating her powers. Anasuya brought their husbands back to their original form and handed them over to their respective consorts.

This incident is supposed to have taken place at Gnanaranya, now called Suchindram in South India.

There are many such stories in Hindu mythology and their aims were to direct the learner towards the acquisition of noble qualities. These stories, in order to be "experiential" were presented to the children in musical forms and they may be classified as follows:—

1. Kathaprasangam
2. Isai Chithram
3. Sangeetha Upanyasam
4. Baratha Natyam

All these forms were based on the South Indian classical system, *i.e.* The Music of the Tamils.

Before we proceed further, let us examine what this "Music" is. The best way to understand it is to study it in relation to the classification of flowering plants:

1. The flowering plants are divided into Natural Orders: Leguminosae, Compositae, Orchidaceae etc. So are the Tamil songs. They are also classified into "Natural Orders". These "orders" are called "Ragas": Kalyani, Mohanam, Kambothi, etc. In ancient times these "Ragas" were called "Panns".

2. The Natural Orders in plants are divided into two major groups:

    1. Monocotyledonous (one cotyledon)
    2. Dicotyledonous (two cotyledons)

    The "Ragas" or the "Orders" in songs are also divided into two major groups:

    1. Prathi-Maththimum
    2. Suththa-Maththimum

    In the former the fourth note in the Octave is of a higher frequency while in the latter it is of a lower frequency.

3. Some natural orders in plants are further divided into sub-orders, *e.g.* Leguminosae. Its sub-orders are:

   (*a*) Papilionaceae
   (*b*) Caesalpiniaceae
   (*c*) Mimosaceae

   Similarly, certain ragas are also divided into sub-orders, *e.g.* Harikambodhi. Its sub-orders are:

   (*a*) Ethukulakambodhi
   (*b*) Kambodhi

4. The life of a flowering plant is divided into three stages:

   1. Germination
   2. Growth
   3. Senescence

   So is the "life" of a classical Tamil song. It is divided into:

   1. Pallavi
   2. Anupallavi
   3. Saranam

   These three stages correspond to the three stages in the life of a plant and carry the same meaning, practically.

5. The characteristics of a Natural Order in plants are determined by the molecule of life—DNA. And this is divided into two strands.

   Likewise, the characteristics of a raga are also determined by its own "molecule of life"—the Octave. This is also divided into two "strands":

   (*a*) Arohanam — ascent
   (*b*) Avarohanam — descent

The theory behind this is that if the arrangement of the genes in the DNA of an individual is similar to the arrangement of the notes in the Arohanam and Avarohanam of a particular raga, that raga when rendered will activate the genetic code of the individual concerned. This "activation" probably gives the

learner an "experience" of the subject embodied in the story. The reader might think that it is a far-fetched idea but he will revise his opinion if we recall what Professor Hofschneider of the Max Plank Institute of Bio-Chemistry, Martinsried, Germany, had said, concerning the DNA and Music:

"One can imagine such a molecule as a very long filament bearing notes. However, instead of the seven basic notes of the Octave, there are only four, which we term A.C.G.T.*

These notes are strung together on the nucleic acid as in the sequence of sounds in musical notes. A gene is thus to be compared with a melody; taken together, all the melodies of a song constitute the genetic information of this cell or the "genome".

The nucleic acid has two important properties. Before a cell divides into two subsidiary cells, it duplicates itself, so that the same genetic melodies can be passed on to both subsidiary cells. In addition, the melody is played in the cell like a tape recording. Just as we can recognize individual melodies as such and react to them differently, the cell reacts to the sound of the genetic melodies by a specific action. As the expert would say, the genes are expressed, *i.e.* gene-specific proteins are synthesized. In turn, these build up the cell and control its metabolism."[17]

If we include the 20 naturally occurring amino acids, we get 24 "notes" in the genetic material. Strangely enough the total number of musical intervals in the ancient Tamil music was also 24. This may be a coincidence, but certainly strange.

What is particularly interesting in this system of music is that there seems to be an opening for a new genetic theory which may answer some fundamental questions with regard to the behaviour of the DNA. The present theory does not explain what the DNA does to produce the proteins. All what the biologists tell us is that DNA promotes protein-synthesis. But, how?

Most likely the genetic material execute certain vibrations in a pre-determined sequence as in a raga. For instance, let us

* A—Adenine, C—Cytosine, G—Guanine, T—Thymine

take the raga "Kamas". The arrangement of the notes for this particular raga is as follows:—

Arohanam (ascent)	SA	MA	GA	MA	PA	DA	NI	SA
	(1)	(4)	(3)	(4)	(5)	(6)	(7)	(8)
Avarohanam (descent)	SA	NI	DA	PA	MA	GA	RI	SA
	(8)	(7)	(6)	(5)	(4)	(3)	(2)	(1)

While ascending one must play the 4th note after the 1st, come back to 3, and then proceed according to the normal order of the numbers. For Avarohanam one can use all the notes.

The ease with which a South Indian musician identifies these ragas implies that these ragas form distinct patterns on the ear-drum of the hearer. We can explain this process with reference to Chladni's figures.

Chladni (1756 - 1827) was a German Physicist. In order to study the behaviour of sound waves he sprinkled some sand on a metal plate and while holding the plate at one point stroked

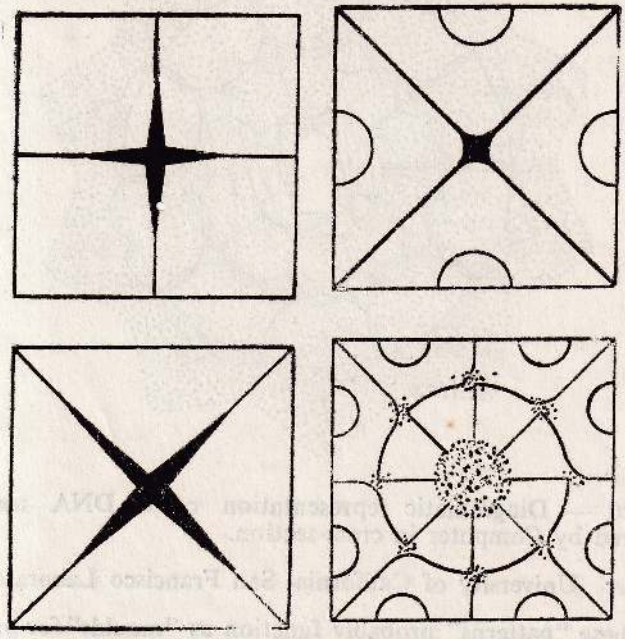

Fig. 19. (*The Physics of Music*, p. 62, 63)

it with a violin bow. The bow while slipping over the edge of the plate produces waves which move across the plate. At the edges they are reflected back. And on their return they are met by the on-coming waves. The interaction of these two sets of waves produces patterns of nodal lines "where the plate is at rest separating segments of the plate which are in motion. The sand gets thrown off the vibrating segments of the plate and gathers along the nodal lines".[18]

By touching at different points Chladni was able to produce different patterns (Fig. 19).

Coming now to the behaviour of the DNA, we can say that a similar process takes place inside the living cell. The genetic code of a particular organism produces a particular "raga" which in turn produces a particular pattern on the cytoplasmic material of the living cell. The following illustration (Fig. 20) seems to confirm this possibility.

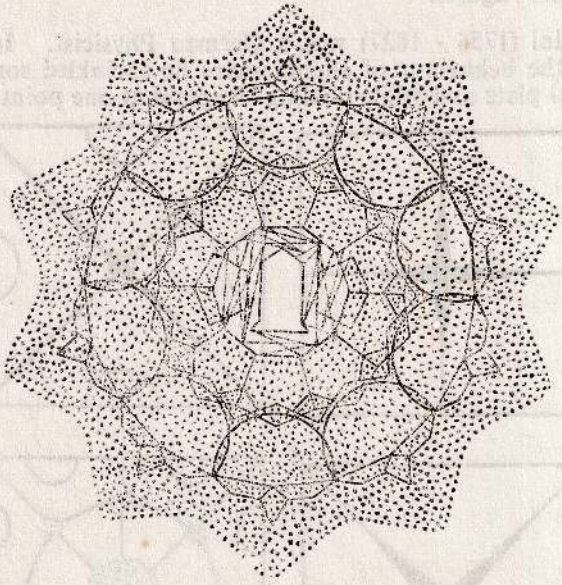

Fig. 20 — Diagramatic representation of a DNA molecule rendered by Computer in cross-section.

(*Source:* University of California, San Francisco Laboratories.)

These "patterns" probably function as "moulds" for protein-synthesis.

Another important aspect of this system is that ragas can be "spliced". For example the Arohanam of Mohanam and the Avarohanam of Sankaraparanam are combined to produce what is called the Bilahari raga. This is not much different from biology's latest awe-inspiring creation, the Recombinant DNA. What is most valuable in this interpretation is that with a limited number of genes we can produce millions of "designs" and each "design" can determine the entire characteristics of a particular plant or animal. In other words this theory tends towards "conservation of energy". "Conservation of Energy", as observed in Chapter II, is the ultimate determinant of progress, evolutionary or otherwise.

We shall now describe the four musical forms mentioned earlier.

1. **Kathaprasangam**

This is one of the earliest method of dramatization. Here the story is verbally narrated. The voice is raised or lowered according to circumstances. Now and again a raga is used to break the monotony.

2. **Isai Chithram**

In this method the ragas are used to illustrate different situations. For example, the raga Neelamburi is used for lullabies. Muhari is used to convey sadness; Mohanam for prayers and so on.

3. **Sangeetha Upanyasam**

This is a combination of Kathaprasangam and Isai Chithram.

4. **Baratha Natyam**

This is the South Indian classical dance and it is the oldest of the Indian dance forms. As Haskell says, "Dancing is deeply rooted in Hindu life and thought. Traditional belief says that God Siva set the world in motion with a dance, a belief perhaps derived from the world's first cultured people whose priests declared the stars moved in a dance."[19] Capra in the "Tao of Physics" explains this concept — Siva's Dance very clearly as follows:

> "The Eastern mystics have a dynamic view of the universe similar to that of modern physics, and consequently it is not surprising that they, too, have used the image of the dance to convey their intuition of nature. A beautiful example of such an image of rhythm and dance is given by Alexandra David Neel in her Tibetan Journey, where she describes how she met a Lama who referred to himself 'as a master of sound' and gave her the following account of his view of matter.

'All things ..... are aggregations of atoms that dance and by their movements produce sounds. When the rhythm of the dance changes, the sound it produces also changes ..... Each atom perpetually sings its song, and the sound, at every moment, creates dense and subtle forms'.[1]

The similarity of this view to that of modern physics becomes particularly striking when we remember that sound is a wave with a certain frequency which changes when the sound does, and that particles, the modern equivalent of the old concept of atoms, are also waves with the frequencies proportional to their energies. According to field theory, each particle does indeed 'perpetually sing its song' producing rhythmic patterns of energy (as virtual particles) in 'dense and subtle forms'.

The metaphor of the cosmic dance has found its most profound and beautiful expression in Hinduism in the image of dancing Shiva ..... According to Hindu belief, all life is part of a great rhythmic process of creation and destruction of death and rebirth, and Shiva's dance symbolizes this eternal life-death rhythm, which goes on in endless cycles". [1]

In the words of Ananda Coomaraswamy "Nature is inert and cannot dance till Shiva wills it. He rises from this rapture, and dancing sends through inert matter pulsing waves of awakening sound, and lo: matter also dances, appearing as a glory round about him".[20]

Most probably Baratha Natyam was developed for the purpose of communicating this "Dance" — of Shiva, to the people. Later on it was extended to other areas. At the beginning the performances were held in the Temples and the dancers were called Deva-Dasis (servants of the Lord). Public performances came in long afterwards. Whatever it is one thing remained constant, *i.e.* the themes were always religious.

There are some adventurers who are now attempting to introduce Baratha Natyam to other kinds of music. The answer to this comes from an old Marx brothers film, "A Night in Casablanca". As the story goes Groucho, the eldest of the Marx brothers arrives in Casablanca. Chico, his brother playing the role of a travel agent offers to take him round in his camel-taxi. Groucho asks for his charges and Chico says: "A camel with two humps, ten dollars; a camel with one hump five dollars". Groucho then asks: "What about a camel with no humps?" And Chico says, "A camel with no humps is a horse".

Similarly, if Baratha Natyam is applied to any thing other than the South Indian classical music it will no longer be Baratha Natyam.

Plato, as we believe, had something interesting to say about such adventurers. He compares them to the baldy old tinker, who having been discharged from service, scrapes up his belongings, goes out, buys himself a coat, takes a bath and comes round in his new outfit to marry the landlord's daughter because they have become poor!

Music does not mean munching the words and stretching them like chewing gum. The words, or the notes, have to be rhythmically formulated into meaningful codes such that if and when the necessity arises we must be able to trace them down to the "smallest number of dominating principles". This is the basis of science. Needless to say, Tamil music is built on it.

In bringing this work to a conclusion the writer would like to repeat what Einstein once said:

> **All religions, arts and sciences are branches of the same tree. All these aspirations are directed toward enobling man's life, lifting it from the sphere of mere physical existence and leading the individual toward freedom.**[21]

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* The "Yarl" is probably the oldest musical instrument of India. It is Tamilian in origin and it is the equivalent of the harp of the Early Egyptians. It is believed that the ancient Chaldeans also had an instrument similar to the "Yarl". It is very surprising that the "great" Aryans who, as some believe, gave civilization to India, did not bring any such musical instruments when they "poured" into India chanting their Vedic hymns. May be, they sang their songs in Yarlmuri pann — a raga which cannot be played on a Yarl !

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