SUGGESTED GUIDELINES WHICH WILL MAKE THE TEACHING OF BIOLOGY IN THE SECONDARY SCHOOLS OF KERALA STATE, INDIA, MORE EFFECTIVE IN MEETING THE NEEDS OF THE PEOPLE

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ABSTRACT

SUGGESTED GUIDELINES WHICH WILL MAKE THE TEACHING OF BIOLOGY IN THE SECONDARY SCHOOLS OF KERALA STATE, INDIA, MORE EFFECTIVE IN MEETING THE NEEDS OF THE PEOPLE

By

K. Annamma Varghese

The purpose of this study was to formulate guidelines that will make the teaching of biology in the secondary schools of Kerala State, India, more effective in helping to meet the needs of the people.

To accompoish this purpose, the geographic, historical, cultural and economic backgrounds of the state were investigated to identify the social problems confronting the state. Selected literature reflecting the views of science educators on the objectives, content, methods of instruction, and evaluation of science education was reviewed. The historical development of the educational systems, their present administrative organization and the examination system were studied to gain an understanding of the current scene of science education in the secondary schools of Kerala. Based on these findings, objectives for improving the teaching of biology were formulated. The current biology program of the

secondary schools of Kerala, specifically the content of the Standard VIII biology syllabus, was examined in terms of the objectives selected. Guidelines were then proposed for improving the teaching of biology.

The following social problems were identified as demanding urgent attention: (1) High rate of population growth, (2) Unemployment and underemployment, (3) Poor sanitation, unhygenic practices and ill health, (4) Ignorance and superstition, (5) Great food deficit and malnutrition, and (6) Lack of scientific minded citizens.

Objectives selected to help in solving the social problems included: (1) Understanding of scientific concepts, facts and principles about living things, (2) Development of scientific attitudes, (3) Development of scientific thinking applied to solving the problems of life, (4) Development of instrumental skills, (5) Development of understanding of the physical environment and appreciation of the natural world, and (6) Development of interest and appreciation in science, its achievements and application to human welfare.

These objectives functioned as criteria for evaluation of the current biology program. The examination of the present Standard VIII biology syllabus revealed that it is not oriented towards achieving the objectives selected. The content bears little relation to the needs of the individual or the problems of society. The methods of

instruction and evaluation practiced are not useful in attaining the goals selected.

The study of the centralized educational administrative organization revealed that the organization is cumbersome in dealing with change. Not enough freedom is granted local authorities to initiate and implement changes based on the needs of the community.

Traditionally trained teachers who are bound by a rigid, examination controlled curriculum are reluctant to introduce changes.

Among other recommendations, the following major ones were made to improve the existing biology program: (1) The content of the syllabus should be modified to include topics related to the needs of the individual and the society. (2) Methods of teaching should concentrate on the development of scientific attitudes instead of mere dissemination of facts. (3) A comprehensive, continuous evaluation process should replace the existing internal and external examination system. (4) The centralized educational organization should be more flexible in allowing local schools to initiate and implement changes according to the needs of a community. (5) Teacher training institutions should provide instruction for current needs. In service training should be an integral part of each teacher's preparation.

Since the biology program forms only a part of the whole school curriculum, further research was recommended not only in related science areas, but in educational practices as a whole.

SUGGESTED GUIDELINES WHICH WILL MAKE THE TEACHING OF BIOLOGY IN THE SECONDARY SCHOOLS OF KERALA STATE, INDIA, MORE EFFECTIVE IN MEETING THE NEEDS OF THE PEOPLE

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DEDICATION

To my loving parents
(Late) Mrs. Kunjamma Varghese
and
Mr. K. J. Varghese

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CHAPTER I

INTRODUCTION

The role of education varies with the times and needs of society. One of the aims of modern education is to help people to live in a world of change. The world today is one of accelerated change, produced to a large extent by science and technology. A background in science, in its principles and in its characteristic approaches to natural phenomena, can help people to adjust to these changes in modern life.

In many advanced countries major projects for the revision of science teaching have been carried out so as to be helpful in meeting the changing needs of the society. New instructional technologies have been designed specifically to improve learning. But quite a different condition prevails in Kerala State and India as a whole, with regard to science education. The report from the Biological Sciences Curriculum Study pointed out the defects of science teaching in the secondary schools of India as follows:

> Science, for all of its achievements and social potentialities has not found its way into the main currents of the life of the people. The reasons for this are many. The teaching of science in schools has

> been more in the direction of pursuing the specialized knowledge of the discipline and imitating its procedures. There has been little consideration of the part science might play in the intellectual development of adolescents, their need for self understanding, or to recognize the demands that will be made on them to deal with the problems of a bio-social nature.... The science presented in the school courses is only remotely relevant for improving the welfare of mankind.[1]

The Purpose of the Study

The major purpose of this study is to formulate guidelines that will make the teaching of biology in the secondary schools of Kerala, India, more effective in dealing with major social problems within the state.

The Need for the Study

Since India's independence in 1947, Kerala has been striving hard to improve the living conditions of its people. Many economic and social problems still exist in the state which are dominated by poverty and accentuated by the continuing growth of population. The basic problems facing the state in its march toward progress are many and varied in nature. Over population, unemployment, decreased food production, idleness of the people, ignorance and deep rooted superstition are the most important among them.

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[1]Biological Sciences Curriculum Study, International Newsletter, No. 8, November 1969.

The societies in Kerala, which are mostly traditional, are slow to accept changes. Numerous people in the state are still under the bondage of ignorance and superstition. The common man follows the primitive ways in his trade. The peasant is still knee deep in his rice fields, the fisherman in the lagoon and the farmer scratching dry earth with his wooden plough. The enormous growth of population has eroded the benefits from economic development. Many unhygenic practices are prevalent among the people due to ignorance and superstition. A good majority of the people living in rural areas know very little about the causes of diseases, how they are spread or how they can be cured. About 40% of the working force in the state is either unemployed or underemployed.

Science education must push back the walls of ignorance and tradition and in so doing become an endless pursuit of a great adventure. A properly organized biological curriculum can help people to acquire new habits of thinking which are equal to new demands of a new age. The learning experiences gained through an effective biological science education can help to eradicate the false ideas and superstitious beliefs prevalent among the people. Concepts about the real cause and spread of diseases will lead to the awareness of the need for better sanitation and improved hygenic practices. Effective biology programs can lead to the understanding of better farming and improved food production. Knowledge about

human growth and development will help in adapting ways of checking population growth.

The biological science education in Kerala which is influenced very much by the secondary educational system of the whole country is not effective in dealing with the social problems. The defects of secondary education in India were realized long before independence. After independence many committees and commissions were appointed to improve India's secondary education. In 1952 the Secondary Education Commission was appointed to study the various aspects of secondary education throughout the country. The Commission recommended that the emphasis in science teaching should shift from verbalism and memorization to learning through purposeful, concrete and realistic situations, and for this purpose, the principles of 'Activity Method' and 'Project Method' should be assimilated in school practice. The Commission also suggested that special emphasis should be placed on demonstrations, field trips and practical projects which may link up school science with actual life problems and situations.[2]

However, the recommendations of the Secondary Education Commission were only partially implemented and the desired effect was not achieved. Being aware of this fact and the great need for a drastic change in the educational system of the country, the government of India again appointed a

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[2]India, Report of the Secondary Education Commission, Ministry of Education, Government of India, 1954. P. 100.

commission in 1964, under the eminent leadership of Professor D. S. Kothari, Chairman, University Grants' Commission. Twenty consultants from different countries were made available for advice to the education commission, which submitted its report in 1966.[3] The Kothari Commission studied the existing system of science education in the secondary schools throughout the country and reported:

> There can be no hope of making the country self-sufficient in food unless the farmer himself is moved out of his age-long conservatism through a science-based education, and is ready to adopt techniques that increase yields. The same is true of industry. The skilled manpower needed for the relevant research and its systematic application to agriculture, industry and other sectors of life can only come from a development of scientific and technological education. Similarly economic growth is not merely a matter of physical resources or of trained skilled workers; it needs the education of the whole population in new ways of life, thought and work.[4]

Realizing this position, the Kothari Commission recommended:

> ... The quality of science teaching has also to be raised considerably so as to achieve its proper objectives and purposes, namely, to promote an ever deepening understanding of basic principles, to develop problem solving analytical skills and the ability to apply them to the problems of the material environment and social living and to promote the spirit of inquiry and experimentation. Only then can a scientific outlook become part of our way of life and culture.[5]

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[3] B. D. Bhatt and J. C. Aggarwal, Educational Documents in India, Arya Book Depot, Karol Bagh, New Delhi - 5, 1969. P. 252.

[4] Ibid., pp. 255-256.

[5] INDIA - Report of the Education Commission, Ministry of Education, Government of India, 1966. Pp. 6-7.

The Commission also criticized the existing content and method of teaching biology in the secondary schools of the country and suggested the following:

> ... Again, the present content of the school course in biology is traditional in nature. The concept of biology as a method of inquiry by means of accurate and conformable observations, quantitatively and mathematically analysed, and controlled experimentation should be impressed on the minds of the young learners.[6]

Based on the results of the study made by the Kothari Commission, it was found that new steps had been taken to improve general science instruction in different parts of the country and the desired goals have not yet been achieved. As reported in the BSCS Newsletter (1969), the general science presented in the school courses is only remotely relevant for improving the welfare of mankind.[7] Most educators today increasingly emphasize that the objectives of science teaching should be in accordance with the needs of the society as indicated by the Secondary Education Commission and the Kothari Commission.

In view of these expressed positions and interests prevalent among educational leaders and the effective role biology can play in solving the problems of the society, there is a great need for improving the teaching of biology in the secondary schools of Kerala.

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[6] Ibid., p. 199.

[7] BSCS Newsletter, op. cit.

Design of the Study

This study is designed to formulate guidelines that will make teaching of biology in the secondary schools of Kerala State, India, more effective in meeting the needs of the people. In order to achieve the above purpose, the following operational objectives are sought:

1. Examine the geographic, historical, cultural and economic backgrounds of the state to identify the basic problems that hinder its progress.
2. Review selected literature on science education, especially biology, including objectives, content, methods of instruction and evaluation, with special emphasis on its role in solving social problems.
3. Describe the current biological science curriculum in the secondary schools of Kerala, together with those factors influencing the same, such as historical development of education, administrative set-up and examination system.
4. Select suitable objectives for a course in biology in the secondary schools of Kerala so that the same shall be helpful in solving some of the basic problems of the state. The information collected in steps 1, 2 and 3 will be used as a basis for formulating these objectives.
5. Examine the current biological science curriculum on the basis of the objectives selected.

6. Suggest guidelines for improvements based on the discussion in step 5.
7. Make recommendations for further studies in selected areas.

Definitions of Terms

Learning experience:

The term "learning experience" is not the same as the content of the course nor the activities performed by the teacher. The term "learning experience" refers to the interaction between the learner and the external conditions in the environment to which he can react.[8]

Standard:

Term used in the Indian educational system for "Grade" in the American schools.

General science:

General science in the secondary schools of Kerala includes units on physics, chemistry and biology. The term "Science" is used often in place of "General Science".

Secondary school:

Standard VIII, IX and X comprise the secondary schools in Kerala (age group 12-16).

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[8]Ralph W. Tyler, Basic Principles of Curriculum and Instruction, Illinois; The University of Chicago Press, 1963. P. 9.

Syllabus:

A formal outline of the prescribed content to be covered in Biology in Kerala State.

Basic Assumptions

1. Modern science and technology can bring about dynamic changes in a state which is economically backward and industrially undeveloped.
2. The existing biological science curriculum in the secondary schools of Kerala needs a thorough change so as to be more helpful in meeting the needs of the people.
3. Reports on research conducted in advanced countries, especially the United States of America, on the teaching of biological science at the high school level can be used as a guide in this study.

Limitations of the Study

1. This study is directed towards suggesting only guidelines to improve the teaching of biology in the secondary schools of Kerala.
2. It is not the purpose of this study to suggest a complete syllabus showing the details of the changes recommended.

Organization of Thesis

In this chapter an introduction to the study and need for the study have been presented. Additionally, the design of the study, the basic assumptions and limitations, definitions of terms and an orientation to the organization of the thesis are presented.

In Chapter II background information about the geographic, historical, cultural and economic conditions of Kerala State is provided to help in identifying the major social problems within the state.

Chapter III is a review of selected literature on science education, particularly biology, with special emphasis on objectives, content, methods of instruction and evaluation. Literature on the role of biology in dealing with social problems is also reviewed.

In Chapter IV the present educational system of Kerala is discussed in relation to its historical development, current organization, administration and examination system as they influence science education, particularly biology. Further, the current biological science curriculum also is described in this chapter.

In Chapter V objectives suitable for a biology course in the secondary schools of Kerala are selected from the list of objectives suggested in Chapter III, so that the biology education may be helpful in solving some of the problems

identified in Chapter II. In addition, the current biology curriculum in the secondary schools of Kerala is examined and guidelines for further improvement are suggested.

Conclusions and recommendations for further study in related areas are made in Chapter VI.

CHAPTER II

BACKGROUND TO UNDERSTANDING OF THE KERALA STATE EDUCATIONAL SCENE

Through the ages Kerala has been an integral part of the Indian Sub-Continent. Its history is part of the general history of India, and its culture is one of the major forces that have enriched the composite culture of the country. At the same time Kerala has had the distinction of being an independent geographical and political entity from very early days. Its unique geographical position and peculiar physical features have invested Kerala with a distinct individuality. Consideration of these background factors is basic to an understanding of Kerala's educational system and its problems.

Geographic Background

The land of Kerala comprises the narrow coastal strip which forms the extreme southwestern part of India. Buttressed by the Western Ghats on the east, its shores are washed by the waves of the Arabian Sea on the west. This geographical position has helped to some extent Kerala's political and cultural isolation from the rest of the country and also facilitated its extensive and active contacts with

the countries of the outside world.[1] It has a total area of 15,002 square miles. Its coastal line is nearly 360 miles in length.[2]

Kerala is rich in water potential. The large number of rivers in Kerala have considerably influenced its historical and cultural developments. In addition to rivers, Kerala has a continuous chain of lagoons and backwaters. The diversity of the physical features of the state has resulted in a corresponding diversity of climate. The high ranges have a cool and bracing climate throughout the year, while the plains are hot and humid. The average temperature is $90^{o}F$ and the average annual rainfall is about 96 inches.

The variations in climate and seasons have great impact on vegetation and the development of agriculture. The location between the Ghats and the sea and a plentiful rainfall have endowed Kerala with certain unique features not found anywhere else in India. These features have also caused infertility of the soil due to erosion and leaching. In general, Kerala is rich in fauna, flora and mineral resources. Its forests abound with a variety of animals and birds. Spices like pepper, cardamom and cinnamon, and timber such as Rosewood and Teak had attracted foreigners centuries

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[1]A. Sreedhara Menon, A Survey of Kerala History, Sahitya Pravarthaka Co-operative Society Ltd, Kottayam, 1967.

[2]Techno Economic Survey of Kerala, published by National Council of Applied Economic Research, New Delhi, 1962.

before the dawn of the Christian era ... from the days of Solomon (1000 B.C.).[3] With its abundant cash crops, Kerala is earning enormous foreign exchange for India.[4]

Historical Background

Kerala's early history is buried in obscurity; however, there are references in the Hindu Puranas and epics to show that Kerala was a well-established and powerful kingdom long before the Christian era.[5] The discovery of microliths points to the presence of man in Kerala as far back as 4000 B.C. The people were well-advanced in navigation from pre-historic times, and trade was carried on by sea with several foreign countries. From 3000 B.C. until 800 B.C. trade contacts with Assyria were kept up through Mesopotamia. Historical records show that the Romans and Greeks also traded with Kerala in A.D. 30. Excavations reveal that the ports on the Malabar and Coromandel coasts were large trading centers with huge warehouses for foreign merchants.[6]

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[3]L. A. Krishna Iyer, Social History of Kerala, Book Centre publications, Madras 2, 1968.

[4]D. R. Mankekar, The Red Riddle of Kerala, P. C. Manaktala and Sons, Private Ltd., Bombay 1965.

[5]P. K. S. Raja, Mediaeval Kerala, published by The Nava-kerala Co-op. publishing House LTD, Calicut - 1, 1966.

[6]L. A. Krishna Iyer, op. cit.

It is believed that the Jews arrived on the coast of Kerala about the 6th century B.C. and settled down in Kerala early in the 1st century A.D. Chinese sailors also visited ancient Kerala in search of commodities. The Arabs were engaged in trade between the ports of Kerala and Arabia even from the beginning of the 7th century. In A.D. 1498, Vasco da Gama, the Portuguese Captain, came to Kerala and began a struggle for Kerala pepper among the nations of Europe.

Like the Portuguese and the Dutch, the English also came to Kerala for purposes of trade in 1583. Later on the East India Company was founded and finally British supremacy was established over the different regions of Kerala.

Before India's independence, Kerala was comprised of three different kingdoms, Travancore, Cochin and Malabar. Each one was ruled by separate rulers. In 1949 Travancore and Cochin were integrated into one unit. In 1956 Kerala State was formed by the Union of Travancore-Cochin and Malabar as one administrative unit with a governor as its head.

Cultural Background

Kerala is the most thickly populated state in India with 21.28 million people according to the 1971 census. About 13.1 percent of the population live in towns of sizes varying from four to fifteen square miles, while the remaining

86.9 percent reside in villages.[8] Agriculture is the main occupation of the majority of the people. The staple food is rice, along with tapioca, yams, sweet potatoes and other starchy root crops. Coconuts, bananas, and pineapples, among other foods, supplement the diet of the people. The coastal areas have a wider range of fruits and fish to supplement the predominantly starchy food.

In spite of a century and more of social reform, Kerala still remains a museum of races and cultures.[9] The most significant feature of Kerala's life from the earliest times has been a wide sense of tolerance and mutual respect among the different communities who have made their homes there. Nowhere in India have so many religious faiths flourished as in Kerala. The oldest homes of Christianity in India and the earliest abode of Islam are in this state. Christians, Muslims and Jews live side by side with the Kerala Hindus in a state of perfect understanding and amity, respecting each other's customs and avoiding interferences.[10] Each one is proud of belonging to his respective community and wishes to preserve its culture and traditions.

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[8]National Council of Applied Economic Research. Industrial Programmes for the Fourth Plan--Kerala. New Delhi, 1969.

[9]K. V. Krishna Ayyar, A Short History of Kerala, Pai and Company, S. India, 1966.

[10]K. M. Panikkar, A History of Kerala, published by The Annamalai University, 1960.

Kerala is a land of temples and mosques, of cathedrals and synagogues. Sixty-one percent of the people are Hindus, twenty-two percent Christians, and sixteen percent Muslims. Nearly nine percent of the total population belongs to Scheduled castes and Scheduled tribes.[11] There are two main languages in the State. Nearly 90% of the population have Malayalam as their mother tongue. Tamil is spoken by 9% and the remaining 1% speak other languages.

Kerala has a rich cultural tradition. In the realm of art, it is the land of Kathakali (dance-drama) and Ravi Varma, the great Indian painter. It also gave modern India one of her greatest poets, Vallathol Narayana Menon.

I. Social structure

Kerala has a traditional caste system. Castes are the primary units of the society and the various castes are hierarchically arranged. The Brahmins, though they form a very minor part of the population, are at the apex of the caste system and the untouchables are at the bottom. The main features of the caste system are (1) a segmented division of society, (2) hierarchy, (3) restriction on feeding and social intercourse, (4) civil and religious discrimination, (5) lack of unrestricted choice of occupation; and restriction on marriage.[12]

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[11]S. C. Joseph, Kerala--The Communist State, The Madras Prenuer Co., Madras, 1959.

[12]K. C. Alexander, Social Mobility in Kerala, published by Dr. S. M. Katre for the Deccan College Post Graduate and Research Institute, Poona - 6, 1968.

Till the beginning of the 20th century the caste stratification was dominant in every aspect of life, such as food, dress and denotations of houses of various castes. The rules of caste organization strictly governed the behaviour and conduct of the people of respective castes and also the social intercourse between different castes. The joint family system helped to a great extent to maintain these traditional norms.

The low castes were mostly illiterate. While the upper castes enjoy several privileges such as entrance to temples, public schools and government services, these were restricted to the lower castes. Untouchability and unapproachability prevailed throughout the land, and each caste was completely segregated from the other. As a result, social mobility was prevented to the maximum extent.

The dawn of the 20th century witnessed the emergence of a new social order in Kerala under the impact of diverse social, economic and cultural influences. Modernity, science and technology penetrated into the traditional societies, and the traditional social structure began to show signs of tottering. Since many societies started embracing modernism, a wide gap exists between the traditional and modern societies. Modern science and technology play a prominent role in changing the attitude, values and beliefs of the younger generation. As a result, the traditional societies are in the melting pot, and the age-old customs and traditions are gradually disappearing.

II. The tribes of Kerala

Kerala, with 5,318 square miles of Government Reserve Forest, and 1,265.5 square miles of private forests, is the home of forty-eight distinct tribes representing many aspects of aboriginal life. According to the 1961 Census, the population of these tribes was 207,996.[13]

The shady jungles at the foot and the cool meadows at the top of the mountains give shelter and subsistance to the jungle tribes. For many centuries, the real ruler of the people has been the environment. It has shaped their bodies, influenced their arts and architecture, and has been their policy maker. Tribal art, culture, social organization and traditional institutions are still strong and vigorous. The clan system has united them, and has extended the co-operative spirit over a wide field in the village community. Here they have led a life of isolation, being restricted to a small chain of mountains and jungles. Habitual existence in forests far away from educational institutions, advanced society, industry and commerce hinder their advancement. Polygamy and polyandry are popular among these primitives. Religious conventions, existence of taboos, and sororate and levirate marriages have also made them a separate group from the changing society.[14]

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[13]L. A. Krishna Iyer, op. cit.

[14]A. A. D. Luiz, Tribes of Kerala, published by the Bharatiya Adimjati Savak Sangh, New Link Road, New Delhi, 1962.

Taboos, popular among these primitive societies, occupy an important place. Taboos related to puberty in both sexes, menstuation, child birth and death are strictly observed among most of the tribal communities.

Sanitation is badly lacking among the tribes. Drainage is defective and huts are overcrowded and poorly ventilated. Infant mortality is high. Lethal diseases have penetrated into their hamlets. Leprosy, elephantiasis, syphilis and small pox are common. Most of the diseases are believed to be due to the wrath of gods and evil spirits. These dreadful diseases have contributed to the decline of the birth rate and increase in the death rate.

The literacy percentage among the Kerala tribes is low. It varies from 5% to 25%. The problem of the education of the primitive tribes was undertaken by the missionaries early in this century. The government has since opened schools for most of the tribes. Education, especially science education, undermines superstition and upsets the habits of the people. The frequent access to the people of the plains also is weakening the tribal taboos and social solidarity. The opening of dispensaries is breaking down the superstition and magical practices for curing diseases.

The impact of the forces of modernization has had the effect of making the partly educated unwilling to go back to their traditional occupations and more anxious to secure employment with the government. The introduction of universal

adult franchise and the modern democratic method of election to the legislatures have revolutionized the life of tribal people who are passing through a critical stage of transition.[15] An educational revolution based on modern science and technology seems to be indespensible to uplift these aboriginal tribes from the bondage of age-long primitive culture and superstitions and to help them to be a part of the changing civilized society.

III. Outlook and beliefs

The Kerala society is a highly Hindu predominant one. The majority of the population live in villages where more than 50% of the people are illiterate. Superstitions, taboos and rituals are interwoven with the life of the people in most villages. The supernatural powers that guide the destinies of human life here and hereafter, and the manner of their propitiation or worship have a wide variety of conceptions and practices. People evince great belief in the cure of diseases by simple magical means. The spirits to whose influence are attributed all illnesses, accidents and other misfortunes in a family are amenable to harnessing. The belief in exorcism is prevalent among most of the castes from the highest to the lowest. Some of the castes follow sorcery as a heriditary occupation.

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[15]M. S. A. Rao, Social Change in Malabar, The Popular Book Depot, Lamington Road, Bombay 7. 1957.

The worship of cobras has gained special emphasis in Kerala. Propitiation of cobras is supposed to be very essential to the well-being and prosperity of the household. It is generally believed that sterility, death of children, blindness, itches and other skin diseases caused by the wrath of the Serpent God can be remedied by properly propitiating them. The belief that one's destiny is guided by the movements of planets demands the propitiation of the planets for one's well-being. Votive offerings are given to deities to get rid of certain diseases.[16]

Economic Background

From time immemorial, Kerala has been looked upon as the "treasureland of the East". But its potential resources have been overshadowed by problems of over-population, unemployment, under consumption and poverty.[17] Food scarcity and unemployment are the two key issues which have made Kerala the "problem State". Kerala, though the smallest, is the most thickly populated state in India with a density of population of 1400 per square mile. Population explosion is one of the major problems that threatens the State. In addition, the rate of growth of population has also been higher in Kerala

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[16]M. S. A. Rao, op. cit., pp. 143-156.

[17]A. K. Gopalan, Kerala--Past and Present, Lawrence & Wishart, London. 1959.

than in any other part of the country as is evident from Table I. Family planning programs are not effective due to the ignorance of the people.

Table I. Growth of Population in Kerala State

Year	Population in Millions	Growth over Previous Period In Millions	Growth over Previous Period In Percentage	All-India Increase Percentage During the Period
1931	9.5			
1941	11.03	1.53	16.04	14.23
1951	13.55	2.52	22.82	13.34
1961	16.90	3.45	24.55	21.49
1971	21.28	4.38	25.91	22.80

The high rate of population growth unaccompanied by a corresponding economic growth has led to large scale unemployment in the State. Further, the fact that people are selective in accepting jobs has aggrevated this situation. It may appear to be paradoxical that Kerala, with the highest rate of literacy in India (63% as per 1971 census), has the highest unemployment rate too. In 1966 the number of persons unemployed was 13.6% of the labor force, or 4.4% of the total population. In 1968, the unemployment was about 12% and underemployment was over 25% of the total labor force of the

State.[18] Unemployment among the educated is a serious problem. While among the employed 8% are high school graduates and above, among the unemployed there is a larger percentage (26.5%) who have high school graduation or higher qualifications. All efforts by the government to reduce the unemployment rate have so far been ineffective because of the enormous rate of growth of population. The approach to the problem of unemployment has to be two-sided. Measures to curb population growth form one aspect, while creation of more job opportunities forms the other. Since the agricultural sector is already overloaded and cannot provide any more jobs, industries, both large scale and small, have to be developed.

The distribution of the State income follows a pattern typical of an under-developed region. The primary sector (agriculture) contributed 49.1%, the secondary sector (production other than agriculture) contributed 14.6% and the territory sector (services and other miscellaneous services) contributed 36.3%.[19]

The State is rich in agriculture, forest and fishery resources but lacks metallic minerals and coal. One of its chief assets is the vast potential for generation of low cost hydroelectric power.

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[18]NCAER--Industrial Programmes for the Fourth Plan--Kerala. 1969. P. (V).

[19]NCAER--Techno--Economic Survey of Kerala. 1962.

The agricultural sector of Kerala is distinguished by the predominance of a large number of plantation crops like tea, rubber, coffee, and cardamom. Since most of these crops are raised for the market, this sector in Kerala is highly commercialized and supports a large number of intermediaries.

The high pressure of population has resulted in an urge toward an intensive pattern of land utilization. Intensive cropping is very high in Kerala, to the extent that field crops are raised 1½ times a year on the average. However, the state has a large deficit in food production. Kerala produces only 50% of the food grains it requires for its people. Because of the shortage of grazing lands, cattle breeding has not developed to the extent required. Ordinary Keralaean diet lacks animal fat in the form of ghee and curds. Apart from these special deficiencies, the daily food intake of a rice eating Keralean is low in general nutritional value, standing at 1,500 to 1,700 calories which is below all the accepted standards of adequate nutrition. Since there is little possibility of bringing more land under food production, the only way out is to produce more from the existing area by resorting to scientific methods of cultivation.

Plantation and other perennial crops occupy about 45% of gross cropped area and contribute 55% of the net value originating from agriculture. Productivity has to be raised in the cash crops, too, by proper manuring and agricultural operations.

The animal husbandry sector of the economy in the State is relatively poorly developed. The milk yield per cow is the lowest in the Country, if not in the world. This is true of the yield of meat from sheep and goats. The low productivity of meat products is partially due to the poor and inherent breed characteristics and partly to conditions under which animals are raised. In view of these factors, there is an urgent need for the improvement of animal husbandry in Kerala. The development programs may not create any new employment but would help in reducing unemployment through providing additional source of work for family members. Development of poultry is another area where biological education can contribute towards economic growth of the country.

Forestry and fishing are two other major sectors contributing towards the national income of the state. Due to the non-availability of metallic minerals and fossil fuels, heavy industries have not flourished in this part of India.[20] The coir and cashew industries which employ a major percentage of the industrial workers are still unmechanized, and, as a result, the earning capacity of the workers is very low. On the whole, Kerala is still unindustrialized in spite of its earnest efforts through the past three five-year plans and the fourth one now in progress. There are immense possibilities for starting many new cottage industries and expansion of existing heavy industries.

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[20]NCAER--Industrial Programmes for the Fourth Plan--Kerala. 1969.

With all its potentialities, Kerala is still economically backward with a national per capita income of less than $40 per year.[21] As a result, even though Kerala spends about 38% of its total budget for education, the expenditure per student per year is only about $13. The state is facing a difficult situation--for its economic growth, properly and scientifically educated manpower is required; and for imparting proper education, financial resources are highly essential.

Summary

In this chapter, the geographic, historical, cultural and economic background of Kerala State has been presented so as to give an understanding of the forces affecting the educational system of the state and the basic problems that hinder its progress.

The unique geographic position and peculiar physical features have invested Kerala with a distinct individuality. This has also been responsible in part for its political and cultural isolation from the rest of the country. Kerala, with its ample supply of rainfall and abundance of water resources, is rich in fauna, flora and a variety of animals and birds. But the undulating terrain with abundance of rainfall has caused infertility of the soil both by erosion and by leaching.

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[21]M. Mukherji, National Income of India, Trends and Structure, Indian Statistical Institute, Calcutta, 1969.

History shows that Kerala was a well-established and powerful kingdom even before the Christian era. Kerala had also flourished early in trade contacts with several foreign countries, mainly with the Dutch, Portuguese and the English. These early trade contacts with foreigners have created isolated ethnic groups in different parts of the state.

Kerala is the most thickly populated state in India. Most of the people live in villages. Agriculture is the main occupation of the majority of the people. Kerala is a land of traditional culture with a variety of races, castes, and religions. The main religions are Hinduism, Christianity and Muslim. Hindus predominate in the population. In addition to these, still existing in the state there are different scheduled castes and backward tribes. These different tribes continue to cling to their primitive cultures which include many unhygenic and unsanitary practices. The traditional caste system still existing in the state has a great impact on the various aspects of the progress of the society. The division of labor associated with the caste system has caused an attitude of disrespect for manual labor among most of the people.

The state has a high level of literacy when compared to the other parts of India (63% as per the 1971 census). But still, many superstitions, taboos and rituals are prevalent in the different parts of the state. Though societies have started embracing modernism, a wide gap exists between the traditional and modern societies.

Kerala has been looked upon as the "treasure land of the East". But problems like over-population and unemployment overshadow the state. The high rate of population growth accompanied by a low economic growth has produced a high rate of unemployment and underemployment. The state has a large deficit of food production. The primitive and unscientific methods of agriculture and non-industrialization are the main causes for low food production. Even with all its potentialities, Kerala is still economically backward, and many crucial problems stand in the way of further economic development.

The basic problems facing the state are: (1) population explosion, (2) high rate of unemployment and underemployment, (3) poor sanitation, unhygenic practices and ill health, (4) ignorance and superstition, (5) food deficit, and (6) lack of scientific minded citizens.

CHAPTER III

REVIEW OF SELECTED LITERATURE RELATED TO SCIENCE EDUCATION

Science and social problems are interrelated. As such, a properly organized science education may be able to offer some approaches to the solutions of these problems. If science education is to be effective, however, it should be founded on sound principles of the educational process, which is generally thought of in terms of four major elements: (1) the determination of goals or objectives, (2) methods of instruction, (3) selection of learning experiences and grade placement, and (4) evaluation or appraisals of results obtained. These four main elements form the basis for the development of any curriculum.

In the first part of this chapter selected literature expressing the views of educators on the role of science education, particularly biology, in solving social problems will be reviewed. The rest of the chapter will be devoted to reviewing professional literature on the four facets related to science education.

Role of Biology Education in Meeting Social Needs

Biological education can help to solve many of the social problems threatening the welfare of humanity. Lee, in his article on "Teaching Biology in the 1970's", described:

> Many of our problems have implication for teaching in general and for biology teaching in particular. The density of our population is one of our troubles; among others are pollution, hunger, drugs, pesticides, disease,....[1]

Lee added that the educators should recognize the important role that biology teaching can and must play in the present revolution and in the solution of the scientific and social problems that besiege society in the current environment.

Mayer, when writing about teaching biology, emphasized the role of biology. He stated that, "Biology is called upon to play an ever increasing role in the complex society of the latter half of the 20th century. It will be used as a source of data on such problems as pollution, population, conservation, urbanization and many others".[2] Hurd, in his article on "Inquiry Objectives for the Teaching of Biology in the 1970's", wrote: "... biological knowledge generated through research is brought into a context of human values,

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[1]Addison E. Lee, "Teaching Biology in the 1970's." American Biology Teacher, Vol. 33, No. 2 (1971), p. 79.

[2]William V. Mayer, "Biology--Synthesizer of Science or Disintegrating Discipline." American Biology Teacher, Vol. 30, No. 10 (1968), p. 804.

where it can be used to improve the condition of man as a person and as a member of a social group".[3]

Objectives of Science Teaching

I. Views of American educators

It is axiomatic that planning is a requisite to the development of effective educational programs. As a first step in the process of planning, it is essential that goals or objectives be identified. The objectives to be sought through educational programs then become the reference points or standards by which the major facets of instructional programs are developed, implemented and evaluated.

Many competent and dedicated individuals and groups have from time to time taken up the task of setting goals for education. Their statements on objectives have varied widely in approach, mode of presentation and elaboration.

The development of objectives for science education has a long history. In 1920 the Science Committee of the Commission on Reorganization of Secondary Education attempted to relate science instruction to the attainment of the famous seven cardinal principles or objectives of secondary education that had been developed by the Commission.[4]

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[3]Paul DeHart, "Inquiry Objectives for the Teaching of Biology in the 1970's," American Biology Teacher, Vol. 32, No. 9 (1970), p. 553.

[4]Commission on Reorganization of Secondary Education. Report of Subcommittee on the Teaching of Science. United States Bureau of Education, Bulletin No. 36, Washington D.C.: Government Printing Office, 1920.

The importance of scientific method as an objective of science instruction was set forth by a special committee of The American Association for the Advancement of Science in a report which was published in 1927.[5] The Thirty-First Yearbook of the National Society for the Study of Education, published in 1932,[6] held the view that the purpose of science teaching should be the development of the understanding of the major generalizations and of associated scientific attitudes.

In 1944 a report of the Educational Policies Commission recognized the role of science instruction in attainment of the goals of general education for the American pupil. The purposes were to:

> 1. Equip him to enter an occupation suited to his abilities and offering reasonable opportunity for personal growth and social usefulness; 2. Prepare him to assume the full responsibilities of American citizenship; 3. Give him a fair chance to exercise his right to the pursuit of happiness; 4. Stimulate intellectual curiosity, engender satisfaction in intellectual achievement, and cultivate the ability to think rationally; and 5. Help him develop an appreciation of the ethical values which should undergird all life in a democratic society.[7]

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[5]American Association for the Advancement of Science. "Committee Report on the Place of Science in Education." School Science and Mathematics 28. June 1928.

[6]National Society for the Study of Education. Program for Teaching Science. Thirty-First Yearbook, Part I, Chicago: University of Chicago Press, 1932.

[7]Educational Policies Commission. Education for All American Youth. Washington, D.C.: National Education Association, 1944.

A 1945 report of the Harvard Committee on General Education advocated that science instruction should be developed about such broad integrative elements as the comparison of scientific with other modes of thought, the comparison and contrast of the individual sciences with one another, the relations of science with its own part and with general human history, and of science with problems of human society.

One of the objectives of science in education, as stated in the list of general goals of the President's Commission on Higher Education (1947) was: "To understand the common phenomena in one's physical environment, to apply habits of scientific thought to both personal and civic problems, and to appreciate the implications of scientific discoveries for human welfare."[8]

The Forty-Sixth Yearbook of the National Society for the Study of Education also played a vital role in shaping science education in America. The yearbook committee set forth its position on the objectives of science instruction to the effect that objectives represent directions of growth and not final outcomes to be completely and perfectly attained. The committee recommended the following types of objectives for science teaching.

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[8]President's Commission on Higher Education, Higher Education for American Democracy--Establishing the Goals. Vol. I, Harper, New York, 1947, p. 52.

Science instruction should result in growth toward patterns of behaviour which reflect attainment of:

1. Functional facts, concepts, and principles of the major fields of science. The acquisition of facts should be approached, not as an end in itself, rather as a means of gaining understanding of concepts and principles, of developing scientific attitudes, and in gaining an understanding of and skill in the use of the intellectual processes of science.

2. Instrumental skills related to the ability to read and understand science content, perform fundamental operations of mathematics with accuracy, read and interpret maps, graphs, charts, tables and the like, manipulate science equipment and to make accurate measurements.

3. Problem solving skilIs which include the ability to sense and define problems, recognize and procure available information pertinent to the problems, develop, select, and test hypothesis, and draw valid conclusions.

4. Attitudes such as open-mindedness, intellectual honesty, inquisitiveness and suspended judgment.

5. Appreciations of the scientific enterprise and members of its community.

6. Interest in some phase(s) of science as vocational or avocational pursuits.[9]

The major goal of science instruction, according to Pauli is the development of conceptual understanding. This objective is not a goal of acquisition of correct answers. Pauli described the objective as: Not merely to reach a specific goal, an answer which can be found in a book, or which some one can tell us, but to attain understanding of

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[9]National Society for the Study of Education. Science Education in American Schools - Forty-Sixth Yearbook, Part I. Chicago: University of Chicago Press, 1947. Pp. 28-29.

the relationship which connects the answer to the problem.[10]

Wolfe wrote in "Trends in Science Education" that a guiding principle would be to teach the sciences not as bodies of knowledge, but as systems of inquiry, and to present phenomena directly through experiences in the laboratory, in the field, in the classroom, and by film and television.[11]

Most scientists conclude that one of the major objectives of science education today is to develop critical thinking ability.

Russel associates critical thinking with problem solving. He asserted that critical thinking is "usually included in one of the activities which are essential to problem solving at the stage when various hypotheses are being examined...."[12] Ennis defined critical thinking "as the process of correctly assessing statements."[13] Critical thinking in science is also defined as the ability to evaluate or assess various hypotheses being investigated.

George, writing in "The Effect of Critical Thinking Ability Upon Course Grade in Biology" stated that, "Science is a process by which critical thinking is applied in the

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[10]W. Pauli, "Confusion and Problem Solving," Clearing House, 35 (1960), pp. 79-82.

[11]Deborah Partridge Wolfe, "Trends in Science Education," Science Education, Vol. 54, No. 1 (1970), p. 71.

[12]David H. Russel, Children's Thinking, Ginn, New York, 1956, p. 282.

[13]Robert H. Ennis, "Needed Research in Critical Thinking," Educational Leadership, 21 (1956), p. 463.

evaluation of various hypotheses. We cannot separate critical thinking from science learning."[14]

"However, individuals can be helped to improve their abilities to do critical thinking, which does not develop automatically. This ability does improve through instruction designed for that purpose."[15]

The teaching of critical thinking is an important objective of science education. The assumption has been made that the best success in teaching critical thinking would probably be had when the teacher both possessed and used the skills involved.

Kastrinos concluded his writing about critical thinking in high school biology by saying that "A critical thinking approach to teaching of high school biology can produce significant changes in the student's critical thinking ability as measured by the tests used in the study."[16]

II. Views of Indian educators

K. L. Shrimali, former Minister of Education, Government of India, suggested that:

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[14]Kenneth D. George, "The Effect of Critical Thinking Ability Upon Course Grade in Biology," Science Education, Vol. 52, No. 5 (1968), p. 421.

[15]George, "Effect of BSCS and Conventional Biology in Critical Thinking," Journal of Research in Science Teaching, Vol. 3, No. 4 (1965), p. 294.

[16]William Kastrinos, "Teaching of Critical Thinking in High School Biology," Journal of Research in Science Teaching, Vol. I, No. 4 (1963), pp. 341-352.

> Science should be applied to the service of mankind. It should also enable the pupils to form 'habits of accurate observation and of testing experience by experiment'; ... the study of science should not only help the child to discover truth but also lead him to a faith in the scientific method.[17]

The Secondary Education Commission (1954) reported the following about science education in the secondary schools of India:

> An understanding and appreciation of the fundamental principles of the natural and physical sciences is essential to effective living in the world today.... Its aim is to give basic understanding and appreciation of scientific phenomena--biological and physical which may prepare the "non-scientist" for a fuller and more complete life. At the same time, the courses should give fundamental principles to those relatively few, who will later specialize in science. Special emphasis must be placed on demonstrations, field trips, and practical projects which may link up school science with actual life problems and situations--concrete problems like local sanitation, water supply, elimination of pests, etc.[18]

The commission appointed by the Government of India in 1964 to suggest improvements on the secondary education of India stated the following objectives for science education in Indian schools:

> All this emphasizes the need from the earliest stage of science education for a proper understanding of the basic principles and the process of scientific abstraction and creative thinking. It must communicate to the pupils a feeling for discovery and creativity and a realization that science is open ended and man's greatest intellectual enterprise today.... Science teaching at all levels has to be creative teaching.[19]

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[17]K. L. Shrimali, Wardha Scheme. The Gandhian Plan of Education for Rural India, Vidhya Bhavan Society, Udipur, Rajasthan, 1949, p. 106.

[18]India--Report of the Secondary Education Commission, 1954, p. 100.

[19]India--Report of the Education Commission, 1964-66, Published by the Manager of Publications, Delhi, 1966. P. 397.

The NCERT, in writing on the summary of recommendations of the Education Commission, reported as follows:

> ... The quality of science teaching has also to be raised considerably so as to achieve its proper objectives and purposes, namely, to promote an ever deepening understanding of basic principles to develop problem solving analytical skills and the ability to apply them to the problems of the material environment and social living and to promote the spirit of inquiry and experimentation. Only then can a scientific outlook become part of our way of life and culture.[20]
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> ... Science strengthens the commitment of man to free inquiry and to the quest for truth as his highest duty and obligation. It loosens the bonds of dogmatism and acts as a powerful dispeller of fear and superstition, fatalism and passive resignation. By its emphasis on reason and free enquiry, it even helps to lessen ideological tensions which often arise because of adherence to dogma and fanaticism. Although it is largely occupied with the understanding of nature at present, its development is tending more and more to help man to understand himself and his place in the universe. This concept of mingling of 'science and spirituality' is of special significance for Indian education.[21]

III. Objectives of biology teaching

All the objectives of science teaching stated in general are applicable to the teaching of biology also. In addition there are specific objectives which are related to biology teaching alone.

In identifying the objectives for a high school biology course, Stone stated as follows: "It is the teacher's job to ... develop increased acuity of perception, understanding of concepts, ability to use critical judgment, and an

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[20]NCERT, Report of the Education Commission--Summary of Recommendations, 1967, P. 16.

[21]Ibid., p. 16.

appreciation of scientific methods and attitudes.[22]

Alexenburg, writing about biology education in the elementary school, stated:

> The objectives of biology education are generally stated in terms of (1) the development of knowledge of scientific concepts and facts about living things and (2) the development of understanding of the scientific method employed in discovering these concepts and facts.[23]

Mayer, writing about biology in "Synthesizer of Science," said:

> ... biology needs be interpreted as a multifacted discipline that is both experimental and quantitative. By its methods it must exemplify science, and by its content provide data for the interpretation of our living world.... Biology serves to bring together the normally discrete sciences and use them in a synthesis for solving every day problems.[24]

Methods of Science Instruction

Very little research has been done on the methods of teaching science in the secondary schools of India including Kerala State. Studies made in the United States for evolving effective methods of science teaching will be helpful in suggesting improvements for science education in Kerala State. So, great emphasis is given to the review of literature on

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[22]Dorothy F. Stone, Modern High School Biology, Bureau of Publications, Teachers College, Columbia University, New York, 1959, p. 86.

[23]Melvin L. Alexenburg, "Biology Education in the Elementary School. The first task and central purpose." American Biology Teacher, Vol. 29, No. 3 (1967), pp. 175-179.

[24]William V. Mayer, op. cit., p. 804.

the different methods of teaching science in the United States of America.

I. Inquiry method

Inquiry is receiving considerable attention as a method of changing behaviour and attitudes through science instruction. Many interpretations of how experiences with inquiry can function to change behaviour have been made by scientists and educators. Many science educators claim that the inquiry method is one of the best and most effective ways of teaching science.

The literature in science education includes various uses and definitions of the term inquiry. In general, inquiry can be defined as a seeking of information by the asking of questions. It is in support of this that Dewey stated the following:

> ... The mind of man is being habituated to a new method and ideal: There is but one sure road to access to truth--the road of patient, cooperative inquiry operating by means of observation, experiment, record and controlled reflection.[25]

Inquiry, then, as a method of teaching science, would be highly desirable. The Mid-Continent Regional Educational Laboratory and the Biological Sciences Curriculum Study have jointly developed a position paper, "Inquiry Objectives in the Teaching of Biology", edited by Richard M. Burgman.

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[25]John Dewey, "Faith and Its Object," Basic Problems of Philosophy, Prentice-Hall, Inc., Englewood Cliffs, New Jersey, 1964. P. 497.

Inquiry, as defined in the paper, is a set of activities directed towards solving an open number of related problems in which the student has as his principal focus a productive enterprise leading to increased understanding and application. Success in any particular inquiry involves some, but probably not all, possible inquiry behaviours and skills.[26]

A Biological Sciences Curriculum Study, made in 1953 by Schwab lists "Science as Inquiry" as one of the nine themes around which subject matter and laboratory experiences are integrated. Schwab said, "The essence of teaching science as inquiry would be to show some of the conclusions of science in the framework of the way they arise and are tested."[27] Novak wrote, "Inquiry is the total configuration of behaviours involved in the struggle of human beings for reasonable explanations of phenomena about which they are curious."[28] Grobman, in writing about school biology of the future, stressed the importance of inquiry in biological education. He stated:

> It seems reasonably clear that the biological education of the near future will place increased stress on inquiry and discovery. For all the reasons now widely discussed which have led to the present efforts to alter

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[26]Barbara Snowbarger, "New Perspectives for Viewing Inquiry," American Biology Teacher, Vol. 32, No. 5 (1970), pp. 302-303.

[27]Joseph Schwab, Biological Teachers' Hand Book, Biological Sciences Curriculum Study, Wiley, New York, 1963.

[28]Alfred Novak, "Scientific Inquiry," Bioscience, 14 (1964), pp. 25-28.

> our science curricula, the methods of teaching will inexorably change. There will be less attention paid to the accumulation of factual information by students and more to an understanding of the organization and philosophy of the science with particular stress on how information is obtained ... and it seems that the last third of the century is to be dominated by an inquiry approach.[29]

Balzer (1970), in "Teacher Behaviors and Student Inquiry in Biology" wrote that much emphasis had recently been placed on inquiry as an outcome of instruction in biology. Problem-solving, the nature of science, and processes of science are also given frequently as desirable outcomes. It would appear that inquiry is being seen as a desirable outcome of science instruction because of the productive mental processes and favourable affective condition involved.[30]

Although many factors are operative in the promotion of inquiry, the essential and pivotal role of specific teacher behaviours in facilitating inquiry is clear. The teacher can prevent inquiry by failing to give opportunities for inquiry or by providing information prematurely. He can decrease the involvement and enthusiasm of students by positioning himself as the center of attention.[31]

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[29]Arnold B. Grobman, Rutgers. "School Biology of the Future: Some Considerations," American Biology Teacher, Vol. 29, No. 5 (1967), pp. 351-355.

[30]LeVon Balzer, "Teacher Behaviors and Student Inquiry in Biology," American Biology Teacher, Vol. 32, No. 1 (1970), pp. 26-28.

[31]Ibid., pp. 26-28.

II. Problem solving method

Problem solving has been included as one of the methods of science education. But it has often been neglected in the science classrooms. In early years, the secondary school science was mainly content oriented, but by 1920 the trend was towards using science as a tool for interpreting the environment and helping pupils to adjust to it.[32] Pieper, in writing for the National Society for the Study of Education, Thirty-First Yearbook, suggested that pupils should be given the opportunity to apply scientific knowledge to solving problems as a method of developing scientific attitudes.[33]

Many studies have been conducted to identify behaviours related to problem solving skills and how to teach them. Katz found that a group of educable retardates who learned by a problem solving method significantly demonstrated that they were better able to solve problems based on learned principles than the group who learned by rote.[34]

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[32]Paul F. Brandwein, "Curriculum Problems and Policies in Science Education," The Bulletin of the National Association of Secondary School Principals, Vol. 37, No. 191 (1953), pp. 50-55.

[33]Charles J. Pieper, "Science in the Seventh, Eighth, and Ninth Grade," A Program for Teaching Science. In: National Society for the Study of Education. Thirty-First Yearbook, Part I. Chicago: University of Chicago Press, 1932, Chapter XIII, pp. 198-200.

[34]Paul J. Katz, "Transfer of Principles as a Function of A Course of Study Incorporating Scientific Method for the Educable Mentally Retarded," Dissertation Abstracts, XXIII, Pt. 4 (1963), pp. 42-44.

Efforts to memorize scientific facts are practically useless in developing clear concepts about scientific definitions, laws, principles and logical reasoning. The study of science needs careful attention and thinking. In the modern age of science and technology, the emphasis of science education has been significantly shifted from the product or accumulation of factual knowledge by more memorization to a real understanding and concept formulation about laws, principles and theories of sciences:

> One of the most important phases of effective study of science is the habit of problem solving. Problem solving abilities indicate the range of understanding and concept development. Problem solving habits can help students to reach the desired objectives of science learning. In problem solving approach, students need to spend enough time in exploring, defining, planning, investigating, observing, hypothesizing, judging, devising, applying, evaluating, predicting etc. In meaningful problem solving situations, students should develop abilities for testing hypotheses and drawing conclusions.[35]

III. Laboratory method

Science educators early perceived the value of and insisted upon facilities for laboratory work and also insisted upon conceptualization rather than memorization.

Whenever the development of the scientific method of thinking, teaching of scientific attitudes, and mastery of scientific skills are among the objectives of teaching science, laboratory work comes to the front as a way of fulfilling these objectives.

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[35]Abu Obaidul Hugue, "Studying Science Effectively," Science Education, Vol. 54, No. 1 (1970), p. 89.

A number of local experimental programs have been reported in the literature, but the results of these programs were inconclusive. Robinson reported in 1959 on a new ninth grade laboratory centered science program developed by the local teachers at Whittier, California. He reported that the program seemed to be effective in increasing pupil interest in science.[36]

A study conducted by Kruglak to compare the performance and achievements of physics students with and without laboratory work showed:

> The experimental evidence of this investigation supports the conclusion that students who got laboratory instruction by the individual or demonstration method are superior to students without such instruction on tests designed to measure laboratory outcomes.[37]

In 1956 Carpenter reported on a study that had significance for the laboratory method of teaching science. He found that students who had an opportunity to handle and manipulate irregularly shaped solid objects were able to classify and understand the shapes of the objects more thoroughly than those who were just told about the objects while they were allowed to look at them.[38] Toohey, in comparing

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[36]James T. Robinson, "General Science in the Secondary School," Science Education, Vol. 43 (1959), pp. 415-419.

[37]H. Kruglak, "Achievement of Physics Students With and Without Laboratory Work," American Journal of Physics, No. 21 (1953), p. 15.

[38]Finely Carpenter, "The Effect of Different Learning Methods on Concept Formation," Science Education, Vol. 40 (1956), p. 285.

the effectiveness of the laboratory method to the lecture demonstration method of teaching in earth science and general science, found that the laboratory method was definitely superior to the lecture demonstration method in achieving both science learning and retention of science information.[39]

Novak emphasized the importance of laboratory work in developing an appreciation of scientific inquiry:

> Laboratory exercises must be investigational rather than verificational. They must, for the most part, pose real rather than contrived problems. In biology, the laboratory investigations must deal with events not just with things. They ought to involve biological materials, not mortological specimens.[40]

As Anderson explained:

> The students must become involved in the planning of the experiments and analyzing the results. Then only the laboratory work is of little value in achieving the objectives in teaching an understanding of the nature of the scientific enterprise.[41]

A student's laboratory experience should include activities which serve to help him discover and explore the principles being studied. In the teaching of biology, the laboratory method is considered as very effective. Pilaggi,

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[39]Jack V. Toohey, "The Comparative Effects of Laboratory and Lecture Methods of Instruction in Earth Science and General Science Classes," Dissertation Abstracts, 24:3241; No. 8 (1964), 996 R.

[40]Alfred Novak, op. cit., pp. 25-28.

[41]Ronald D. Anderson, "Using the Laboratory to Teach the Nature of Science," American Biology Teacher, Vol. 30, No. 8 (1968), p. 633.

in writing about stimulating the potential biologist, concluded: "Having taught biology at various levels for eight years, I have come to value the investigative project as a means of awakening and enriching the scientific experience of the student."[42]

The research concerning the laboratory method of science teaching is not conclusive. Yet, a number of science educators have emphasized the need of using this approach in the teaching of science. Watson, writing in relation to the importance of laboratory experimentation in teaching high school sciences, makes a plea for a spirit of inquiry in secondary sciences. He felt that: "At the core of such efforts to create some understanding of scientific inquiry is the most important invention of the past four hundred years--experimentation."[43] At the same time Stollberg said, "... we find that modern education psychology strongly supports the laboratory as a tool of science education."[44]

Originally biology was more descriptive and empirical than it is today. This was partly because the research

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[42]Robert D. Pilaggi, "Stimulating the Potential Biologist," American Biology Teacher, Vol. 32, No. 1 (1970), pp. 24-25.

[43]Fletcher G. Watson, "Experience and Experiment--Characteristics of High School Science Teaching," The Bulletin of the National Association of Secondary School Principals, 37: 96-100, January 1953.

[44]Robert Stollberg, "Learning in the Laboratory," The Bulletin of the National Association of Secondary School Principals, 37: 100-110, January 1953.

methods used by the Physical Sciences were not used in biology. Eventually, biology came to enjoy the rigor needed to be considered as an experimental science.

> Biology ... its rightful place was not accorded to it for a variety of reasons, one of which is the fact that for the most part biological scientists were engaged mainly with the scientific world rather than with the theoretical side. In addition, much of the experimental work had never been done with sufficient control to satisfy the rigor demanded in experimentation by the physical scientist.[45]

The study of biology was looked upon as a means of training the mind rather than a means by which scientific attitudes could be taught.

In 1955 ground work was laid by the American Institute of Biological Sciences (AIBS) to prepare new approaches and materials for biological education. One of the purposes of these new programs was to emphasize laboratory experiences and to design laboratory activities in such a way that the student learns the techniques of inquiry and the nature of the scientific process through self discovery and direct experience.

IV. Demonstration method

The term "demonstration" is defined as a planned manipulation of equipment and materials to the end that students observe all or some of the manifestations of one or more

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[45]Alfred Novak, "Scientific Inquiry in the Laboratory," American Biology Teacher, Vol. 25, No. 5 (1963), p. 342.

specific principles. It is performed by the teacher and may be contrasted to the method which involves the individual student laboratory activity.[46]

The demonstration method is preferred by some science teachers because "it is accepted by the science teacher as an effective and economical means of helping students to visualize, memorize and understand specific kinds of specific information."[47] A demonstration can also be given inductively by the instructor who asks several questions to stress inquiry. It involves thinking and motivation of the students and gives the teacher immediate feedback from their answers.[48]

Even though the demonstration method is advantageous in many respects, it has its limitations and disadvantages. Students have little opportunity to get acquainted with the materials used in the demonstration. Further, it is likely that during the demonstration most of the students remain inactive.[49] They only have interest in work they can be

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[46]John H. Woodburn and Ellsworth S. Obourn, Teaching the Pursuit of Science. New York, Macmillan, 1965, p. 321.

[47]Nathan Washton, op. cit., p. 14.

[48]Robert B. Sund and Leslie W. Trowbridge, Teaching Science by Inquiry in the Secondary School. Charles E. Merril Books, Inc., Columbus, Ohio, 1967, p. 10.

[49]Walter A. Thurber and Alfred T. Collette, Teaching Science in Today's Secondary School, 2nd ed., Allyn & Bacon, Inc., Boston, 1965, p. 133.

involved in; and attention can not be held long if there is no interest.

V. Field trips

Field trips are gaining greater emphasis in recent years in the program of biological sciences. Classroom experiences seldom carry the student beyond chalkboard living, and a chalkboard interpretation has only a superficial resemblance to reality. For the learning of many important concepts, however, students cannot become involved in direct experience while confined in the classroom. Therefore, for these concepts it is important, whenever possible, to get students out of the classroom and into contact with the real thing.

> Biology and nature are one. Biology is a study of living organisms--life histories, growth processes, conditions for maintaining life, and inter-relationships in a space environment.... Young learners should understand the nature of the environment under which life has evolved and is maintained.[50]

As Neal suggested, for pupils to learn essential biological concepts, they must become involved in studies with living plants and animals in ecological situations where organisms normally live. When good learning is a desired end result, there is no substitute for children's direct involvement with living specimens.[51]

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[50]Louise A. Neal, "Multifunctional Use of a Natural Laboratory for Teaching Biology to Elementary Pupils," American Biology Teacher, Vol. 29, No. 3 (1967), p. 217.

[51]Ibid., p. 217.

Moseley, in writing about field trip and outdoor science teaching, expressed the following views:

> The child must see real things before he can form clear mental pictures of the things he reads about. Science instruction given by means of books, recitations and lectures is of little use without a background of experience in which impressions are made on the senses by the things that are discussed. We recognize this by providing laboratories and lecture table experiments. But many things which children should observe and understand cannot be brought into the school room. The experience of these things gained in a haphazard way is usually meagre and not very enlightening. Nature study is the natural beginning of education.[52]

Green wrote that the best place for ecological observations and environmental studies is the outdoors, providing a variety of habitats and organisms as well as examples of complex environmental problems. Facilities range all the way from vacant lots and public parks, in town, to wild lands in more remote areas. Regardless of the facility, however, the teacher has a vast storehouse of teaching resources available within reasonable field trip distance.[53]

> An organism is the product of its heredity and its environment. This is the basic concept of living things. This is the basic concept of life. It should be the basic concept of biology curricula and biology courses.... To gain an understanding of environments, scientists go to the environments. Children must also go there. Although the classroom is an environment, the environment of most living things are out of doors. We must go there to learn about them.[54]

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[52]E. L. Moseley, "A Plea for More Outdoor Science Teaching," School Science and Mathematics, Vol. 24, No. 1 (1924), pp. 151-155.

[53]Kingsley L. Green, "Natural Environment Awareness--Part II: Including Field Trips," American Biology Teacher, Vol. 30, No. 7 (1968), pp. 552-556.

[54]Matthew J. Brennan, "Biology Out-of-Doors in the Elementary School," American Biology Teacher, Vol. 29, No. 3 (1967), pp. 207-210.

Brennan supported the outdoor laboratory when he said:

> ... If we believe in the laboratory as an efficient place to learn science, then the outdoor laboratory must be the most efficient place to learn the science of the out-of-doors of the world in which we live.
>
> The outdoor lab is always there. It is always set up, stocked, and ready to use. And, most important, its lessons change, its conditions change every minute. There are real measurements to be taken, real questions to be answered, real situations to be studied.[55]

Walcott in reporting the progress of a curriculum study for elementary pupils concluded as follows:

> We feel very strongly that all these goals can be reached only by exposing children to an environment that is very rich in biological materials and not by feeding them neatly encapsulated statements about it. Children must work with their own hands and mind; they must become acquainted with nature at first hand. We suspect that such an exposure is a necessary prerequisite to any true appreciation and understanding of the fundamental premises of biological sciences.[56]

VI. Audio-visual media

Students learn science by making use of the five senses; i.e., by seeing, hearing, smelling, tasting and touching. Real things found inside or outside the classroom provide the best resources for science teaching.

However, it is not always possible to furnish first-hand experiences in teaching science. The teachers cannot always take the students out of the classroom to show the different environments in which plants and animals survive.

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[55] Ibid.

[56] Charles Walcott, "Elementary School Biology," American Biology Teacher, Vol. 29, No. 3 (1967), pp. 180-184.

Most of the time human physiology cannot be explained and taught by showing the real internal organs and functions of the human body. In these cases, and many other instances, the actual resources cannot lend themselves to direct sensory observations. It is then that the teachers must provide substitutes for real experiences. These substitutes are commonly called "audio-visual aids". Most of these substitutes predominantly involve vision and/or hearing.

Research on the role of audio-visual aids in improving instruction has confirmed the fact that instruction can be significantly improved through the proper selection and use of audio-visual materials in teaching. The following claims are made by audio-visual theoretitions and practioners:

1. They supply a concrete basis for conceptual thinking and hence reduce meaningless word-responses of students.
2. They have a high degree of interest for students.
3. They make learning more permanent.
4. They offer a reality of experiences which stimulates self-activity on the part of pupils.
5. They develop a continuity of thought; this is especially true of motion pictures.
6. They contribute to growth of meaning and hence to vocabulary development.
7. They provide experiences not easily obtained through other materials and contribute to the efficiency, depth, and variety of learning.[57]

Sometimes real things may be too far away to see or too small to see with the naked eye. Lippmann pointed out that:

> Man has invented ways of seeing what no naked eye could see, of hearing what no ear could hear, of weighing

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[57]Charles F. Hoban, James D. Finn and Edgar Dale, "Audio-Visual Materials," in Encyclopedia of Educational Research. New York, Macmillan Co., 1950, p. 84.

> immense masses and infinitesimal ones, of counting and separating more items than he can individually remember. He is learning to see with his mind vast portions of the world that he could never see, touch, hear or remember. Gradually, he makes for himself a trustworthy picture inside his head of the world beyond reach.[58]

Audio Visual media help not only to see things that are limited by physical obstacles, but also those that are limited by time. Motion picture films, slides, filmstrips, etc., can play a dynamic part in improving science instruction.

Content and Grade Placement

Studies for selection of science content and its placement in different grades are very rare in India as a whole or in Kerala State, but many attempts have been made since the beginning of this century in the planning of science content in the United States of America. Cohen indicated that:

> Studies seeking to identify appropriate course content for various grade levels have utilized techniques such as studies of existing textbooks, children's expressions of interests, surveys of school systems and teacher groups to determine their present practices, and opinions of juries of subject matter.[59]

Many studies were carried out in this area in recent years. As a result, lists of principles adequate for teaching high school science have been identified in several areas

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[58]Walter Lippmann, Public Opinion. New York: Macmillan C., 1949, pp. 16-29.

[59]David Cohen, "The Development of an Australian Science Curriculum Model," Unpublished Dissertation, Michigan State University, East Lansing, Michigan, 1964, p. 103.

of science. The current trend in selection of content of science curricula is mainly to depend on scientists to identify the fundamentals of the discipline--educators also participate in the process of selection, organization, and trial of content. The Course Content Improvement Section of the NSF provided support to projects "initiated and led by outstanding scientists ... in the development of courses and instructional materials that reflect contemporary scientific knowledge and points of view."[60] Studies such as the Physical Science Study Committee (PSSC), the Biological Sciences Curriculum Study (BSCS), the Chemical Bond Approach Project (CBA), and the Chemical Education Materials Study (CHEMS) are of paramount significance in this connection.

The Biological Science's Curriculum Study (BSCS) Committee realized the fact that most of the biology courses were lagging many years behind the recent biological advances. So they decided that new curricula should contain more fundamental concepts rather than a mere collection of facts.[61]

There is difference of opinion concerning placement of different concepts at different grade levels. Grade placement

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[60]National Science Foundation, Division of Scientific Personnel and Education, Course Content Improvement Section, Guidelines for the Submission of Proposals for Course Content Improvement Projects. (Washington, D.C.: National Science Foundation, 1962), p. 1. (Mimeographed)

[61]John I. Goodlad, School Curriculum Reform in the United States. New York: The Fund for the Advancement of Education, 1964, pp. 26, 27.

of content is based upon psychological considerations and interest of children.

Bruner, discussing readiness for learning, indicated that subjects could be taught to any child at any level. Bruner stated:

> We begin with the hypothesis that any subject can be taught effectively in some intellectually honest form to any child at any stage of development. It is a cold hypothesis and an essential one in thinking about the nature of a curriculum. No evidence exists to contradict it; considerable evidence is being amassed that supports it.[62]

Several studies have been made on grade placement of content on the basis of interest to children. Children's interests have been studied through analysing questions they ask and by the use of questionnaires. But considerable doubts have been raised as to the value of such studies as bases for curriculum construction. Fitzpatrick wrote that children's interests were "unstable, inconsistent, ill-considered and unreliable."[63]

Wann, Dorn and Liddle in writing about children's interests felt that:

> Children's spontaneous interests, which at one time were advocated as a basis of selection for an emerging curriculum, cannot be relied on to lead the child into all the areas of knowledge he will need to

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[62]Jerome S. Bruner, The Process of Education. (New York: Vintage Books, A Division of Random House, 1963), p. 33.

[63]Cited by Herbert A. Smith, "Educational Research Related to Science Instruction for the Elementary and Junior High School," Journal of Research in Science Teaching, I, No. 1 (1963), p. 216.

> explore in order to interpret today's world.... It appears that young children can become interested in most any topic which is brought to them in a meaningful way.[64]

Evaluation

Evaluation is the process through which the success of the learning experiences in achieving the objective is tested. Tyler defined the evaluation process as a process for finding out how far the learning experiences as developed and organized are actually producing the desired results.[65]

In order to evaluate the outcomes of education, some sort of measurement is essential. It works best when objectives are clearly defined and are understood by both teacher and learner. Measurement in all areas of science has been advanced by the discovery and rigid definition of suitable units in various topics. Mental age, equal-appearing units, and T-scores were cited as samples of attempts in this direction. None of these units satisfied completely the strict scientific canon of constancy.[66]

Well constructed standardized measurements exist today in three large areas: (1) Achievement tests, (2) Intelligence

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[64]Kenneth D. Wann, Miriam Selchen Dorn and Elizabeth Ann Liddle, Fostering Intellectual Development in Young Children. (New York: Teachers College, Columbia University, 1962), pp. 99, 100.

[65]Tyler, op. cit.

[66]Arthur M. Jordan, Measurement in Education. McGraw-Hill Book Company, Inc., 1953.

tests, and (3) Personality inventories and rating scales. Achievement tests are essentially improved types of examinations or tests which cover an area of learning. Intelligence tests attempt to measure capacities for learning, thinking, reasoning, and so on, without regard to the materials involved. They would measure general intelligence. Personality inventories and rating scales include attempts to measure many dimensions of personality.

In the elementary school, standardized tests of science information have appeared as members of the achievement batteries. At the high school level, tests are constructed for particular subjects such as biology, chemistry and physics. These tests check the knowledge of facts, of course, but they also set problems which require processes of comparison and inference--in short, of reasoning.[67]

In the development of a curriculum, factors concerning the learning process and the learners are important. But there is only limited research on the determination of such factors in science education. Barnes crititized this weakness and stated:

> One of the crucial weaknesses in science education as seen through curriculum research is the almost complete lack of research on the nature of learning as it can affect science teaching. We build curricula and proceed ultimately to specific lesson plans without validated criteria for judging the contributions of specific educational activities as specific objectives. We are not sure they should be called educational.[68]

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[67] Ibid.

[68] Cyrus W. Barnes, "A Definition of Science Education: Curriculum Research," Science Education, Vol. 45 (December 1961), p. 396.

The number of studies relating to research on learners is also very rare. Many critics have drawn attention to the crucial need of developing evaluation procedures that reflect the wider educational outcomes sought in statements of objectives. This need has been stated by Trump,[69] Watson[70] and many others.

Evaluation is also defined as the aiming at getting evidence about behaviour changes in the learners. Any valid method of obtaining this evidence is a desired process of evaluation. Different methods of evaluations could be paper and pencil tests, observation, interview, tape recorder techniques, attitude scales, interest inventories, sociograms, questionnaires, performance tests, anecdotal records or rating scales.[71]

When objectives and learning experiences are selected for science education, a comprehensive evaluation program also should be included in the planning. A successful evaluation program leads to further attempts to improve learning experiences and, in general, the educational program.

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[69]J. Lloyd Trump, "Some Problems Faced in Organizing Science Teaching Differently," The Science Teacher, Vol. 31 (May 1964), pp. 37-39.

[70]Fletcher G. Watson, "Research on Teaching Science," Hand Book of Research on Teaching, N. L. Gage (ed.) Chicago: Rand McNally & Company, 1963, p. 1054.

[71]Gamel A. Elashhab, "A Model for the Development of Science Curricula in the Preparatory and Secondary Schools of the United Arab Republic." Unpublished Dissertation, Michigan State University, East Lansing, Michigan, 1966, p. 102.

Summary

Many of the social problems of Kerala such as over population, hunger, diseases, etc., have implication for teaching in general and for biology teaching in particular. Biology teaching can play an important role in helping to solve many of these problems. This fact has to be recognized by the educators, and the biological science curriculum has to be founded on sound principles of the educational process and related to the needs of a society.

The four major processes constituting the development of a curriculum are: (1) determination of goals or objectives, (2) methods of instruction, (3) selection of learning experience and grade placement, and (4) evaluation or appraisals of results obtained.

Even though there are differences in the statements of objectives, mode of approach and presentation, there is agreement among educators about the general goals of education. It is generally thought that the goal of education is the optimum development of the individual through acquisition of knowledge, skills and attitudes.

The objectives of science teaching were stated by many of the scientists as not memorization of mere facts, but as developing scientific attitudes such as inquiry, critical thinking, problem solving and discovery.

Different methods of science instruction were suggested based on the objectives stated above. They were (a) Inquiry

method, (b) Problem-solving method, (c) Laboratory method, (d) Demonstration method, (e) Field trips, and (f) Audio visual aids. The most important among them is the inquiry method of teaching. A great majority of scientists stress inquiry as the best and the most effective method of changing behavior and attitudes through science instruction. Many classroom techniques have been devised to promote inquiry learning.

Recently, biology has been considered as an experimental science. New programs and approaches are laid which emphasized laboratory experiences in such a way that students learn the techniques of inquiry and the nature of the scientific process through self-discovery and direct experience.

Content and grade placement in science have been subjected to many studies. Studies seeking to identify appropriate course content for various grade levels were originally based on techniques such as studies of existing textbooks, children's expressions of interests, surveys of school systems and teacher groups to determine their present practices, and opinions of juries of subject matter.

The current trend in the selection of the content of the science curricula is to depend mainly on scientists to identify the fundamentals of the discipline. Studies such as the PSSC, BSCS, CBA and CHEMS are prominent in this direction. Educators also participate in the process of selection, organization and trial of content.

Evaluation is the process through which the success of the learning experiences in achieving the objectives is tested. It is also defined as the procurement of evidence about behaviour changes in the learners. Different types of evaluation have been tried out in education. The subjective type of examination which predominated in the beginning of the century gave way to the objective type of examination. Newer methods of testing have been developed to measure the whole personality of the learner.

CHAPTER IV

BACKGROUND OF SCIENCE EDUCATION IN THE SECONDARY SCHOOLS OF KERALA STATE

Kerala State occupies an honoured place among the states of India in terms of educational progress. Even so, the present educational system is faced with complex problems which make it difficult to instigate social changes. In order to understand the present science curriculum and to make effective suggestions for improvement, it is worthwhile to present a short review of the factors influencing science education in the schools of the state. The discussion in this chapter is divided into two parts: description of the educational system, and current scene of science education.

Description of the Educational System

I. Historical development

The ancient educational institutions of Kerala before the 18th century were mainly of three kinds; namely, Village Schools, Sanskrit Schools, and Military Schools, managed by private individuals or organizations. Because of these schools a high degree of literacy prevailed among the people of what was then Travancore. However, when these schools

disappeared early in the British period in the 18th century, illiteracy rose to an alarming rate, a condition which led to the intervention of the government and the formulation of educational policy. Under government patronage several vernacular schools were started in different parts of the state. Side by side with increasing government activity in the field of education, increasing educational activities of private agencies, particularly Christian missionaries, also started.

With the establishment of British rule in India in the 18th century, English education and the study of European sciences were introduced in many parts of the country. The first English school, which symbolized the beginning of western education in the Travancore area, was started in the capital city of Trivandrum in 1834 under the patronage of the Travancore government. English education flourished with the historic proclamation by the King of Travancore in 1844 which decreed that for state employment preference would be given to those educated in English schools. Consequently, a number of English institutions sprang up within a short span of time, and this led to the downfall of indigenous education.

The English schools started at this period had different curricula from the vernacular schools. The medium of instruction was English both in the upper primary and secondary stage. Science, mathematics, geography and history,

along with British history, were included in the curriculum. In fact, study of the English language dominated the curriculum. New administrative patterns were set up and teachers were given training in the new methods and materials of instruction. The Travancore government played a prominent role in establishing the new British schools and in improving the standard of education.

This system of education attracted the upper class of people more than the lower class. As a matter of fact, people who belonged to the upper stratum of the society and who gained English education, were urged to get jobs in responsible posts in government. The lower classes still remained mostly illiterate. The purely literary education was calculated to provide clerks for the government but not to help the majority of the rural population or to stimulate initiative or skill in production. As a result, the system of education that developed in India during the British rule was considered unsuitable and inadequate in many respects. As the national movement for the country's freedom gained strength and popularity, more and more stress was laid on the need to orient education to the national aspirations and requirements of the country.

As early as 1921, Mahatma Gandhi expressed his views in public on the need for changes in educational policy to suit the changing times. The exclusion of indigenous culture and the use of a foreign medium divorced the student

from real life education. Gandhiji emphasized the importance of crafts as an educative process, the mother tongue as the medium of instruction, and the necessity to make the schools self-supportive. Gandhiji's proposals stressed that Indian education must be relevant to the great majority of India's population who are mostly rural and illiterate. He saw that the only way of saving the nation was to revive village economic life and to relate education to it.[1]

After independence in 1947, basic education, formulated on the principles enunciated by Mahatma Gandhi, was accepted both by the Union and the state goverments as the pattern of national education at the elementary schools. It was decided to gradually establish a universal system of basic education throughout the country.[2]

In this system, socially useful work forms the core of education. It seeks to provide education for all children in the age group of six to fourteen, and to eradicate the undesirable difference existing between the cultural life of the village and the city. This system seeks to raise the level of cultural life of the village, thus constituting a significant step forward in the direction of establishing

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[1] India Today, An Exploratory Discussion--By the Faculty of Madras Christian College, published by The Christian Literature Society, pp. 45-56.

[2] Salamatullah (no first name is given in the book), Thoughts on Basic Education, Asia publishing House, 1963. (preface).

democracy in the country. Another principle of basic education is to instill in children love and respect for manual labor and productive work. This attitude would help to eradicate the artificial and unhealthy distinction between physical and mental work. Accordingly, basic schools for children and training schools for teachers were started in different parts of Kerala.

Even though the basic education system was started with much optimism, it did not win the expected acceptance from the public. Due to lack of qualified teachers and sufficient funds, the program could not be implemented in the ideal way visualized by Mahatma Gandhi. Both the village people and the upper class society found it difficult to appreciate the program. The village people considered that the basic schools without proper literary education were not useful to their children since they thought that "weeding and digging" could be taught at home. The upper class people viewed with apathy the training of their children in handicrafts.

At the time of independence in 1947, three types of high schools existed in the state: a) Vernacular (Malayalam), b) Sanskrit, and c) English High Schools. Of these three types, the English schools imparted maximum learning in the fields of science and mathematics. English was the medium of instruction. While the English high schools required eleven years of schooling, the Vernacular and the Sanskrit

High Schools required only nine years and ten years of schooling respectively.

The educational policies evolved by the government of India from time to time had their influence on the educational reforms of the state. The Secondary Education Commission appointed by the government of India in 1952 recommended a radical change in the curricula of secondary schools. The establishment of multi-purpose schools and the change of the medium of instruction to provincial or regional language were two major recommendations.[3]

But even before the recommendations of the Secondary Education Commission, the secondary schools of Kerala had adopted the regional language as the medium of instruction. This changeover to the regional language caused difficulty in the teaching of science due to a lack of proper scientific terms and books in the regional language, and to the fact that the teachers had had their science education in English. In spite of these difficulties, however, the shift of the medium of instruction to the regional language helped the students understand the scientific concepts more clearly and more rapidly.

The recommendations of the Secondary Education Commission were only partially implemented in many of the states. Consequently, another important commission, under the leadership of Professor S. Kothari, was appointed in 1964.

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[3]T. Paul Varghese, "Kerala," Administration of Education in India, ed. S. N. Mukerji, 1962, pp. 387-395.

The effect of the recommendations of the Kothari Commission in remodelling the secondary education of the state is yet to be evaluated.

At present one has to complete ten years of successful schooling in order to get a secondary school leaving certificate. The high school level is three years--Standard VIII, IX and X. In addition to the other subjects, a student has to learn three languages. Even though the medium of instruction is Malayalam in most of the schools, there are also some English medium schools in the state.

The structure of the education system and details of the curriculum at the different stages of schooling are given in Table II, page 71. In all standards after elementary education, science is taught under the subject, "General Science". In high school, general science includes separate units on chemistry, physics and biology.

There was substantial quantitative development in the field of education after independence. During the third five year plan period, the number of high schools in the state increased from 882 to 1155, an increase of 31%. The enrollment in classes IX to X, at the state level, which stood at 179,000 in 1960-61, more than doubled by 1965-66 increasing to 369,000.[4]

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[4] India-Education Statistics District-Wise - 1955/66, Vol. 7, KERALA, Ministry of Education and Youth Services - Government of India, New Delhi, 1969, p. 8.

Table II. Kerala--Structure of Education

Structure of Education		
Integrated Primary Stage		
	Lower Primary	I-IV
	Upper Primary	V-VII
	Secondary	VIII-X
	Higher	VIII-XI (Not yet started)
Curriculum		
Standards (I-IV)		1. Language 2. Arithmetic 3. General Knowledge 4. Arts and Crafts 5. Physical Education
Standards V-VIII		1. First language A and B 2. English 3. Arithmetic 4. General Science 5. Social Studies 6. Crafts 7. Arts and Music 8. Physical Education 9. Hindi (in VI and VII only)
Standards VIII-X (Academic)		1. First Language Parts I and II 2. English 3. Hindi 4. Social Studies 5. General Science 6. General Mathematics 7. Music or Drawing 8. Crafts 9. Physical Education
Standards VII-X (Diversified)		Same as for the academic course, except that in IX and X, in the place of First Language Part I, Music or Drawing and Crafts, the pupil studies elective subjects.

Source: NCERT--Position of Science Teaching in Indian Schools. A Factual Report, page 60 (no date).

This enormous quantitative increase, without sufficient financial resources and facilities, has added to the problem of improving the quality of education. During the third five year plan period in 1961, the National Council of Educational Research and Training (NCERT) was set up as an autonomous organization to work on various areas of research, training and extension work. The NCERT is trying today to implement many improvements in education.

II. Administration

The constitution of India, which was formally adopted on November 26, 1949, and which came into force on January 26, 1950, prescribed the allocation of responsibility for education to the states giving them the authority to make laws regarding education, including higher education, and to have full responsibility and control over the educational facilities within their respective borders.[5]

The central government is concerned with the coordination of educational facilities and determination of standards in respect to higher education, research, scientific and technical education. The central government exercises most of its responsibilities for education through the central Ministry of Education. In addition to its specific constitutional responsibilities, the Ministry performs a broad

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[5]John A. Laska, Planning and Educational Development in India, Teachers College, Columbia University, New York, 1968, p. 9.

leadership function for Indian education. A reform in education supported by the central Ministry finds better acceptance at the state level.

The government of India has also established a number of advisory bodies to assist it in carrying out educational responsibilities. Among these, the Central Advisory Board of Education and the University Grants Commission have an especially important role in determining national educational policy.[6] Coordination in regard to school education is secured through a standing committee of the Central Advisory Board of Education.

This board lays down the general education policy. Its four standing committees dealing with elementary, secondary, university and social education, formulate aims and objectives, assess prevailing positions and draw up future plans in these respective fields. A steering committee of the board coordinates their activities.[7]

At the state level, the Education Minister discharges his executive responsibilities through the Directorate of Education, headed by the Director of Public Instruction (Director of Education). His major functions include the inspection of schools, the development of rules and regulations, the operation of certain educational institutions on behalf of the state, the collection of educational statistics

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[6]Laska, ibid., p. 9.

[7]India: A Reference Annual. Ministry of Information and Broadcasting Research and Reference Division. 1968, pp. 61-75.

and the provision of technical advice in educational matters to the schools and the minister of education. The state also has a Secretariat of Education headed by an Education Secretary. This official works closely with the State Ministry of Education in the formulation of policy.

Other agencies may also participate in the process of educational decision-making at the state level as a consequence of the delegation of state authority. The State Advisory Board assists in the formulation of educational policy. Finally, local governmental authorities and private agencies may be permitted to manage educational institutions.

Upon the formation of Kerala State in 1956, the administrative set-up of the department was reorganized.

The general administrative set-up of education in Kerala State is summarized in Figure 1, page 75. The Director of Public Instruction is the head of the department, assisted by Regional Deputy Directors. Each educational district is under the direction of a District Educational Officer having control over high schools and training schools. The Sub-Districts are under the charge of Assistant Educational Officers, having control over institutions for primary education.

Based on this administrative set-up, the schools in the state can be classified under three categories:

A. Government schools: Both technical and administrative control of these schools rests with the state government.

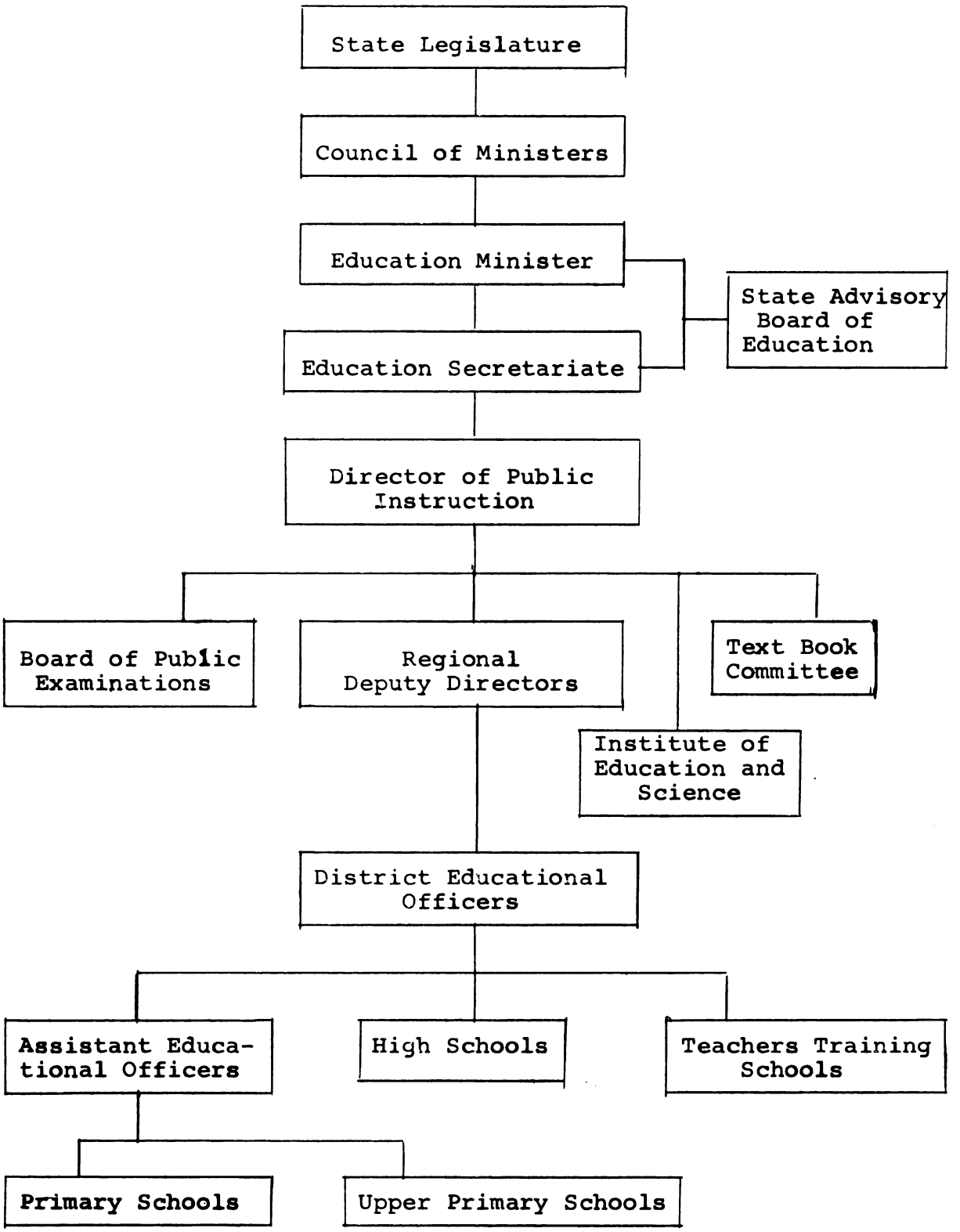

Figure 1. Kerala State education administration set-up.

The administrative officers of the Education Department at different levels are responsible for the proper running of these schools.

B. Aided schools: The salaries of the staff of these schools are paid by the government, but the administrative control rests with the manager of the school who may be an individual owner or the representative of an organization owning the school. The education department imposes technical control over these schools so as to maintain the quality of education.

C. Recognized schools: The education department has little control over these schools except the fact that these schools are entitled to train their students and send them to the high school graduation examination conducted by the education department on a state-wide basis. These types of schools are generally managed by organizations and maintain a comparatively higher standard even though they are few in numbers.

The fact that education is the sole responsibility of the state and that the central advisory committees are only recommending bodies, has both merits and demerits. The state can make its own policies and introduce changes in its education system. But at the state level, all powers in steering the educational system are entrusted to the Directorate and Secretariate. The principals and teachers of schools

have no voice in selecting the materials and methods they have to use to teach their students.

The state government with its poor revenue finds it very difficult to equip the schools adequately for proper science education. Because of the enormous expenditure involved in introducing any reform, the state government often hesitates to equip schools unless the central government extends the required financial aid. Further, it often happens that the state government finds it difficult to utilize a central fund provided under five-year plan programs because the conditions stipulated therein may be unsuitable to the local conditions.

Apart from the fact that sufficient central government funds are not available to equip the schools for proper scientific education, even the available state funds cannot be used for the right purpose at the right time, because of the complicated administrative procedures. The powers of the teachers and principals are very limited in utilizing the fund.

In short, the slow moving centralized administrative set-up, together with the poor financial resources of the state, hardly favours any radical change or experimentation in the present system of science education.

III. Examination system

The existing examination system is one of the main causes of various educational problems of India. Although

attempts have been made from time to time to improve the educational system, the form of examination remains as before.[8]

In all stages, formal examinations are held by internal or external examiners. Respective teachers of schools conduct internal tests and examinations in a traditional way, but the end of the year annual examinations are conducted which cover all that has been taught from the beginning until the end of the year. Promotions to higher grades are decided on the results of these annual examinations. Pupil's performances in other examinations held during the year and other aspects of the student's life are practically ignored when giving promotions.

External examinations are conducted by the boards on a statewide or region-wide basis. Questions for various subjects are set by the examiners who are selected by the board. Examination papers are corrected by teachers who are also selected from different schools of the state.

Standards VIII and IX have internal examinations while the Secondary School Leaving Certificate examination is conducted on a statewide basis by the Board of Public Examinations. Even though the marks obtained by a student in the final examinations of Standards VIII and IX will be recorded on his high school certificate, they will in no way help him

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[8]S. P. Chaube, "The Problem of Examination System," Indian Education, Vol. VII, Nos. 6 and 7 (May and June 1968), pp. 18-20.

to pass the final S.S.L.C. examination. To make things harder, in science and mathematics, the portions taught in Standard VIII, IX and X are covered in the final examination.

Due to the complicated nature of the examination system, the passing of examinations, rather than the development of total personality, has become the main objective of secondary education in Indian schools. N. C. Chanda, Headmaster of a high school in West Bengal, has written extensively about how the public examination system deteriorates the educational standard.[9]

Father Denis, in his study on secondary school examinations in Kerala State, has marshalled evidence concerning the negative effects of statewide examination upon candidates. Some of his findings are:

1. S.S.L.C. Examination affects not only secondary but also elementary and higher education.
2. It discourages learning and encourages learning for the examinations.
3. The examination is more important than the student.
4. It caters to the education of a false elite.
5. It prevents national growth and works against national goals.[10]

The Secondary Education Commission observed painfully that Indian secondary education is examination ridden.[11]

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[9]N. C. Chanda, "Why This Downward Trend," Secondary Education, July 1959.

[10]D. J. Arasarkadavil, Secondary School Examination in India. New York: Asia publishing house, 1963.

[11]India - Report of the Secondary Education Commission, op. cit.

M. Biswas stated that the whole examination system of India fails to satisfy the fundamental objectives of examinations termed as (a) validity, (b) reliability, (c) adequacy of sampling, (d) comparability, (e) economy, and (f) utility.[12]

The Kothari Commission (1966) also came to the conclusion that the evaluation system of Indian secondary schools was defective and needed improvements, both in content and methods.

Many educators have suggested that the present external examinations should be replaced with internal assessment of the whole child by keeping cumulative records. In this connection, the examination system followed in the American schools has been commented on by many Indian educators. Even though in some of the schools in Kerala, monthly tests have replaced quarterly and semi-final examinations, the importance of the final examination, either external or internal, has not been reduced.

To improve the existing system of examinations, the Kothari Commission recommended the establishment of a certain number of experimental schools wherein the external examination at the end of Standard X would be abolished and the schools themselves would be responsible for conducting the final examinations. A change in the internal assessment was also recommended. With regard to the mode of the examination, the Commission suggested that:

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[12]M. Biswas, op. cit., p. 4.

> (a) the technical competence of paper-setters should be raised through an intensive training program sponsored by the State Boards; (b) the question papers should be oriented to testing not merely the acquisition of knowledge, but the ability to apply knowledge and the development of problem-solving abilities.[13]

Many measures are being taken by the NCERT in various parts of the country to improve the existing system of examinations. Experimental projects on internal assessment are also being carried out in different levels.[14] Kerala is no exception. Steps are being taken to reform the examination system prevalent in the state. Workshops and seminars are being conducted in different parts of the state to give the examiners new ideas of evaluation, methods of testing and measurement. Kerala originally had the traditional essay type of questions in the examinations. The use of objective types of questions are among the suggestions made by the NCERT.

Much reform of the present examination system can be expected by the end of the fourth Five-Year Plan period. Implementation of an effective and systematic scheme of internal assessment of students' performance and minimizing the dominance of external examinations are two important procedures proposed in the fourth plan for the improvement of examination system.

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[13] Ibid., p. 245.

[14] NCERT, 1967-1968, p. 16.

Current Scene of Science Education in Kerala State

I. Recent developments in science education

Since the inception of the NCERT in 1961 the National Council has been concerned with the state of science education in Indian schools. A department of science education was formed under the NCERT at the national level. It worked on the improvement of existing syllabi in science and mathematic subjects at the secondary level.

A detailed survey of the position of science in the school curriculum has been carried out by the NCERT. It revealed serious shortcomings in the method and content of science teaching in the secondary schools throughout India. The Council stated:

> The curriculum is for the most part dated. It does not include modern concepts on the understanding of science.... No organic relationship exists in teaching the biological sciences, physical science and mathematics; each falls into a separate pinhole. Text books used are of poor quality. Teachers have not been provided with manuals, guides and other instructional materials. Laboratory apparatus and equipment are of the dated conventional type unsuited to teaching science along modern lines.[15]

With the ideas of introducing school teachers to new developments and acquainting them with modern curricula and new techniques of teaching and demonstration, summer Institutes were organized on a national level for secondary school teachers, with the help of American experts who were

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[15]National Council of Educational Research and Training. Report 1966-67, 1968, p. 44.

associated with these institutes. The teacher participants were selected from all over the country.[16]

A science institute was also established on the state level in Kerala State, as well as in other states of the country. Every year teachers are selected from different parts of the state to be given in-service training in this institute. Those personnel who received training in the Central Summer Institutes are the instructors in the State Science Institute. Teachers are given short term training in new methods of teaching biology, chemistry and physics using demonstrations and experiments. They are also given training in making improvised apparatus and using teaching aids like kits, films and filmstrips.

Further, the Central Ministry of Education, in cooperation with the University Grants Commission and the United States Agency for International Development, has been offering training in the Central Summer Institutes in which the Physical Science Study Committee, Biological Sciences Curriculum Study, the Chemical Education Materials Study, and the Chemical Bond Approach (PSSC, BSCS, CHEM Study and CBA) courses from the United States are taught. Such courses help to broaden the vision of science teachers and inform them as to how the problems of science curricula and teaching methods are discussed and changed in other countries.

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[16] Ibid., pp. 46-47.

The National Planning Commission is giving very high priority to the expansion and strengthening of facilities for better science teaching in the Five-Year Plan.[17]

The first Indian Biology Institute was held in Madras. The BSCS materials have played a key role in these Indian Biology Institutes. The institute programs have emphasized the use of the laboratory in teaching biology as a science. Special attention has also been given to ways in which the participants could implement the teaching methodology stressed in BSCS Biology within the framework of their existing syllabus.

II. Science curriculum

From Standards I-IV science is taught as General Knowledge. Lessons are on personal and environmental hygiene, the sun and moon, night and day, domestic animals, plants of the neighborhood, food, birds and insects, reptiles, the human body, air, water, fish and frogs.

From Standards V-X, science is taught as General Science. The General Science for the high school consists of units on physics, chemistry, biology, first aid and hygiene. There is no elective science up to Standard X. The unit on biology consists of lessons on botany, zoology and human physiology--including first aid and hygiene. In the Appendix a detailed

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[17] (Article provided by NCERT in India) "Science Teaching in Secondary Schools in India," Science Teacher, Vol. 34, No. 1 (January 1967), pp. 32-34.

syllabus for Standard VIII biological science as taught in the secondary schools of Kerala is given.

The total time of schooling varies from state to state. The time allotment at different stages of the school also varies widely as shown in Table III, page 86. The range of time alloted for science at the various stages of the school in Kerala State is as follows (expressed in percentage):[18]

Primary	Middle	High School
5.7 to 8.5	8.5 to 11.1	14.3

The text books for all subjects including general science are standardized by the state for all classes. In the beginning of each year, the syllabus for each subject is prepared by the education department and sent to the schools. Teachers in different subjects are expected to follow the syllabus and finish the portions within the prescribed length of time. The syllabus does not provide for any practical work even on the high school level. Every year the same units are repeated without much change in the content.

> The biology taught today in schools does little to promote an understanding of modern man, to consider his place in nature, to recognize his evolution as a product influenced by social and cultural forces as well as biological.[19]

A. Methods and materials of instruction

In Standards VIII-X (secondary schools) the prescribed biology text books are the main materials used for instruction

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[18]NCERT, Position of Science Teaching in Indian Schools. Ministry of Education. 1960-62, pp. 33-40.

[19]BSCS International News Notes, 1969, op. cit., p. 46.

Table III. Kerala--Time Allotment (Hours per Annum)

Classes	Regional Language	English	Hindi	Social Studies	General Knowledge	Arithmetic	Crafts	Physical Education	Music	Drawing Painting	Percentage for Science
Lower Primary											
I	257	--	--	70	47	164	94	94	47	47	5.7
II	257	--	--	70	47	164	94	94	47	47	5.7
III	187	117	--	70	70	164	47	94	47	24	8.5
IV	187	117	--	70	70	164	47	94	47	24	8.5
Upper Primary				General Science							
V	164	164	--	94	94	117	70	47	47	24	11.1
VI	164	164	70	94	70	117	47	47	24	24	8.5
VII	164	164	70	94	70	117	47	47	24	24	8.5
Secondary				General Mathematics							
VIII	164	140	70	117	117	117	47	24	24	--	14.3
IX	164	140	70	117	117	117	47*	24	24*	--	14.3
X	164	140	70	117	117	117	47	24	24*	--	14.3

*This time is given to General Science for those who offer the advance course.

Source: NCERT, Position of Science Teaching in Indian Schools, p. 62 (no date).

in many of the schools. Teachers still follow the traditional methods of teaching, which is predominantly teacher oriented. Very limited chance of participation is given to pupils in the classroom activities. In biology teaching the lecture method is predominant with very few teacher demonstrations or experiments. To explain topics related to human physiology and other topics of the kind, biological charts are often used. Specimens, usually preserved ones, may be used at times, but use of the laboratory for biology teaching is rare and in most of the schools not many facilities are available for the purpose. Field trips or outdoor teaching, as valuable as they are, do not form a part of biology instruction.

Up to Standards VII, no form of practical work in the laboratory is provided for the pupils. Practical activities for children are, however, implied in many of the syllabi. No provision for a laboratory is prescribed in most of the schools up to Standard VII. Most of the schools do not have laboratories unless they are attached to a secondary school where common facilities are available.

The teachers, as a whole, are often concerned with imparting knowledge from the prescribed textbooks and finishing the portions detailed in the syllabus within the alloted time. They prepare the students mainly for their examinations so that they can memorize facts and reproduce them in their examinations.

B. Evaluation

Evaluation in science courses follows the examination system previously described in this chapter. Examinations up to Standard IX are internal. No practical work is prescribed nor are students tested on practical work. Questions are commonly traditional essay type, demanding students' knowledge in memorizing facts and theories, but objective types of questions have recently been introduced and they are gaining in importance. In Standard X, external examinations are held as the S.S.L.C. Examination. Only theory is tested and practical work is of no significance in these examinations. Examinations are held in General Science Part A and B, both including chemistry, physics and biology. Questions are set by the examiners on topics covered in Standard VIII, IX and X. Students have to review and memorize most of the things they learned in these grades. Facts, theories, concepts, experiments, diagrams, etc., are given importance in the examinations. Thirty-five percent is considered necessary for passing in science in the S.S.L.C. Examination.

Summary

A clear understanding of the factors influencing the science education in the state is essential before making any suggestion for improvements. The historical development of education, with its pervasive authoritarian

philosophy, its administrative set-up and the general examination pattern are three major factors influencing the science curriculum.

The Kerala State educational scene has been subjected to numerous changes since the nation gained independence in 1947. These frequent changes have brought about a state of confusion and non confidence in the minds of both teachers and students in the success of any new program. Most of the teachers now working in the secondary schools had their high school education when it was oriented towards training only "office assistants" or "clerks". The teachers who were trained in the old school of thought are not generally suitable agencies to carry out changes. They try to fit the new ideas with the old system, probably with the result of losing the good results of both the systems.

The Indian constitution defines education as state's responsibility. With the limited financial resources, the state finds it difficult to introduce major changes in science education programs requiring financial commitments. At present, teachers and principals have had little part in the formulation of science curriculum for the schools.

The current program of Kerala secondary education is examination-oriented. The day to day performance of the student has no significance in promotion to higher standards. The external examination system for high school graduation compels the teacher to prepare his student for the examination

rather than care for his intellectual growth, oriented towards solving the social problems. The teacher has no freedom to include topics related to the social problems of his community in the biological science curriculum.

In the secondary schools of Kerala biology is taught as a unit of general science which includes physics, chemistry and biology. The content of the course has not undergone any appreciable change even though biological science has advanced much during recent years. The lecture dominated traditional method of teaching is still followed.

This review indicates that the background training of teachers, the organization of the existing educational system and the evaluation pattern present problems for introducing improvements in the teaching of biological science in the secondary schools. These problems have to be given due consideration in suggesting changes.

CHAPTER V

PROPOSALS FOR IMPROVING THE TEACHING OF BIOLOGY IN THE SECONDARY SCHOOLS OF KERALA STATE

Kerala is still underdeveloped and economically backward despite its earnest efforts for improvements since 1947. Many basic problems which retard the progress of the state are yet to be solved. Among these are over population, superstition and ignorance, hunger and malnutrition, unemployment and a lack of scientific attitude among her citizens. A properly organized biological science curriculum can act as an agent in helping to solve most of the problems.

In suggesting guidelines to improve the teaching of biology, the selection of sound objectives is imperative. The first part of this chapter discusses selected objectives for a course in biology in the secondary schools of Kerala based on the needs of the state as reflected in its cultural and economic backgrounds. In the second part of the chapter, the existing biology syllabus is examined in relation to the objectives selected. The third part presents suggestions for improving the biological science instruction in the secondary schools.

Selection of Objectives for a Biology Course in the Secondary Schools of Kerala State

Table IV (page 93), and Table V (page 96) give a summary of the objectives of science education in general, and biology in particular, as expressed by American and Indian educators in the selected literature.

I. Criteria for selecting objectives

The objectives summarized in the tables cannot be adopted in toto to the educational conditions of Kerala. Suitable objectives have to be selected from the lists. Before any can be chosen, however, the following questions must be considered:

1. Are the objectives clearly defined in terms of behavioral change in the student?
2. Are the objectives helpful to young people in fitting themselves into their society?
3. Are the objectives helpful in maintaining physical health and well being of the students?
4. Are the objectives helpful in giving pupils exploratory experiences and personal interests leading to vocational choice?
5. Are the objectives helpful to students in meeting the problems of every day living?

Table IV. Summary of Selected Statements of the Objectives of Science Education--American Educators

Source	Major Emphasis
Commission on Reorganization of Secondary Education Science Committee 1920	Contribution of science education to the cardinal principles of education--health, command of fundamental process, worthy home membership, vocation, citizenship, use of leisure and ethical character.
American Association for the Advancement of Science 1927	Scientific method as a major objective.
National Society for the Study of Education. Thirty-first Yearbook Committee 1931	Understanding of major generalizations and scientific attitude.
Educational Policies Commission. 1944	To enter into an occupation, personal growth and citizenship, intellectual curiosity, rational thinking appreciation of ethical values.
Harvard Committee 1947	Solve problems of human society, scientific thought.
President's Commission on Higher Education 1947	Understand physical environment, apply habits of scientific thought, apply scientific discoveries to human welfare.

N.S.S.E. Forty-Sixth Yearbook Committee 1947	Behaviors--functional information, concepts and understandings, instrumental skills, problem solving skills, attitudes, appreciations, interests.
NSTA Conference on "Planning for Excellence" 1959	Process and product.
NSSE Fifty-Ninth Yearbook Committee 1960	Learning of concepts, generalizations or principles, and scientific methods and attitudes.
National Science Foundation Division of Scientific Personnel and Education 1961	"Substantive content and nature of contemporary science itself.
National Science Foundation Science Course Improvement Project 1962	"To go beyond the presentation of what is known and to provide students with experience in the processes by which the facts, principles and techniques are developed."
AAAS Commission on Science Instruction. 1962	Science is a two-dimensional subject: "The dimension of knowledge or content and the dimension of performance or process."
NSTA Conference of Scientists 1964	"The nature of science or the process by which new knowledge is obtained." The development of an understanding of the basic ideas of science concomitantly with an appreciation of the methods of science.
George D. Kenneth 1965, 1967, 1968	Develop critical thinking.
Deborah Partridge Wolfe 1970	As systems of inquiry present phenomena directly through experiences.

continued

Table IV--continued

Source		Objectives of Biology Teaching
Dorothy F. Stone	1959	Develop acuity of perception, understanding of concepts, critical judgment, scientific methods and attitudes.
Melvin L. Alexenburg	1967	Development of scientific concepts and facts about living things, understanding of scientific methods.
William Mayer	1968	For solving everyday problems, as a multifaceted discipline, for interpretation of our living world.
Micheal Bassey	1963	To develop better understanding of the natural and physical world, understanding of changes taking place within the human body, to understand the methods used in science, prepare for effective citizenship, cultivate attitudes to solve problems.

Table V. Objectives of Science Education--Indian Educators

Source		Major Emphasis
K. L. Shrimali	1949	To form habits of accurate observation, experimentation and scientific method.
Secondary Education Commission	1954	To deal with the actual life problems and situations, appreciation of scientific phenomena.
Kothari Commission	1966	Scientific abstraction, creative thinking, feeling of discovery.
NCERT	1967	Develop problem solving and analytical skills, to apply them to the problems of life, to promote the spirit of inquiry and experimentation.
M. V. Raja Gopal	1967	"Develop proper understanding of the main facts, concepts, principles and processes in the physical and biological environment. Acquisition of knowledge, together with the ability to think logically, to draw conclusions and to make decisions at a higher level."

6. Are the objectives helping students to encourage scientific attitudes and the scientific way of thinking?
7. Are the objectives helpful in understanding concepts, generalizations and principles?[1]

Still further criteria should be considered before adopting objectives from another culture. Among the other objectives Elashhab listed the following:

1. Are the objectives desirable in terms of a set-up of values derived from the values of the culture?
2. Are the objectives helpful in understanding and solving the problems of the society?
3. Are the objectives broad enough to encompass all types of outcomes needed to be attained by the school?[2]

II. Current problems of Kerala State

The final objectives in this study are chosen on the basis of their appropriateness in meeting the needs of the individual and eventually contributing to the needs of the society. The problems of the state which need urgent attention have been derived from the discussion in Chapter II and are listed as follows:

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[1]Gamal Elashhab, op. cit.

[2]Ibid.

1. Population explosion
2. High rate of unemployment and underemployment
3. Poor sanitation, unhygenic practices and ill health
4. Ignorance and superstition
5. Food deficit (hunger and malnutrition)
6. Lack of scientific minded citizens

Based on the objectives presented by American and Indian educators and further tested in the light of the criteria used to judge all objectives, as well as considerations for choosing those for a new culture, the following list is proposed as guidelines for the improvement of the teaching of biology in Kerala State. These objectives will then again be tested against relevant problems in Kerala.

III. A suggested list of objectives for a course in biology in the secondary schools of Kerala

1. Understanding of scientific concepts, facts and principles about living things.
   a. Learning about personal growth and citizenship, vocational choice, and appreciation of ethical values.
   b. Learning about social problems and the role of science in dealing with them.
   c. Learning about the human body, its growth and developments.

2. Development of scientific attitudes.
    a. To learn and accept change as a universal phenomena.
    b. To form attitudes of experimentation, adventure, creativity and acuity of perception.
    c. To develop objective thinking which would encompass respect such ideas as manual labor.
    d. To develop an attitude of cooperation.
    e. To develop an attitude of belief in cause and effect.
    f. To promote the spirit of inquiry.
3. Development of scientific thinking applied to solving the problems of life.
    a. To state a problem precisely
    b. To form habits of accurate observation.
    c. To state an hypothesis.
    d. To draw a conclusion.
4. Development of instrumental skills.
    a. Reading and understanding.
    b. Measuring accurately.
    c. Identifying instruments and manipulating them scientifically.
    d. Developing and interpreting tables and data.
    e. Writing reports precisely.
5. Development of understanding of the physical environment and appreciation of the natural world.

6. Development of interest and appreciation in science, its achievements and application to human welfare.

Table VI, page 101, tests the objectives against the selected social problems of Kerala State.

Examination of the Present Standard VIII Biology Syllabus Used in Kerala State

An examination of the biology syllabus used in the secondary schools of Kerala (Appendix) reveals that there are no set objectives stated. Furthermore, it would be difficult to attain most of the objectives suggested in this study by following the syllabus.

The first objective proposed in this chapter is the understanding of scientific concepts, facts and principles about living things. The present syllabus is oriented mostly towards learning only factual knowledge which is not directly related to everyday life. Topics which will lead the student to an understanding of the social problems such as the population explosion, food deficit, superstition, etc., which hinder the progress of the society, are not included in the syllabus. The students are given little understanding of the role of modern science and technology in dealing with the problems of the state. As a result, the students are left unaware of the crucial problems or the urgent needs of the state or how to cope with them in the future as responsible citizens. This is one of the greatest weaknesses of the existing syllabus.

Table VI. Objectives and Related Problems

Objectives			Related Problems	
1 Understanding of scientific concepts facts and principles about living things.	a	Learning about personal growth and citizenship, vocational choice and appreciation of ethical values.	(1)	Population explosion
			(2)	Unemployment
	b	Learning about social problems and the role of science in dealing with then.	(3)	Ignorance, superstitions and traditional beliefs
			(4)	Non hygenic practices
	c	Learning about human body, its growth and development.	(5)	Food deficit
			(6)	Lack of scientific minded citizens
2 Development of scientific attitudes.	a	To learn and accept change as a universal phenomena.	(1)	Population explosion
	b	To form attitudes of experimentation and adventure.	(2)	Unemployment
			(3)	Ignorance, superstitions and traditional beliefs
	c	To develop objective thinking which would encompass such ideas as respect for manual labor.	(4)	Non hygenic practices
			(5)	Food deficit
	d	To develop attitudes of cooperation.	(6)	Lack of scientific minded citizens
	e	To develop an attitude of belief in cause and effect.		
	f	To promote the spirit of inquiry.		

3	Development of scienδific thinking applied to solving the problems of life.	a	To state a problem precisely.		(1)	Ignorance, traditional and superstitious beliefs
		b	To form habits of accurate observation.		(2)	Lack of scientific minded citizens
		c	To state an hypothesis.			
		d	To draw a conclusion.			
4	Development of instrumental skills.	a	Reading and understanding.		(1)	Food deficit
		b	Measuring accurately.			
		c	Identifying and menipulating instruments.		(2)	Industrial under-development
		d	Developing and interpreting tables and data.			
		e	Writing reports precisely.			
5	Development of understanding of the physical environment and appreciation of the natural world					All Problems
6	Development of association in science and its achievements and application to human welfare.					Lack of scientific minded citizens

The content of the programs very seldom gives a chance for the students to understand the changes taking place within their bodies. For example, even though the systems of the human body are included in the syllabus, the emphasis is not on developing an understanding of the physical and psychological changes taking place in the human body particularly during adolescence. A knowledge about human growth and development is greatly needed to understand effective family planning programs which would check the exploding growth of population in the State. Particularly, the large majority of students who discontinue their education after high school are without any real knowledge of their part and responsibility in checking the rapid growth of population which threatens the state. As a consequence, they remain ignorant and reluctant to adopt any family planning measures.

Development of scientific attitudes is one of the major objectives of biology instruction. The syllabus provides very little opportunity for students to change from the existing traditional ways and age-old customs which hinder the progress of the society and to accept new scientific ways. There are no specific suggestions in the syllabus to help the students develop attitudes of experimentation, creativity and acuity of perception.

Developing objective thinking which would encompass such ideas as respect for manual labor, which is indispensable for the progress of the state, is ignored throughout

the syllabus. The state, being one of a high traditional caste system, still preserves the division of labor according to castes. Moreover, since manual labor is considered to be a mean job, educated people feel they should not do any kind of manual work. One of the main reasons for disrespect for manual labor is that students are not given enough opportunities to develop respect for manual work in their younger age. If students were trained to develop this attitude of respect, they could help to a great extent to reduce the rate of unemployment in the future since there are more opportunities for manual labor than there are for professional jobs. An attitude of cooperation is greatly lacking in the schools. No topic is given in the syllabus to encourage this attitude. Group activities and team work which are necessary to develop cooperative spirit are given little significance in the syllabus. As a result, even though there are ample opportunities for many cooperative enterprises, people do not often encourage them. The attitude of belief in cause and effect is one of the most important attitudes to be developed in the students of the state. But unfortunately, not much significance is given to this in the syllabus. A majority of the people living in villages and rural areas are still ignorant of the cause of many contageous diseases and how they are spread. If children are given opportunities to form the attitude of believing in cause and effect, they will help to reduce the ignorance and

superstitions prevalent in the state. Promoting the spirit of inquiry related to social problems is not provided for, as such, in the present syllabus.

Development of scientific thinking is not encouraged by following the present syllabus. The students are not trained to state a problem precisely, to formulate solutions, to observe accurately or to draw conclusions. Because the syllabus is examination oriented, learning experiences are limited, and the trend is toward memorization rather than toward other forms of intellectual growth. Opportunities for the development of various forms of scientific thinking which are essential for producing scientific minded citizens are lacking in the existing biology programs.

The instrument skills of measuring accurately, identifying instruments, and manipulating them scientifically, developing and interpreting tables and data, and writing reports precisely, are not given any significance in the syllabus. In all fairness, it should be stated that some of these skills are dependent upon laboratory equipment which is unavailable, but students are not encouraged by requirements of the syllabus to develop these skills which are of great importance to scientific minded citizens.

Understanding of the physical environment and appreciating the natural world is a main objective of biology instruction. To gain real understanding of the environment and the living world, students have to be given opportunities

to go out of doors and examine living things in their natural environment. Only then can they appreciate the natural world. But according to the present biology program, the students are always confined to the four walls of the classroom, and no opportunities are provided for field trips or any outdoor experiences. They learn and memorize about plants and animals. They see no interrelations among living things.

The last objective chosen is the development of interest and appreciation in science, its achievements and application to human welfare. According to the present syllabus very little opportunity is provided for the students to develop an interest in science or appreciate its achievements. Recent developments in science and current scientific discoveries applicable to human welfare are not given much significance.

From the above discussions it is evident that the existing biology syllabus needs to be changed to attain fully the objectives selected. Besides, the present examination system and the methods of teaching followed are not oriented towards achieving the objectives. The teachers and students, under the pressure of examinations, are forced to concentrate their attention on factual informations rather than the development of scientific attitudes.

Suggestions for Improving the Teaching of Biology in the Secondary Schools of Kerala

From the above discussions it is evident that the present biological science education does not provide guidelines for helping to solve the social problems of Kerala. Most of the objectives selected in this study for a course in biology based on the cultural and social backgrounds and the needs of the society are not attainable by following the existing biology programs. A drastic change must be made in the biological curriculum of the secondary schools, including content, methods of instruction and evaluation.

I. Content

The content of the biological science program of the secondary schools should be suitably modified so that the students will be led toward the attainment of the broader objectives selected.

1. In order to prepare the students to be helpful in solving the social problems, topics related to these problems should be included in the biology syllabus. For example: Topics on the reproduction of plants, animals and human beings should have as their basic purpose sex education and an understanding of population growth.
2. Topics which touch upon the immediate needs and everyday problems of the students should be an

important part of the biology program. Subject matter like poor sanitation, unhygenic practices and ill health, which deal with the daily lives of the students should be given greater significance. These topics would be more relevant to the students than topics which do not deal with their actual life problems.

3. The content of the syllabus should have topics which will initiate objective thinking which will lead to respect for all kinds of physical work and co-operative enterprises. This will help them choose to work irrespective of quality, thus helping to solve the problem of unemployment or underemployment.
4. Topics which will deal directly with the elimination of ignorance and superstition should have greater emphasis in the syllabus. For example, no topic is included in the syllabus dealing with the cause, spreading and prevention of the common contageous diseases that are prevalent in the different parts of the state. To help pupils understand ignorance and superstition, topics related to them should have a vital part in the syllabus.
5. A study of the principles underlying types of soil, use of fertilizers, improved farming methods, selection of better seeds, etc., are essential for better food production. But none of these topics is

included in the syllabus. In school, the children are not given any opportunity to deal with the problems concerning food production.

6. The syllabus should contain topics which could be assimilated into learning experiences which would serve the wide range of objectives. For example, subjects which are merely of informational value and that fail to fit into the program which aims at teaching scientific methods and attitudes should be de-emphasized or used as a basis for developing scientific methods and attitudes.
7. There are many topics in the biology syllabus which are largely insignificant to the students. For example, in the present Standard VIII biology syllabus about thirty class periods are allotted for teaching descriptions about leaves, their functions and so on. Very little specific purpose is served by teaching all these details about leaves. Such unnecessary details should be eliminated from the syllabus.
8. Modern scientific discoveries and topics reflecting contemporary scientific knowledge applicable to human welfare should be given significance in the content selection. This would help the teacher and student to be in touch with up to date scientific knowledge.

II. Methods

As mentioned earlier in Chapter IV, Biology in the secondary schools is taught in the traditional way consisting mainly of lectures without many discussions, demonstrations or any laboratory work. The objectives of teaching biology cannot be attained by this kind of teaching-learning process. The methodology of the program is as important as its contents. In order to achieve the objectives, a complete change in the method of instruction is desirable.

1. The authoritarian or teacher dominated approach of instruction which presents a body of organized information for pupils to assimilate should be limited to a minimum. Instead, the discovery approach which confronts students with problems to be solved should be introduced into the biology classrooms.
2. Students should be given more freedom for participation in such classroom activities as discussions, oral presentations, reports, group activity, etc. These will help to develop students' communication skills and give opportunity to learn to express themselves orally and in writing. Current topics which are related to the social problems of Kerala may be used for this purpose.
3. Biology has to be changed from a descriptive to an experimental science. The lecture method should give way to more modern techniques of instruction.

The laboratory should become an integral part of biology instruction where the students can do experiments by themselves. Laboratory activities should be designed in such a way that students learn the techniques of inquiry and the nature of the scientific process through self discovery and direct experience.

4. Biology, taught as constituting essentially a body of established facts and informations, should be changed. Instead, biology should be stressed as a body of methods of inquiry. The inquiry approach and problem solving method should have a vital place in the methods of instruction, and be applied to current problems.
5. The effective role of field trips in biology instruction should be given due importance. These give opportunity to the student for developing scientific thinking and appreciation and understanding of the natural and social world.

III. Evaluation

As was pointed out in Chapter IV, evaluation is primarily thought of as synonymous with testing. Much emphasis is given to the achievement of the student in the final examinations. This kind of evaluation in science fails to satisfy the fundamental objectives of science education.

1. The present method of evaluation, based on factual information and emphasizing annual examinations for promotions, should be changed.
2. More importance should be given to internal assessment programs.
3. All activities related to the learning process should be evaluated and given due credit for promotion. These changes in the method of evaluation will more nearly lead the student to the attainment of the objectives of science education than rote memorization of facts for examinations.
4. The science teacher needs to perceive evaluation in the broadest sense possible. He should see evaluation as a continuous and integral part of the whole teaching-learning process, as an effective technique for helping him to improve his teaching and enhance the learning of all pupils.
5. The standardised examination system for high school leaving certificate should be eliminated. Instead, a comprehensive evaluation program should be included in the planning when objectives and learning experiences are selected.
6. The process of evaluation followed in advanced countries like the United States of America should be used as a model in formulating a new evaluation scheme for the educational system of the state.

IV. Agencies for implementing the program for improvement

In view of the points raised in Chapter IV, it is clear that the present administrative machinery should be revised to allow for formulating and implementing proper changes in the curriculum. Therefore, it is suggested that the following actions be considered for the successful implementation of the programs.

1. A State Curriculum Committee consisting of sociologists, psychologists, scientists, economists and educators, including representatives from the teachers should be appointed. The sociologists and economists could examine the cultural and economic problems, social values and beliefs of the state. The psychologists could take over the task of examining research findings on learning, the nature of the adolescents, and evaluation. The services of the scientists could be utilized to examine the structure of science and identify the fundamentals of the discipline. The implications of these examinations could provide helpful information for the educators for planning the program.
2. It would be desirable to have curriculum subcommittees at the subdistrict level so that they may be able to formulate necessary changes suitable for the community. These subcommittees should include principals, specialists, teachers and parents.

3. Teachers should be given more freedom to adopt suitable methods and materials of instruction within the framework of the syllabi approved by the state department.
4. Principals and teachers should be given more freedom to utilize the funds available for improving the teaching methods.
5. In the State Science Institutes the present biology teachers should be given inservice training in the new science programs and up-to-date teaching techniques.
6. During summer vacations, workshops, seminars and short-term training courses should be conducted at the subdistrict level.
7. The inservice training programs for science teachers should be made compulsory. Sufficient financial aids should be given to teachers so that they may be encouraged to participate in the programs.
8. In the training programs for student teachers more emphasis should be given to current methods and materials of instruction and evaluation applicable to biological science programs.
9. Communities should become involved in isolating local problems and implementing methods for their solution.

CHAPTER VI

CONCLUSIONS AND RECOMMENDATIONS

Scientific education and the application of modern science and technology offer approaches to the solving of social problems.

This study has attempted to formulate guidelines that will make the teaching of biology in the secondary schools of Kerala State, India, more effective in meeting the needs of the people. In this process of suggesting guidelines, the geographic, historical, cultural and economic backgrounds of the state were investigated to identify the basic problems of the society. Literature reflecting the views of both American and Indian educators on science teaching was reviewed, and from it, objectives for science programs in general, and biology in particular, were further tested by selected criteria and applied to the social problems of Kerala. The historical development of education was described and the present administrative set-up and examination system were presented as part of the present educational scene. The current biology program of the secondary schools of Kerala, specifically the content of the Standard VIII biology syllabus, was examined in terms of the objectives selected in this

study. Guidelines were then proposed for improving the teaching of biology.

Before the final conclusions are listed, however, the writer would like to state that she realizes in a diverse culture, during a period of transition, the very social problems discussed in this study have made it difficult to implement necessary innovative changes. But difficult and expensive as these changes are, they must be made as soon as is feasible.

Conclusions

This study revealed the following social problems currently requiring attention in Kerala:

1. High rate of population growth
2. Unemployment and underemployment
3. Poor sanitation, unhygenic practices and ill health
4. Ignorance and superstition
5. Great food deficit and malnutrition
6. Lack of scientific minded citizens.

The description of the historical development and the present administration and practices of Kerala's education system indicate the following:

1. The Kerala educational system has evolved from the nature of its culture, the changing political scene, especially with the advent of British rule and subsequent independence of India, requiring reorganization and increased financial burdens.

2. The centralized educational administrative organization is cumbersome in dealing with changes. Not enough freedom is granted to authorities on the local scene to initiate and implement changes according to the needs of the community.
3. The examination oriented system dictates a rigid form of evaluation of students and necessitates adherence to methods which are not useful in meeting the needs of the society.
4. The rigidity and inflexibility of the curriculum force the teachers to adhere strictly to a prescribed syllabus and to be confined to the lecture method of instruction.
5. The lack of financial support eliminates the use of necessary laboratory equipment, classroom supplies, and teacher training aid.

The examination of the current biology syllabus for Standard VIII, the methods of instruction and evaluation reveal that most of the objectives selected in this study cannot be achieved in the present program.

1. The content does not provide for realization of the wide range of objectives.
2. The content is focussed mainly on factual knowledge which is not relevant to meet the needs of the students or to help solve the problems of the society.

3. The method of instruction is mere dissemination of facts rather than development of scientific attitudes in students--the authoritarian rather than the discovery approach.
4. Biology is taught as a descriptive rather than an experimental science.
5. Few opportunities are given for direct experiences in understanding the natural and social world.
6. Methods of inquiry and the problem solving approach are not used in the science program.
7. Evaluation in the form of an examination which demands mostly memorization dominates the program and neglects the over-all developments and behavioural changes in students.
8. Importance is not given to internal assessment programs or to all activities related to learning.

Consideration of present social needs of Kerala; the current educational background; objectives of science programs, biology in particular, as proposed by American and British science educators; and a study of the Standard VIII syllabus all dictate the selection of the following objectives for a biology course in the secondary schools of Kerala which would make biology more effective in helping to meet the social needs of the state (detailed in Chapter V):

1. Understanding of scientific concepts, facts and principles about living things

2. Development of scientific attitudes
3. Development of scientific thinking
4. Development of instrumental skills
5. Development of understanding and appreciation of the natural world
6. Development of interests and appreciation in science and its achievements.

Recommendations for Further Studies

The guidelines presented in this study are limited in scientific support because of the lack of research in the related areas applicable to the conditions of Kerala State. Yet, biological science education is only a small part of the whole school curriculum which needs modification with the changing social conditions. It is hoped that this study will initiate follow-up studies in science education, as well as for other subjects. In addition, the format which is used in this study can also be used as a model for studies in other areas of education.

The following are suggested considerations for further research:

1. The effectiveness of the present educational administrative organization in improving the quality of science education in the secondary schools of Kerala.

2. The effectiveness of the present administrative organization in initiating change.
3. Exploration of ways through which experimentation and innovation can be fostered through the present administrative set-up.
4. Adaptation of the improved teaching methods experimented with in advanced countries like the United States of America to the adolescents of Kerala.
5. Effective methods to be used in the evaluation process for the Kerala secondary schools.
6. Effective techniques and instruments for evaluating desirable behavioral outcomes.
7. The teacher's behavior and personality related to behavioral changes in the student.
8. Initiating change in attitude toward curriculum change.
9. Evaluation of the effectiveness of change.
10. The role of teacher education institutions in solving educational problems.

ADDENDA

This study is an approach to the task of helping to solve the social problems of Kerala through an improved biological science curriculum. The writer realizes that all the changes suggested cannot be implemented at once. They require time, reorganizations, finances, trained personnel, and changed attitudes. But from personal experience as a biology teacher in the Kerala secondary schools, the writer believes that even within the existing system with its rigid curriculum, the teacher can do many things to redirect the program toward achieving at least some of the objectives proposed in this study. Modern methods of teaching can be introduced. Laboratory facilities can be provided in an inexpensive way by using improvised materials. The students can be encouraged and guided to develop projects outside the school. Field trips and audio-visual aids should be used to the maximum extent possible, during after school hours if necessary. If teachers are creative, fruitful programs can be introduced even though changes may not be initiated from the top level.

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APPENDIX

APPENDIX

THE SYLLABUS OF BIOLOGY FOR STANDARD VIII

1. Plants and Animals
   (a) How they resemble and differ.
   (b) Parts of a plant--vegetative and reproductive organs.

2. The leaves.
   (a) Descriptive terms like node, internode, axil.
   Parts of a leaf--petiole, blade, veins, stipules, margin, apex.
   Show the parts of a leafy twig. Let children sketch a twig and name the parts.
   Let children draw leaves of two or three plants and name the parts. 3
   (b) How leaves are arranged on plants--alternate, opposite, whorled; the significance of this arrangement.
   Show how leaves are arranged on a number of plants.
   Let children classify them into three groups.
   Let them draw sketches. 2
   (c) How veins are arranged on leaves--netted and parallel functions of veins.
   Show leaves of different plants.
   Let children observe how veins are arranged, classify them into two groups, and draw the arrangement of veins of a few leaves.
   Show them skeletons of decayed leaves. 2
   (d) Simple and compound leaves, pinnate and palmate, familiar examples.
   Show a number of leaves, simple leaves with entire margin, simple leaves deeply lobed and compound leaves, point out separate blades in compound leaves.
   Show how leaflets are arranged in two parallel rows in some, and all arising from the base in some.
   Let children sketch a number of compound leaves. 2

3. Structure of a leaf.
   (a) Leaves are made of cells, the epidermis and mesophyll. Examine under the microscope transverse section of a leaf.
   Let children draw the section and name the parts. 2

(b) Epidermis, nature of the cells. Upper and lower epidermis, cuticle, stomasta, structure of stomata, guard cells. 2
Peel off the upper and lower epidermis of yan and betel leaves and examine them under the microscope. Let children sketch what they observe.

(c) How cells are arranged in the mesophyll, palisade and spongy tissue, airspaces.
Let children examine under the microscope prepared slides of stomata, and draw what they observe. 1

(d) The veins, what they are, vascular bundles.
Let pupils observe under the microscope prepared slides of sections of veins, and draw sketches of what they observe. 1

(e) Parts of a cell--protoplasm, cell wall, mucleus, cell sap, plastids.
Let children examine prepared slides under the microscope. 2

4. Function of leaves.

(a) Transpiration--its importance, transpiration pull, keeping plant cool. Factors that influence transpiration--solar energy, humidity, air currents, temperature. How transpiration is controlled--actions of the stomata. Adaptation to reduce transpiration in xerophytic vegetation.
Demonstrate using a clear dry bell jar.
Show adaptations in xerophytic plants like the cactus. 3

(b) Carbon assimilation, Synthesis of food from water and carbon dioxide, how they enter the plant, the visible product--starch, test for starch. Chlorophyll--its role in the formation of food. Extraction of chlorophyll. Starch is formed only in green parts. Why plants turn towards sunlight; starch is formed only in parts exposed to sunlight. The process of photosynthesis, evolution of oxygen. What happens to the food prepared by leaves--translocation and storage; the usual storage organs--roots, stems, seeds.
Demonstrate using leaves with parts that have no chlorophyll. Demonstrate covering part of a leaf with dark paper or light screen. Demonstrate the presence of starch by iodine test. Demonstrate evolution of oxygen from submerged water plants. Demonstrate extraction of chlorophyll.
Let pupils make a list of plants which store food in different parts, and classify them according to the organs wherein food is stored. 5

(c) Plants without chlorophyll--bacteria, molds, mushrooms. How they obtain food. Seprophytes and parasites.
Show mold growing on moist bread and mushrooms growing on decaying vegetable matter. 1

(d) Parasites, reference to common parasitic plants of the locality--loranthus, cuscutta, sandal-wood tree, how they obtain food from the host, haustoria.
Let children observe loranthus and cuscutta growing on other plants. Take sections of the twigs in which the parasites grow to how the intimate relationship between parasite and host. 1

(e) Respiration in plants. No special organs, all parts respire, stomata and lenticels, Comparison of photosynthesis and respiration.
Show lenticels on the barks of stems demonstrative respiration by leaves. 2

(f) Carbon cycle in nature, its importance.
Let pupils draw the carbon cycle chart and discuss its significance. 2

5. Mammals.

(a) The rabbit--external features, body covering, limbs, sense organs, skeleton (main parts only), a vertebrate. Position of important internal organs. Food and feeding, adaption of teeth. Reproduction--ovum and sperm, fertilisation, growth of the embryo, viviparous, food of the newborn.
Rabbit, a mammal, characters of mammals.
Let children observe the external features of a rabbit. Show the position of important internal organs in a dissected rabbit.
Let children examine the nature of muscle, tendon, bone, ligament, blood vessels and nerves in a dissected rabbit. 5

(b) Groups of mammals and their main characteristics--carnivores, ungulates, rodents, whales, elephants, bats, Economic importance of these groups.
Show pictures of animals coming under these groups. 4

6. Birds.

(a) The pigeon--external features. Feathers--kinds and structure, arrangement of the body. The skeleton--main parts, the keel, bird a vertebrate. Adaptation of body for flight--shape, lightness, modification of forelimbs into wings, etc.

Let pupils examine the external features of a pigeon.
Let them observe and draw the different kinds of feathers.
Show the parts of a bird's skeleton. Let children observe the position and shape of the keel. 3

(b) Flightless birds such as ostrich and penguin, how they move about. 1
Show picture of the ostrich and penguin.

(c) Adaptation of feet and beak to mode of life--the kite, the woodpecker, the parrot, the duck, the crane, the kingfisher.
Show preserved specimens. Let children visit a zoo where they can observe different kinds of birds 4

(d) Structure of a hen's egg, the embryo and its food.
Let pupils draw the sketch of a hen's egg and mark the parts. 1

(e) How birds are useful, need for bird protection.
Idea of balance of nature. 2

(f) Mammals and birds are warmblooded animals. 1

7. The general build of the human body.

(a) The position of the important internal organs.
Let children observe the various parts in a torso.
Let pupils draw a sketch and mark the parts. 2

(b) Tissues, organs, systems. 1

8. The skeletal system.
Main parts of the skeleton--vertebral column, vertebrae, the skull, breast bone and ribs, the girdles, bones of the limbs. Ball and socket joint, hinge joint.
Let children observe parts of a human skeleton.
Let children draw the various parts. Show in a dissected rabbit how bones are joined together by ligaments. 6

9. Muscular system.
Voluntary and involuntary muscles, cardiac muscle.
How muscles bring about movement, muscular fatigue, cause, importance of systematics exercise.
Show charts of muscles in the human body.
Let children examine muscle fibres under the microscope. Show in a dissected rabbit or frog how voluntary muscles are attached by tendons to bone. 4

10.	First aid for fractures, dislocation and sprain. Give practical training in bandaging, application of splints, etc. Show first aid charts.	4
	Revision	12
	Total	175