Chapter III

METHODOLOGY

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CHAPTER III
METHODOLOGY

3.1 INTRODUCTION

This chapter describes the methodology of the present study. The principal aim of this study is to find out the influence of the selected psycho-social correlates such as intelligence, attitude towards science, home environment and study habits on the acquisition of biological concepts of secondary school students. The details of Method adopted, Variables selected, Tools used for the collection of data, Sample selected, Procedure for collection of data, Scoring and consolidation of data and Statistical techniques used for the analysis of data in the present study, are described in detail under the suitable heads as given below.

3.2 METHOD ADOPTED

The topic and objectives of a study and the type of data required in a study determine the methods to be adopted in that study. Based on the topic and objectives of the present study, the investigator has adopted the normative survey method for this study. The word survey indicates the gathering of data regarding current condition. It attempts to describe and interpret what exists at present in the form of conditions, practices, processes, trends etc. The word normative is used because surveys are frequently made for the purpose of ascertaining which is the
normal or typical condition or practice at the present time. Thus the normative survey method attempts to find out the normal or typical condition or practice at the present time.

3.3 VARIABLES OF THE STUDY

"Variables are the conditions or characteristics that the experimenter manipulates, controls or observes" (Best and Kahn, 1999). The present study is an attempt to find out the influence of certain psycho-social correlates in the acquisition of biological concepts of secondary school students. Hence ‘Acquisition of Biological concepts’ is taken as the dependant variable in this study. The different psycho-social correlates such as ‘Intelligence’, ‘Attitude towards Science’, ‘Home environment’ and ‘Study habits’ are taken as the independent variables. The difference in sex (boys / girls), location of school (rural / urban), type of management of school (Government / Private) are taken as the background variables in this study. The independent variables are also sub categorised as high, medium and low.

3.4 TOOLS USED FOR THE STUDY

The data collected for present study are collected using the following tools:

3.4.1 Test of Biological concepts

3.4.2 Home environment questionnaire

3.4.3 Study habits inventory

3.4.4 Scale of attitude towards science

3.4.5 Intelligence test
A description of these tools are given below.

3.4.1 Test of Biological concepts

This test was prepared and standardized by the investigator with the help of the supervising teacher(2001). The aim of this test is to measure the acquisition of biological concepts of standard IX students.

For the construction of the test, the following general principles are adopted. They are,

A. Planning

B. Preparation

C. Try out

D. Evaluation

The details of each one are given below.

A. Planning of the Test of Biological concepts

The important points to be considered while planning a test are,

i. The subject, standard and unit for which the test is to be constructed.

ii. Weightage to content units.

iii. Weightage to objectives.

iv. The form of questions and their weightages.
v. Weightage to difficulty level of the item.

vi. Length, time limit, maximum marks, method of answering and scoring procedures of the test.

vii. Sample for try out and final administration and other such details.

The details of each point are given below.

i **Subject, standard and unit of the test.**

The test to be prepared in the subject Biology and is meant for the students of standard IX. The units planned to include in the test are, (1) Excretion in man (2) Modern methods of plant breeding (3) Reproduction in organisms (4) Preservation of food (5) First aid (6) Modern agricultural practices (7) Food and health (8) Genetics (9) Growth in organisms (10) Economic importance of plants (11) Economic importance of animals

ii **Weightage to content units**

The second step in planning for a test is to outline the contents to be tested. The different topics in biology for standard IX were studied and selected 11 topics for the test. After consultation with the teachers teaching biology in the secondary school classes, the final weightage of marks to content units are fixed. Weightage to content units are given in Table 1.
### TABLE 1

**WEIGHTAGE TO CONTENT UNITS**

<table>
<thead>
<tr>
<th>Sl. No.</th>
<th>CONTENT UNITS</th>
<th>WEIGHTAGE GIVEN BY TEACHERS</th>
<th>AVERAGE MARKS</th>
<th>PERCENTAGE</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Excretion in man</td>
<td>1 2 1 1 1 1 1</td>
<td>1</td>
<td>2.5</td>
</tr>
<tr>
<td>2</td>
<td>Modern methods of plant breeding</td>
<td>6 6 7 8 7 8</td>
<td>7</td>
<td>17.5</td>
</tr>
<tr>
<td>3</td>
<td>Reproduction in organisms</td>
<td>5 7 7 6 5 7</td>
<td>6</td>
<td>15</td>
</tr>
<tr>
<td>4</td>
<td>Preservation of food</td>
<td>5 5 3 3 5 4</td>
<td>4</td>
<td>10</td>
</tr>
<tr>
<td>5</td>
<td>First aid</td>
<td>2 3 3 4 3 4</td>
<td>3</td>
<td>7.5</td>
</tr>
<tr>
<td>6</td>
<td>Modern agricultural practices</td>
<td>4 4 5 4 4 3</td>
<td>4</td>
<td>10</td>
</tr>
<tr>
<td>7</td>
<td>Food and health</td>
<td>7 7 6 6 6 6</td>
<td>6</td>
<td>15</td>
</tr>
<tr>
<td>8</td>
<td>Genetics</td>
<td>2 2 1 2 3 2</td>
<td>2</td>
<td>5</td>
</tr>
<tr>
<td>9</td>
<td>Growth in organisms</td>
<td>5 5 4 3 5 4</td>
<td>4</td>
<td>10</td>
</tr>
<tr>
<td>10</td>
<td>Economic importance of plants</td>
<td>2 3 2 2 2 1</td>
<td>2</td>
<td>5</td>
</tr>
<tr>
<td>11</td>
<td>Economic importance of animals</td>
<td>2 1 1 1 2 1</td>
<td>1</td>
<td>2.5</td>
</tr>
<tr>
<td></td>
<td><strong>Total</strong></td>
<td></td>
<td><strong>40</strong></td>
<td><strong>100</strong></td>
</tr>
</tbody>
</table>

Based on the weightage to content in Table 1, double the number of questions are to be prepared for the draft test.
iii Weightage to Objectives

Objectives occupy a central position in the teaching-learning process. Therefore determination of objectives has a significant role in any achievement test construction.

After studying a number of standard text books on teaching and evaluation and publications of NCERT, the objectives such as knowledge, understanding and application were selected for the test of biological concepts.

The list of objectives and weightage to be given is shown in Table 2.

**TABLE 2**

**WEIGHTAGE TO OBJECTIVES IN THE TEST OF BIOLOGICAL CONCEPTS**

<table>
<thead>
<tr>
<th>Sl. No.</th>
<th>OBJECTIVES</th>
<th>NUMBER OF QUESTIONS</th>
<th>MARKS</th>
<th>PERCENTAGE</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Knowledge</td>
<td>9</td>
<td>9</td>
<td>22.5</td>
</tr>
<tr>
<td>2</td>
<td>Understanding</td>
<td>18</td>
<td>18</td>
<td>45</td>
</tr>
<tr>
<td>3</td>
<td>Application</td>
<td>13</td>
<td>13</td>
<td>32.5</td>
</tr>
<tr>
<td>Total</td>
<td></td>
<td>40</td>
<td>40</td>
<td>100</td>
</tr>
</tbody>
</table>
iv The form of questions and their weightages

The investigator has planned to include objective type multiple choice items in the Test of Biological concepts.

"The objective item, which is highly structured and requires the student to apply a word or two to select correct answer from a number of alternatives" (Gronlund and Linn, 1990)

The main characteristics of objective type tests are the following.

i. The scoring is quite objective.

ii. They are more valid and reliable.

iii. An adequately representative sample of topics can be covered.

iv. They are free from opportunities of irrelevant answers.

v. They can easily be scored.

vi. They have higher diagnostic value.

vii. There is greater administrative ease and control.

viii. They discourage cramming and rote memorization.

Multiple choice items: A multiple choice item carries two or more responses, of which only one is correct or definitely better. It can measure a variety of learning outcomes from simple to complex.
The maxims for writing multiple-choice items are the following.

1) The stem of the item should be meaningful by itself and should present a definite problem.

2) The item stem should include as much of the items as possible and should be free from irrelevant material.

3) Use a negatively stated item only when significant learning outcome require it.

4) All the alternatives should be grammatically consistent with the stem of the item.

5) An item should contain only one correct or clearly best answer.

6) Item used to measure understanding should contain some novelty but beware of too much.

7) All the distracters should be plausible. The purpose of a distracter is to distract the uninformed from the correct answer.

8) Verbal associations between the stem and the correct answer should be avoided.

9) The relative length of the alternative should not provide a clue to the answer.

10) The correct answer should appear in each of the alternative positions in an approximately equal number of times, but in random order.

11) Use sparingly special alternatives such as 'none of the above' or 'all the above'.

12) Do not use multiple choice items when other item types are more appropriate.

13) Break any of these rules when you have good reason for doing so. (Gronlund and Linn, 1990)

v **Weightage to Difficulty level of the item.**

The easy, average and difficult items to be included in the test. The relative weightage to difficulty level for the final test are given in Table 3.

**TABLE 3**

**WEIGHTAGE TO DIFFICULTY LEVEL OF ITEMS**

<table>
<thead>
<tr>
<th>Sl. No.</th>
<th>TYPES OF QUESTIONS</th>
<th>MARKS</th>
<th>PERCENTAGE</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Easy</td>
<td>10</td>
<td>25</td>
</tr>
<tr>
<td>2</td>
<td>Average</td>
<td>22</td>
<td>55</td>
</tr>
<tr>
<td>3</td>
<td>Difficult</td>
<td>8</td>
<td>20</td>
</tr>
<tr>
<td></td>
<td><strong>Total</strong></td>
<td><strong>40</strong></td>
<td><strong>100</strong></td>
</tr>
</tbody>
</table>

Based on the Table 3, double the number of items are to be included in the draft test.

vi **Length, Time limit, Maximum marks, Method of answering and Scoring procedures of the test**

The investigator has planned to include 40 items in the final test, which may be answered in 40 minutes. Forty minutes time is
Methodology

allowed for the final test, because normally in secondary schools a period consists of 45 minutes and nearly five minutes may be needed for distribution of test items and giving instructions before the test. The subject need to put a cross mark (x) on the appropriate letter in the answer sheet, which he thinks is the correct answer. Scoring of the test can be done by using punched scoring key.

vii Sample for the try out for construction of test of biological concepts.

A sample of 400 pupils studying in standard IX is to be selected for the try out of the draft test consisting of 80 items. From the data collected, difficulty index and discriminating power of each item can be found out. Based on these values 40 items are to be selected for the final test. Before finalising, the test can be administered on another sample of 400 students of standard IX for calculating the validity and reliability of the test.

B. Preparation of the Test of Biological Concepts

The preparation of table of specifications, the actual writing of test items, arranging the written items, printing question papers and answer sheets with necessary directions are all included in this stage.

i Preparation of Table of specifications

A tabular form showing the different content units to be tested and objectives to be measured is called the table of specifications of the test. Table 4 shows the table of specifications for the final test.
<table>
<thead>
<tr>
<th>CONTENT UNITS</th>
<th>KNOWLEDGE</th>
<th>UNDERSTANDING</th>
<th>APPLICATION</th>
<th>TOTAL MARKS</th>
<th>% OF MARKS</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>RECALLS</td>
<td>RECOGNISES</td>
<td>ILLUSTRATES</td>
<td>DISCRIMINATES</td>
<td>DETECTS</td>
</tr>
<tr>
<td>1</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>2</td>
<td>1</td>
<td>2</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>3</td>
<td>1</td>
<td>2</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>4</td>
<td>1</td>
<td>1</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>5</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>6</td>
<td>1</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>7</td>
<td>2</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>8</td>
<td></td>
<td>1</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>9</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>2</td>
</tr>
<tr>
<td>10</td>
<td></td>
<td>1</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>11</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Total</td>
<td>2</td>
<td>7</td>
<td>5</td>
<td>5</td>
<td>1</td>
</tr>
</tbody>
</table>
ii  Writing of Test Items

In order to write items for the test, the topics selected for the study were analysed in detail. Experienced teachers in the field were also consulted. The concepts thus selected are given in Table 5.

**TABLE 5**

**LIST OF CONCEPTS**

<table>
<thead>
<tr>
<th>SL NO.</th>
<th>CONTENT UNITS</th>
<th>CONCEPTS</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Excretion in Men</td>
<td>i. Diseases of kidney</td>
</tr>
<tr>
<td>2</td>
<td>Modern methods of plant breeding</td>
<td>i. Genetic engineering</td>
</tr>
<tr>
<td></td>
<td></td>
<td>ii. Plant breeding</td>
</tr>
<tr>
<td></td>
<td></td>
<td>iii. Mutation</td>
</tr>
<tr>
<td></td>
<td></td>
<td>iv. Hybridization</td>
</tr>
<tr>
<td></td>
<td></td>
<td>v. Tissue culture</td>
</tr>
<tr>
<td></td>
<td></td>
<td>vi. Pollination</td>
</tr>
<tr>
<td></td>
<td></td>
<td>vii. Asexual methods of propagation</td>
</tr>
<tr>
<td>3</td>
<td>Reproduction in organisms</td>
<td>i. The Development of embryo</td>
</tr>
<tr>
<td></td>
<td></td>
<td>ii. Parthenogenesis</td>
</tr>
<tr>
<td></td>
<td></td>
<td>iii. External fertilization</td>
</tr>
<tr>
<td></td>
<td></td>
<td>iv. Emasculation</td>
</tr>
<tr>
<td></td>
<td></td>
<td>v. Regeneration</td>
</tr>
<tr>
<td></td>
<td></td>
<td>vi. The embryo formation</td>
</tr>
<tr>
<td>4</td>
<td>Preservation of Food</td>
<td>i. Ancient methods of preservation of food</td>
</tr>
<tr>
<td></td>
<td></td>
<td>ii. Micro organisms and food</td>
</tr>
<tr>
<td></td>
<td></td>
<td>iii. Pasteurization</td>
</tr>
<tr>
<td></td>
<td></td>
<td>iv. Plasmolysis</td>
</tr>
<tr>
<td>SL NO.</td>
<td>CONTENT UNITS</td>
<td>CONCEPTS</td>
</tr>
<tr>
<td>--------</td>
<td>-----------------------------------</td>
<td>-----------------------------------</td>
</tr>
<tr>
<td>5.</td>
<td>First Aid</td>
<td>i. First aid for bone fracture</td>
</tr>
<tr>
<td></td>
<td></td>
<td>ii. Muscle cramps</td>
</tr>
<tr>
<td></td>
<td></td>
<td>iii. First aid for major burns</td>
</tr>
<tr>
<td>6.</td>
<td>Modern Agricultural practices</td>
<td>i. Biological control</td>
</tr>
<tr>
<td></td>
<td></td>
<td>ii. Soil testing</td>
</tr>
<tr>
<td></td>
<td></td>
<td>iii. Control of Plant diseases</td>
</tr>
<tr>
<td></td>
<td></td>
<td>iv. The hygiene of the explant</td>
</tr>
<tr>
<td>7.</td>
<td>Food and Health</td>
<td>i. The role of pulses in diet</td>
</tr>
<tr>
<td></td>
<td></td>
<td>ii. The need of food for different age groups</td>
</tr>
<tr>
<td></td>
<td></td>
<td>iii. Vitamin deficiency diseases</td>
</tr>
<tr>
<td></td>
<td></td>
<td>iv. Vitamin B complex</td>
</tr>
<tr>
<td></td>
<td></td>
<td>v. Role of proteins</td>
</tr>
<tr>
<td></td>
<td></td>
<td>vi. The role of minerals</td>
</tr>
<tr>
<td>8.</td>
<td>Genetics</td>
<td>i. Chromosome number in organisms</td>
</tr>
<tr>
<td></td>
<td></td>
<td>ii. Heredity</td>
</tr>
<tr>
<td>9.</td>
<td>Growth in organisms</td>
<td>i. Germination of seeds</td>
</tr>
<tr>
<td></td>
<td></td>
<td>ii. Characteristics of plant hormones</td>
</tr>
<tr>
<td></td>
<td></td>
<td>iii. Lateral meristem</td>
</tr>
<tr>
<td></td>
<td></td>
<td>iv. Metamorphosis</td>
</tr>
<tr>
<td>10.</td>
<td>Economic importance of plants</td>
<td>i. Tuberous crops</td>
</tr>
<tr>
<td></td>
<td></td>
<td>ii. Nitrogen fixing bacteria and pulse crops</td>
</tr>
<tr>
<td>11.</td>
<td>Economic importance of animals</td>
<td>i. Silk worms</td>
</tr>
</tbody>
</table>
The General maxims for item writing are given below,

1) Keep the reading difficulty of the test items low in relation to the group who are to take the test, unless the purpose is to measure verbal and reading abilities.

2) Do not lift statements verbally from the text book.

3) If an item is based on opinion or authority, indicate whose opinion or what authority.

4) In planning a set of items for a test, take care that one item does not provide cues to the answer of another item or items.

5) Avoid the use of interlocking or independent items.

6) In a set of items, let the occurrence of correct responses following essentially a random pattern.

7) Avoid trick and catch questions.

8) Try to avoid ambiguity of statement and meaning.

9) Beware of the items dealing with trivial.

iii Preparation of the draft test

Keeping in mind the above points and details of Table 4 and Table 5, the draft test was prepared and is shown to experts in the field of Education and Biology. Based on their suggestions necessary modifications were made and thus prepared the draft test.
iv Arrangement of items in the draft test

Test items were arranged according to the difficulty. Each question bears four alternative answers marked as A, B, C and D.

The draft test consisting of 80 items was printed in the form of a booklet, in which the necessary directions were given. Separate answer sheets were provided for marking the answers. A scoring key was also prepared for the test. The subject answers the items by making a cross mark (X) on any of the alternatives, which he consider as the correct answer. Copies of draft test booklet and its English version are given as Appendices I(a) and I(b). The scoring key of the draft test booklet is given as Appendix I(c).

C. Try out of the test of Biological concepts.

The draft test has been prepared according to the plan and is subjected to try out.

Try out means administering the test to small group representing the whole population. It helps,

1) to identify the weak or defective items.

2) to determine the difficulty of each individual item.

3) to determine the discriminative power of each individual item.
4) to provide data needed to determine how many items should be constituting the final test (Linquest, 1963).

The try out includes the following:

**Sample for Try out**

The draft test prepared was administered on a sample of 400 pupils of standard IX selected from the schools in Ernakulam revenue district. Details regarding sample selected are given in Table 6

<table>
<thead>
<tr>
<th>SI. No.</th>
<th>NAME OF SCHOOL</th>
<th>URBAN / RURAL</th>
<th>GOVT. / PRIVATE</th>
<th>BOYS / GIRLS/MIXED</th>
<th>No. OF BOYS</th>
<th>No. OF GIRLS</th>
<th>TOTAL</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>C.C.P.L.M.Anglo Indian H.S.,Perumanoor</td>
<td>Urban</td>
<td>Private</td>
<td>Mixed</td>
<td>39</td>
<td>30</td>
<td>69</td>
</tr>
<tr>
<td>2</td>
<td>S.H.H.S.S.,Thevara</td>
<td>Urban</td>
<td>Private</td>
<td>Boys</td>
<td>45</td>
<td>-</td>
<td>45</td>
</tr>
<tr>
<td>3</td>
<td>S.R.V.H.S.S.,Ernakulam</td>
<td>Urban</td>
<td>Govt.</td>
<td>Boys</td>
<td>40</td>
<td>-</td>
<td>40</td>
</tr>
<tr>
<td>4</td>
<td>St.Thomas H.S.,Perumanoor</td>
<td>Urban</td>
<td>Private</td>
<td>Girls</td>
<td>-</td>
<td>50</td>
<td>50</td>
</tr>
<tr>
<td>5</td>
<td>St.MARY'S H.S.,Aluva</td>
<td>Urban</td>
<td>Private</td>
<td>Boys</td>
<td>46</td>
<td>-</td>
<td>46</td>
</tr>
<tr>
<td>6</td>
<td>Govt.H.S.,Vennala</td>
<td>Urban</td>
<td>Govt.</td>
<td>Mixed</td>
<td>19</td>
<td>21</td>
<td>40</td>
</tr>
<tr>
<td>7</td>
<td>Govt. Girls' H.S.S.,Aluva</td>
<td>Urban</td>
<td>Govt.</td>
<td>Girls</td>
<td>-</td>
<td>40</td>
<td>40</td>
</tr>
<tr>
<td>8</td>
<td>Govt.Girls H.S.S.,Ernakulam</td>
<td>Urban</td>
<td>Govt.</td>
<td>Girls</td>
<td>-</td>
<td>70</td>
<td>70</td>
</tr>
<tr>
<td></td>
<td><strong>Total</strong></td>
<td></td>
<td></td>
<td></td>
<td>189</td>
<td>211</td>
<td>400</td>
</tr>
</tbody>
</table>
ii Administration and scoring of draft Test

After obtaining permission from heads of schools, the draft test was administered by the investigator and the concerned class teachers of these schools were present during the administration of the test. After motivating the students properly, the test was given with necessary instructions. Enough time was given to answer all the questions. When the pupils completed the test, the test booklet along with response sheets were collected back. The average time used was noted for the final test.

The answers were scored using the punched scoring key already prepared.

iii Item analysis

"Item analysis refers to the application of statistical techniques to assess two characteristics of item, their difficulty and the extent to which they are correlated with other measure" (Wood, 1960). It include the finding out of difficulty index and discriminating power of the items.

Difficulty index: Test item difficulty means the percentage of students who correctly answer to a given test item. The difficulty index serves to arrange items in order of difficulty.

Discriminating power: A test item has adequate discriminating power when it is capable of differentiating between superior and inferior student.

Different methods are used to find out the difficulty index and discriminating power of items.
In the present study the method suggested by Ebel (1972) was used to calculate the difficulty index and discriminating power of each item. Based on the marks obtained, the response sheets of draft test were arranged in descending order of magnitude, that is from highest to lowest. Of the 400 answer sheets, defective sheets were removed and thus the total number was reduced to 370. The first 27 percent and the last 27 percent answer sheets were used for item analysis. The difficulty index and discriminating power are calculated using the formula,

\[
\text{Difficulty index} = \frac{U + L}{2N}
\]

\[
\text{Discriminating power} = \frac{U - L}{N}
\]

where,

\(U\) = the number of pupils who gave correct answers to the item in the high group

\(L\) = the number of pupils who gave correct answers to the item in the low group.

\(N\) = Number of pupils in each group.

Items having difficulty index between 0.25 and 0.70 and discriminating power above 0.30 were selected for final test.

The difficulty index and discriminating power of the items are given in Appendix l(d).
iv Preparation of the Final test of Test of Biological concepts

Out of 80 items included in the draft test, 40 items were selected for the final test, based on the difficulty index and discriminating power of items. The selected items were arranged according to difficulty level of the item. It was decided to give 40 minutes for answering the test. The test was printed in the form of a booklet with necessary instructions. A separate response sheet for marking the answers was also prepared. A copy of the final test, its response sheet and the English version of final test are given as Appendices I(e), I(f) and I(g).

v Administration of the test of Biological concepts to find out its validity and reliability.

To find out validity and reliability of the prepared test consisting of 40 items, it is administered to a sample of 400 pupils selected by stratified random sampling technique from the schools of Ernakulam revenue district. Adequate representation was given to boys and girls and pupil belonging to urban and rural areas. Details of the sample selected for the study are given in Table 7.
TABLE 7

DETAILS OF SAMPLE SELECTED IN THE CONSTRUCTION OF TEST OF BIOLOGICAL CONCEPTS

<table>
<thead>
<tr>
<th>SL. NO</th>
<th>NAME OF SCHOOL</th>
<th>URBAN / RURAL</th>
<th>GOVT. / PRIVATE</th>
<th>BOYS / GIRLS</th>
<th>No. OF BOYS</th>
<th>No. OF GIRLS</th>
<th>TOTAL</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Cardinal H.S.S., Thrikkakara.</td>
<td>Rural</td>
<td>Private</td>
<td>Mixed</td>
<td>42</td>
<td>48</td>
<td>90</td>
</tr>
<tr>
<td>2</td>
<td>Pius Girls H.S., Edappally.</td>
<td>Urban</td>
<td>Private</td>
<td>Girls</td>
<td>–</td>
<td>70</td>
<td>70</td>
</tr>
<tr>
<td>3</td>
<td>Govt. Girls H.S.S., Perumbavoor.</td>
<td>Urban</td>
<td>Govt.</td>
<td>Girls</td>
<td>–</td>
<td>100</td>
<td>100</td>
</tr>
<tr>
<td>4</td>
<td>Star Jesus H.S., Karukutty</td>
<td>Rural</td>
<td>Private</td>
<td>Boys</td>
<td>105</td>
<td>–</td>
<td>105</td>
</tr>
<tr>
<td>5</td>
<td>Govt. H.S., Vennala</td>
<td>Urban</td>
<td>Govt.</td>
<td>Mixed</td>
<td>20</td>
<td>15</td>
<td>35</td>
</tr>
<tr>
<td></td>
<td>Total</td>
<td></td>
<td></td>
<td></td>
<td>167</td>
<td>233</td>
<td>400</td>
</tr>
</tbody>
</table>

After obtaining permission from heads of selected schools, the investigator personally visited the schools and made necessary arrangements for administering the test. The students were made aware of the way of answering the test and were advised to attempt all the questions in the test. Sufficient care was taken to clear their doubts. After the stipulated time of 40 minutes, the test booklets along with the response sheets were collected back. Using the punched scoring key, the answer sheets were scored. The scoring key of the final test is given in Appendix I(h).

D. Evaluation of the test of Biological concepts

Evaluation is the last step in the test construction. After the response sheets have been scored, results must be interpreted and
evaluated from two points of view. First is the quality of the test itself and second is the quality of pupils’ responses.

i Requirements of the test

Any measuring instrument must satisfy some conditions if it is to be a useful one. The most important requirements of the test are

a) Validity
b) Reliability
c) Objectivity
d) Practicability

a) Validity of the Test

"The validity of a test is defined either by - the extent to which the test measures from hypothesized underlying trait, construct or factor.
- the relationship between test scores and some extra test criterion measure" (Brown, 1970).

As far as an achievement test of this nature is concerned content validity and criterion related validity are important.

(1) Content Validity: Content validity refers to the extent to which the content of the test represents the universe of the content they wish to sample (Adams, 1964). This validity is estimated by evaluating the relevance to the test items individually and as a whole.

A careful consideration of the subject matter will yield satisfactory validity with regard to the content.
In this test, procedure adopted for constructing the test provides ample evidence regarding the content validity of the test.

(2) **Criterion Related validity**: “It refers to the relation between the test scores and criterion, this latter being an independent and direct measure of that which the test is designed to predict” (Anastasi, 1954).

The criterion can be school marks, rating by competent raters or marks obtained in a test of same function. In this study the criterion used was the school marks of second terminal examination.

The criterion related validity of this test was calculated by correlating the score of test of biological concepts (administered to 400 students in table 7) with their second terminal examination marks in Biology. The value of correlation coefficient ‘r’ obtained is 0.672. Hence the test can be considered a valid one.

b) **Reliability of the Test**

“This reliability of a measure is commonly defined as the degree to which it measures consistently or accurately, whenever it does measure” (Travers, 1959)

In this study test-retest method and split-half method were used for determining the reliability of the test. The test was administered two times to the same sample (N=40) in an interval of three weeks. The scores of the individuals in the two tests were calculated. The product-moment coefficient of correlation between the two scores of the sample of 40 was calculated.
The value of correlation coefficient ‘r’ (test-retest reliability) obtained is 0.73. The split-half reliability was calculated by correlating the scores of odd numbered questions and even numbered questions for a sample of 100. The product-moment coefficient of correlation was found to be 0.75. These results show that the test is a reliable one.

c) Objectivity of the Test

"The objectivity of a test refers to the degree to which equally competent scores obtain same results" (Gronlund and Linn, 1990). It is an important factor that affects both the validity and the reliability of a test.

Here of objectivity of the test was ensured by including objective type items and providing a scoring key.

d) Practicability of the Test

Duration of the test, provision of scoring key, and type of items included are all added to the practicability of the test of biological concepts.

ii Norms of a Test

Norms of a certain test implies average performance on that test. "Norms represent a descriptive framework of interpreting the score of an individual, a class, group or some large aggregation" (Thorndike and Hagen, 1961). These are various types of norms. The important types are,

(1) Age norms

(2) Grade norms
(3) Percentile norms

(4) Standard scores

In this study percentile norms were calculated and the results are given in Appendix I(i).

iii Test Manual

A test manual was prepared and a copy of it is given in Appendix I(j).

3.4.2 Home Environment Questionnaire

The questionnaire was chosen as the main tool to collect information about home environment of the subjects under study. A questionnaire is a "systematic compilation of questions that are submitted to a sampling of population from which information is desired". (Barr, Davis and Johnson, 1953).

As a data gathering tool, the questionnaire has certain distinct advantages. It permits wide coverage for minimum expense both in money and effort. This greater coverage makes it more valid automatically in the results through promoting selection of a sample that is large and more representative. More considered answers can also be expected from the questionnaire.

The success of the questionnaire depends on the adequacy of construction of questionnaire through which data is to be obtained.
Hence care was taken to construct the questionnaire with as much care as possible bearing in mind, the major points to be kept in view while constructing a questionnaire.

In the present study the home environment questionnaire used is prepared and standardized by the investigator with the help of the supervising teacher (2001). It contains 42 items which may be completed in about 45 minutes.

3.4.2.1 Item Preparation

The items cover different aspects of home environment which facilitate learning such as parent's help and personal attention, importance of student’s achievement to that of his peers, parent’s input in home assignment and discussions, parent’s control over their work habits and general behaviour and student’s freedoms to work at his own pace and his own style. There were 79 items in the draft questionnaire. The draft questionnaire, its English version and the scoring key are given as appendices ll(a), ll(b), and ll(c) respectively.

3.4.2.2 Try out of the Draft Questionnaire and Item Analysis

A try out of the draft questionnaire was made on a sample of 400 secondary school students from the schools mentioned in Table 7. After the try out, ambiguous questions were removed and edited with the help of experts in the field. Finally 42 items were included in the final questionnaire.
3.4.2.3 Administration and Scoring of Final Questionnaire

In the final questionnaire, the subject need to respond to each item by making a tick mark (✓) against either 'Yes' or 'No' in the score sheet. Most of the Yes' response bears one mark and most of the 'No' response bears zero mark. About one hour is allowed for answering the questionnaire. The tool thus prepared was tested for validity and reliability as detailed below.

3.4.2.4 Reliability of the Questionnaire

Reliability of the home environment questionnaire was obtained by the judgment of some experts in the field. Experts changed the words and made necessary corrections in the items. Thus the items were modified.

Split-half method of reliability was calculated for a sample of 100. The value was found to be 0.67. Test-retest method of reliability was also calculated for a sample of 40 students at an interval of 3 weeks. The value obtained is 0.64.

3.4.2.5 Validity of the Questionnaire

Criterion (external) related validity of the test was estimated using average of total class marks obtained for first and second terminal examinations in standard IX and scores for intelligence test are treated as two external criteria. The average of total marks in first and second terminal examinations of 40 students of Standard IX were used as the first criterion. The scores obtained in the home environment questionnaire
were correlated with average of total marks. The coefficient of correlation thus obtained is 0.659. The validity coefficient using the Intelligence test (verbal) as external criteria was 0.442 for the same sample. Construct validity was ensured by giving simple and unambiguous terms in the questionnaire. The content validity of the questionnaire is maintained by careful reference to the current literature.

Thus the psychometric properties of the tool show that it is a valid and reliable tool for measuring the home environment of secondary school pupils of Kerala. The final questionnaire, its response sheet and the English version of the final questionnaire are given as Appendices II(d), II(e) and II(f) respectively. The scoring key of the final questionnaire, the percentile norms of the questionnaire and a copy of the scoring manual are given as Appendices II(g), II(h), and II(i) respectively.

3.4.3 Study Habits Inventory

The study habits inventory is a tool prepared and standardized by the investigator with the help of the supervising teacher (2001). It is aimed to measure a generalized concept of a wide variety of study habits. The inventory contains 50 statements. About 45 minutes can be allowed for responding to this inventory.

3.4.3.1 Item Preparation

The inventory consists of different approaches to study such as surface approach, comprehension learning, evidence and logic, organized
study, relating ideas, achievement motivation, strategic approach, fear of failure and negative attitude to studying as enunciated by Clarke (1986). The inventory was developed from 98 items (draft) containing positive and negative statements. The draft inventory and its English version are given as Appendices III(a) and III(b).

3.4.3.2 Administration and Scoring of the Draft Inventory

The subjects are required to rate each statement on a 3 point descriptive scale (always, sometimes and never). The scoring pattern is as indicated below. [The scoring key of draft inventory is given as Appendix III(c)].

<table>
<thead>
<tr>
<th>Scoring for +ve items</th>
<th>Scoring for -ve items</th>
</tr>
</thead>
<tbody>
<tr>
<td>always - 3</td>
<td>always - 1</td>
</tr>
<tr>
<td>sometimes - 2</td>
<td>sometimes - 2</td>
</tr>
<tr>
<td>never - 1</td>
<td>never - 3</td>
</tr>
</tbody>
</table>

3.4.3.3 Item Analysis

Final items were selected on the basis of discriminating power of each item [given as Appendix III (d)], decided by a preliminary administration on the sample of 400 students (given in Table 7).
The final study habits inventory thus prepared contains 50 items [given as Appendix III (e)] with equal number of negative and positive items. Its response sheet is given as Appendix III(f). An English version of the final inventory is given as Appendix III(g). About one hour is allowed for answering the inventory. The inventory was assessed for reliability and validity.

3.4.3.4 Reliability of the Inventory

Split-half reliability was found for a sample of 100. The value was found to be 0.72. Test-retest method of reliability was calculated for a sample of 40 students in an interval of three weeks and the value obtained is 0.673.

3.4.3.5 Validity of the Inventory

Criterion (external) related validity of the test was estimated using the average of total class marks obtained in the first and second terminal examination in Standard IX and Intelligence test scores are treated as two external criteria. The average of total marks in the first and second terminal examinations of 40 students of Standard IX were used as the first criterion. The scores obtained in the study habit inventory were correlated with average of total marks. The co-efficient of correlation thus obtained is 0.63. The validity coefficient using intelligence test score as external criterion was 0.41 for the same sample. Construct validity of the inventory was ensured by giving simple and unambiguous statements in the inventory. Thus the inventory as a whole is a reasonably valid and reliable
instrument for measuring the study habit of secondary school pupils of Kerala. A copy of scoring key of the final inventory, percentile norms and scoring manual of the inventory are given as Appendices III (h), III(i) and III(j) respectively.

3.4.4 Scale of Attitude towards Science

Attitude towards science was measured using 'Scale of attitude towards Science', constructed and standardized by Sananda Raj and the investigator (2001). This scale was developed following the Likert's method. The items in this scale are statements indicating various degrees of favourableness towards science. These statements cover different aspects of attitude towards science like utility of science, intellectual value of science, individualism of science, social value, a belief in progress and modernization etc. The draft scale consisted of 46 items. The Malayalam and English versions of the draft scale are given as Appendices IV(a) and IV(b) respectively. The final scale contained 30 statements with adequate representation for different areas indicated above. Out of 30 statements 15 are positive and 15 are negative. There is no time limit for responding. However students take an average of about 20 minutes for responding to this scale. The details of the development of the scale are given below.

3.4.4.1 Item Preparation

The items for the draft scale were prepared only after review of relevant literature, and also with the advice of experts in the field. A total of 46 items were included in the draft scale. Each item was prepared in
Malayalam and its English version was also prepared. Positive and negative items were equal in number in the draft scale.

3.4.4.2 Procedure for Administration and Scoring of the Draft Scale

The draft scale of Attitude towards Science was a self-administering one. Instructions to the subjects were given in the draft scale. The scale was administered to 150 students studying in standard IX in the schools mentioned in Table 7.

The test forms were given to the subjects and they were asked to make a tick mark (✓) on each item which they think is applicable to them, in the appropriate space provided. After collecting back the test booklets, the scoring was made. For the positive item in the scale a weightage of 5, 4, 3, 2, and 1 were given for the responses A, B, C, D, and E respectively and for a negative item, the weightage was reversed as 1, 2, 3, 4, and 5 respectively. The scoring key of the draft scale is given as Appendix IV(c). The details of scoring are presented under the sub-section 3.4.4.5.

3.4.4.3 Item Analysis

The procedure suggested by Anastasi (1961) was followed for item analysis. The total sample of 150 students was divided into three groups i.e., High group (H), Average group (A) and Low group (L). In each group, the number of students getting a score of 4 or 5 were counted. Half the number of students getting a score of 3 was added to the above number. The number thus obtained was put under High group, Average group and Low group correspondingly against each item. For obtaining difficulty index
of each item H, A, and L were added. For obtaining discriminating power L is subtracted from H. The details are as follows.

The item which have average difficulty index \((H + A + L)\) ranging from 50 to 100 and item with high discriminating power \((H - L)\) ranging from 30 to 50 were selected for the final scale. The difficulty index and discriminating power of items in the draft scale are given as Appendix IV(d). After item analysis there were 30 items in the final scale. Items having same difficulty level and discriminating power were seen while item analysis. In such cases only one of these is selected for the final scale, in such a way that the content area covered was not represented by another item.

3.4.4.4 Instructions for Administration of the Final Scale

The subject is required to enter a tick mark \((\checkmark)\) on one of the five points to express his / her degree of acceptance or rejection of the idea contained in the statement. The subject should try to respond to all the items.

3.4.4.5 Scoring of the scale

For positive items, agreement is considered to indicate favourableness to science and vice-versa for negative statements. The following weightage is given to each response category.

<table>
<thead>
<tr>
<th>Positive Item</th>
<th>Negative Item</th>
</tr>
</thead>
<tbody>
<tr>
<td>Strongly agree – 5</td>
<td>Strongly agree – 1</td>
</tr>
<tr>
<td>Agree – 4</td>
<td>Agree – 2</td>
</tr>
<tr>
<td>No definite answer – 3</td>
<td>No definite answer – 3</td>
</tr>
</tbody>
</table>
Disagree -2  Disagree -4

Strongly disagree –1  Strongly disagree – 5

Two representative items are given below.

1. More time should be set apart for teaching science than other subjects.  A B C D E  (Item No.5 in the scale)

   This item is showing the intellectual value of science and it is a positive item also.

2. With the advent of computers job opportunities have decreased.  A B C D E  (Item No.10 in the scale)

   This item can scale a subject’s belief in progress and modernization through science and it is a negative item.

Note:  A - Strongly agree

          B - Agree

          C - No definite answer

          D - Disagree

          E - Strongly disagree

3.4.4.6 Reliability of the Scale

   The reliability of the scale was estimated by test-retest method and split-half method. In the test-retest method the scale was administered to the same sample of 100, two times, in an interval of one month. The
Pearson's product-moment coefficient of correlation was calculated between the scores obtained in the two instances. The test-retest reliability coefficient thus obtained is 0.690.

In the split-half reliability method, the test was split into two equal halves on the basis of odd numbered item and even numbered item. Thus there were 15 odd numbered items and 15 even numbered items. The correlation coefficient between the scores of two halves for a sample of 100 was found using Pearson's product-moment formula. The half test reliability estimated was 0.618. The split-half reliability of the whole test was found using Spearman-Brown prophecy formula. Thus the reliability coefficient of 0.764 was obtained. This value of reliability is significant at 0.01 level.

3.4.4.7 Validity of the Scale

The validity of the scale was established on an external criterion viz., the marks for science in school examination. The validity of the test was found to be 0.535 for a sample of 100.

The systematic examination of test content showed that the test covers a representative sample of behaviour, which was intended to be measured. The content validity was established through the review of relevant literature as well as by consultation with experts. A copy of the final scale of attitude towards Science in Malayalam, its English version, its scoring key, percentile norms and scoring manual are given as Appendices IV(e), IV(f), IV(g), IV(h), and IV(i) respectively.
3.4.5 Test of Intelligence

This test was developed and standardized by Sananda Raj (2001). It measures the level of intelligence of secondary school pupils. The test consists of 40 items. Each item carries one mark. The subject needs to complete the test within 20 minutes. This is a simple model in which five alternative responses are given for each item marked as A, B, C, D and E. For the right answer the subject gets one mark and zero mark is given for the wrong answer. Different items in the test are given in the fill in the blanks form. A copy of the intelligence test, its English version and scoring key are given as Appendices V(a), V(b) and V(c).

Usually the intelligence tests belong to power test. This means that items are presented in the increased order of difficulty. No subject will be able to complete all the tasks. The present test is a comprehension of speed test and power test, where in all the items are of almost equal difficulty level. No one will be able to complete the test not merely because of the difficulty of the items, but also because of limit of time given for completing the test.

There are different tasks contained in the various items of the test. These tasks include analogy, numerical reasoning etc.

The task in the analogy type item is, when three sets of letters are given to infer, the fourth set of letters which is missing. The first two sets of letters in the series are related to each other in a particular way. The implied relation has to be found out and applied to the third set of letters in
order to find out the missing fourth set of letters. Examples of items of this type are given below.

Question No.1  ac : bd = pr : ............. [A. bd  B. pq  C. qr  D. qs  E. ac ]

Question No.36  Z : ZZ = X : ............. [A. Xx  B. Zz  C. XX  D. XY  E. XZ]

A numerical reasoning type item consists of a series of numbers, one of which is missing. The number series are formed according to some rule. The task is to examine the given numbers and find out the order, which they follow, and use this rule to guess the missing number. The correct answer has to be identified from the given five alternatives. The examples of items of this type are given below.

Question No.12  88, 44, ........, 11   [A. 11  B. 66  C. 55  D. 33  E. 22]

Question No.28  2, 18, 50, 98, 162, ...... [A. 260  B. 242  C. 324  D. 200  E. 144]

3.4.5.1 Reliability of the Test

The reliability coefficient of the test was found out by test-retest method and it is 0.84 for one month interval, for a sample of 75. The split-half reliability was also obtained for the half test (odd-even halves) was 0.78. After correction for attenuation using Spearman-Brown prophecy formula the reliability coefficient of the whole test was estimated and it was found to be 0.88 (N = 60). All these coefficients were found to be significant at 0.01 level.
3.4.5.2 Validity of the Test

The validity of the intelligence test was estimated against Kerala University Group Test of Intelligence as external criterion. Both the tests were administered on a sample of 80 secondary school students, and correlation between these two test scores were calculated using Pearson’s product-moment coefficient of correlation. The validity coefficient thus obtained was 0.81, which is significant at 0.01 level.

The above indices of reliability and validity indicate that the test will yield reliable and valid scores for the purpose of present investigation.

3.5 SAMPLE SELECTED FOR THE STUDY

According to Best and Kahn (1999) “a sample is a small proportion of a population selected for observation and analysis. By observing the characteristics of the sample, one can make certain inferences about the characteristics of the population from which it is drawn”. “The validity of the results obtained with any psychological test will depend in part upon the adequacy and representativeness of standardization sample” (Freeman, 1960).

3.5.1 Size of the Sample

In fixing the sample size, the investigator took into consideration the following factors;
i. The major consideration in deciding the size of the sample was the type of statistical procedures to be used in the study.

ii. The sample size should be small enough to permit a close study. Since there are a series of tests to be administered to pupils together with other forms of objective information about them, it was estimated that nearly 4 hours of testing time will be required for completing the administration of the tests. Hence the size will have to be small enough to be effectively covered.

The above considerations suggest a sample size of around 900 students from standard IX.

3.5.2 Technique of Sampling

Of the various techniques, stratified random sampling is found to be the best suited for the present study. Stratified random sampling is "a technique designed to ensure representativeness and avoid bias. This scheme is applicable when the population is composed of subgroups or strata of different sizes, so that the representative sample must contain individuals drawn from each category or stratum in accordance with the size of the sub groups" (Garrett, 1973).

The stratified random sampling technique is widely accepted as the best procedure when heterogeneous samples have to be brought under study, as in the present case.
3.5.3 Factors to be represented in the Sample

The next major decision to be taken regarding sampling was the factors to be represented in the sample selection. As such the investigator decided to give representation to the following factors in the sample selection

1) Sex of the subjects

2) Rural-urban location of the school.

3) Type of management of the school.

1) Sex of the Subjects

The performance of the students may be influenced by their sex. Boys are strong in certain areas and weaker in some other areas. The same is the condition in girls. The influence of psycho-social correlates may be also different in boys and girls. Hence sample was taken equally from boys and girls.

2) Rural-Urban location of the School

School performance of the pupils may be connected with location of the school. Generally there may be differences in the performance of students in urban and rural schools. Hence the sample was selected equally from urban and rural schools.
3) Type of Management of the School

The type of management of the school (run by government or run by private agencies) is known to influence educational performance. There may be differences in the performance of students studying in government schools and private schools. Both are having their own merits and limitations. But always a comparison exists between the performances of students of these schools. Hence the sample was taken from both government and private schools.

The study was confined to Ernakulam revenue district of Kerala, and 20 schools were selected for the study. Due representation was given to different geographical areas of Ernakulam district in the selection of schools. These schools contain all categories of students and may be fairly representative of students of Kerala.

3.5.4 The Initial Sample for the Analysis

On the basis of characteristics of population, an initial break up of a tentative sample was worked out and it was decided to cover a basal sample of 900. The break up was estimated as given below.
TABLE 8
BREAK UP OF THE BASAL SAMPLE IN TERMS OF SEX, LOCATION OF SCHOOL, AND TYPE OF MANAGEMENT

<table>
<thead>
<tr>
<th>BOYS</th>
<th>GIRLS</th>
<th>URBAN</th>
<th>RURAL</th>
<th>GOVT.</th>
<th>PRIVATE</th>
</tr>
</thead>
<tbody>
<tr>
<td>450</td>
<td>450</td>
<td>450</td>
<td>450</td>
<td>425</td>
<td>475</td>
</tr>
<tr>
<td>900</td>
<td>900</td>
<td>900</td>
<td>900</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

The number of class division to be tested for each category was worked out assuming that the minimum strength of a class will not be less than 30. The divisions were so chosen as to give adequate representation to the two sexes.

3.5.5 The Final Sample Available for Analysis

Though the basal sample was fixed as 900, the investigator could collect data from a sample of 844 students.

In all the schools, the test was conducted on two different days. So when a pupil was absent for any one test, the remaining data was not usable. Rejecting all such cases a final sample of 800 was available for analysis. The details of the actual sample covered and final sample are given in Table 9 and 10.
**TABLE 9**

**BREAK UP OF THE ACTUAL SAMPLE COVERED**

<table>
<thead>
<tr>
<th>BOYS</th>
<th>GIRLS</th>
<th>URBAN</th>
<th>RURAL</th>
<th>GOVT.</th>
<th>PRIVATE</th>
</tr>
</thead>
<tbody>
<tr>
<td>421</td>
<td>423</td>
<td>416</td>
<td>428</td>
<td>385</td>
<td>459</td>
</tr>
<tr>
<td>844</td>
<td>844</td>
<td>844</td>
<td>844</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

**TABLE 10**

**BREAK UP OF THE FINAL SAMPLE USED FOR ANALYSIS**

<table>
<thead>
<tr>
<th>LOCATION OF SCHOOL</th>
<th>BOYS</th>
<th>GIRLS</th>
</tr>
</thead>
<tbody>
<tr>
<td>Urban</td>
<td>Govt. 86</td>
<td>Private 114</td>
</tr>
<tr>
<td>Rural</td>
<td>Govt. 88</td>
<td>Private 112</td>
</tr>
<tr>
<td>Sub total</td>
<td>174</td>
<td>226</td>
</tr>
</tbody>
</table>

The list of schools from where the final sample was selected is given as Appendix VI(a).
3.6 PROCEDURE FOR DATA COLLECTION

After finalising the sample and tools to be used the programme of testing was arranged. The investigator contacted the heads of the selected schools and the class teachers and had discussions with them in order to fix a schedule for administering the tests.

The investigator studied the basic literature relating to selected psychological tests contained in the test manuals and other references and acquainted himself with the testing procedure, possible eventualities etc., before commencing the actual testing.

The investigator administered the tests with the help of class teachers in 2 or 3 sittings of about 2 hours session each day. The tests were administered for one to three divisions of Standard IX students in each school selected. The investigator gave a short explanation of aim and scope of the study to the subjects and appealed to their conscious participation and co-operation. The detailed instruction for answering each test was given before giving each test. An interval of 5 to 10 minutes was given in between two tests.

Same procedures were observed in administering the tests in different schools. The following steps were strictly followed in administering each test.

a. Distribution of test booklets and score sheets to the subjects.

b. Explaining the instructions given in the test booklet.
c. Giving instructions for filling up the necessary information in the answer sheet before starting the test.

d. Making the students familiar with the score sheets and mode of entering responses.

e. Clearing the doubts of subjects, giving instructions regarding time limit, method of dealing with eventualities etc..

f. Strict adherence to the time limit in the case intelligence test and test of Biological concepts.

g. Giving intervals between tests.

h. Collecting back the test booklets and response sheets.

3.7 SCORING AND CONSOLIDATION OF DATA

The score sheets were scored in accordance with the scoring scheme of each test. Punched scoring keys were used to facilitate scoring.

The relevant data about each subject – the test scores in the case of dependent variable and independent variables, the demographic details like, name, sex, location of the school, management of school were entered in the tabulation sheets. A number of subjects failed to attend all the tests and some students did not attempt all the items in certain tests. Only those subjects who completed the tests in all respects were selected for the analysis. Thus the final sample was reduced to 800.
3.8 STATISTICAL TECHNIQUES USED FOR THE ANALYSIS OF DATA

The data have been analysed with the help of the following statistical techniques.

I In the aspect of variables studied descriptive statistics like, mean, median mode, standard deviation, skewness and kurtosis were calculated for the total sample and subsamples based on sex, location of the school, and management of the school.

II Pearson's Product - Moment Coefficient of Correlation ‘r’ (Best and Kahn, 1995)

For estimating the extent of relationship between dependent and independent variable, the technique of Pearson’s product - moment coefficient of correlation method was used.

The Pearson’s Product moment coefficient of correlation formula for calculating ‘r’ is

\[
r = \frac{N \sum XY - (\sum X)(\sum Y)}{\sqrt{N \sum X^2 - (\sum X)^2} \sqrt{N \sum Y^2 - (\sum Y)^2}}
\]

where, \( r \) = Pearson’s product moment co-efficient of correlation

\[\sum X \] = Sum of the X scores

\[\sum Y \] = Sum of the Y scores

\[\sum X^2 \] = Sum of the squared X scores
\[ \sum Y = \text{Sum of the squared } Y \text{ scores} \]

\[ \sum XY = \text{Sum of the products of paired } X \text{ and } Y \text{ scores} \]

\[ N = \text{Number of paired scores}. \]

The obtained correlation coefficients were interpreted by means of the following approaches.

a) **Verbal interpretation of Pearson's product - moment Coefficient of correlation 'r' (Garret, 1981)**

The verbal interpretation of the significance of the correlation coefficient 'r' is given below.

- 'r' from 0.00 to ±0.20 denotes indifferent or negligible relationship;
- 'r' from ±0.20 to ±0.40 denotes low correlation; present but slightly
- 'r' from ±0.40 to 0.70 denotes substantial or marked relationship.
- 'r' from ±0.70 to ±1.00 denotes high to very high relationship.

b) **Test of Significance of the Correlation Coefficient 'r' (Best and Kahn, 1995)**

The correlation coefficient 'r' is tested to find out whether it is significant or not using the formula,

\[ t = \frac{r \sqrt{N-2}}{\sqrt{1-r^2}} \]
Where, \( r \) = the coefficient of correlation obtained

\[ N = \text{size of the sample} \]

With \( N-2 \) degrees of freedom, a coefficient of correlation is judged as statistically significant when 't' value equals or exceeds the 't' critical value in the t distribution table.

c) **The 0.99 Confidence interval of 'r' (CI 0.99) (Ferguson, 1976)**

For each of the coefficient of correlation 'r' obtained, the 0.99 confidence interval is calculated. The calculation of limits of the 0.99 confidence interval is using the formula,

\[
 r \pm 2.58 \ SE_r
\]

where, \( SE_r \) is the Standard Error of 'r' calculated using the formula,

\[
 SE_r = \frac{1 - r^2}{\sqrt{N-1}}
\]

d) **Shared Variance or Percentage of overlap (Fox, 1969)**

An idea of shared variance or percentage of overlap is given by the square of coefficient of correlation 'r' expressed as percentage (that is, \( r^2 \times 100 \)). This means the contribution of independent variable expressed in percentage, to the variance in the dependent variable.

e) **Test of Significance of difference between two 'r's (Garrett, 1981)**

The test of significance of difference between correlations is done by two-tailed test for the significance of difference between 'r's of large
independent samples, using the formula

\[
CR = \frac{Z_1 - Z_2}{\sqrt{\frac{1}{N_1} + \frac{1}{N_2} - 3}}
\]

Where,

- \( Z_1 \) and \( Z_2 \) = 'r' of two samples converted to Fisher's Z coefficient
- \( N_1 \) and \( N_2 \) = size of the two samples.

III Two-tailed test of Significance of the difference between means for large independent groups

The significance of difference in means scores for the dependent variable and independent variables for the sub samples based on sex, location of school and type of management of school was determined by testing the significance of difference between means of these paired groups, that is, Boys-Girls, Rural-Urban students, Government school – Private school students.

The significance of difference in means scores for the dependent variable was further analysed with more sub-groups. The whole sample was categorized into three groups namely, High, Medium and Low based on the score of each of the four independent variables studied. Significance of difference in mean scores of dependent variable for the sub samples based sex, location of school, management of school in each of the three categories (high, medium and low) of the sample for the four independent variables was estimated separately.
The procedure to work out the t-values (critical ratios) for estimating significance of difference between means is given by the formula

\[ t = \frac{M_1 - M_2}{SE_{(M_1-M_2)}} \]  

(Garrett, 1981)

Where,

- \( M_1 \) = Mean test score of the first group
- \( M_2 \) = Mean test score of the second group

and \( SE_{(M_1-M_2)} \) = The standard error of the difference between means \( M_1 \) and \( M_2 \).

\( SE_{(M_1-M_2)} \) was estimated by using the formula,

\[ SE_{(M_1-M_2)} = \sqrt{SE_{M_1}^2 + SE_{M_2}^2} \]

Where, \( SE_{M_1}^2 \) and \( SE_{M_2}^2 \) are the standard error of the mean scores \( M_1 \) and \( M_2 \) respectively.

If \( N_1 \) and \( N_2 \) are the size of the samples under comparison and \( \sigma_1 \) and \( \sigma_2 \) are their respective standard deviations

then,

\[ SE_{M_1} = \frac{\sigma_1}{\sqrt{N_1}} \]
\[ SE_{M_2} = \frac{\sigma_2}{\sqrt{N_2}} \]
The t-value (critical ratio) obtained is treated as belonging to a normal distribution. If the obtained 't' value falls between +1.96 and -1.96 the difference between means is considered as not being significant at 0.05 level. If the 't' value exceeds ±1.96, then the difference in means was considered as significant at 0.05 level. If the estimated 't' value falls inside the interval ±2.58, then the difference between means was not treated as being significant at 0.01 level and if it falls outside the range ±2.58, it was considered significant at 0.01 level.

IV Multiple Regression Equation (Garrett, 1981)

Multiple regression equations were derived to predict the biological concepts score of the student by using the four high influencing independent variables. The influence of each psycho-social correlate on the acquisition of biological concepts also can be found out.

The regression equation which expresses the relationship between \(X_1\) (the criterion variable - the variable to be predicted) and the four independent variables \(X_2, X_3, X_4, \text{ and } X_5\) given in the score form is

\[
(X_1 - M_1) = b_{12.345} (X_2 - M_2) + b_{13.245} (X_3 - M_3) + b_{14.235} (X_4 - M_4) \\
+ b_{15.234} (X_5 - M_5)
\]

Or transposing and collecting terms the above equation is,

\[
X_1 = b_{12.345} X_2 + b_{13.245} X_3 + b_{14.235} X_4 + b_{15.234} X_5 + k \text{ (a constant)}
\]
Where, \( b_{12.345} \), \( b_{13.245} \), \( b_{14.235} \) and \( b_{15.234} \) are the regression coefficients; \( M_1 \), \( M_2 \), \( M_3 \), \( M_4 \) and \( M_5 \) are the mean scores of the variables \( X_1 \), \( X_2 \), \( X_3 \), \( X_4 \), and \( X_5 \) respectively.

The regression coefficients are given by the formula

\[
b_{12.345} = r_{12.345} \frac{\sigma_{1.2345}}{\sigma_{2.1345}}
\]

\[
b_{13.245} = r_{13.245} \frac{\sigma_{1.2345}}{\sigma_{3.245}}
\]

\[
b_{14.235} = r_{14.235} \frac{\sigma_{1.2345}}{\sigma_{4.1235}}
\]

\[
b_{15.234} = r_{15.234} \frac{\sigma_{1.2345}}{\sigma_{5.1234}}
\]

In these,

\[
r_{12.345} = \frac{r_{12.34} - r_{15.34} \times r_{25.34}}{\sqrt{1 - r_{15.34}^2} \times \sqrt{1 - r_{25.34}^2}}
\]

\[
r_{13.245} = \frac{r_{13.24} - r_{15.24} \times r_{52.45}}{\sqrt{1 - r_{15.24}^2} \times \sqrt{1 - r_{52.45}^2}}
\]

\[
r_{14.235} = \frac{r_{14.23} - r_{15.23} \times r_{52.34}}{\sqrt{1 - r_{15.23}^2} \times \sqrt{1 - r_{52.34}^2}}
\]

\[
r_{15.234} = \frac{r_{15.23} - r_{14.23} \times r_{52.34}}{\sqrt{1 - r_{14.23}^2} \times \sqrt{1 - r_{52.34}^2}}
\]

\[
\sigma_{1.2345} = \sigma_1 \sqrt{1 - r_{12}^2} \times \sqrt{1 - r_{13}^2} \times \sqrt{1 - r_{14}^2} \times \sqrt{1 - r_{15.234}^2}
\]

\[
\sigma_{2.1345} = \sigma_2 \sqrt{1 - r_{21}^2} \times \sqrt{1 - r_{23.1}^2} \times \sqrt{1 - r_{24.13}^2} \times \sqrt{1 - r_{25.134}^2}
\]
Beta (\(\beta\)) coefficients or "beta weights" may be calculated from b's

Thus, 
\[
\beta_{12.345} = \frac{b_{12.345}}{\sigma_i} \times \frac{\sigma_1}{\sigma_i}
\]
\[
\beta_{13.245} = \frac{b_{13.245}}{\sigma_i} \times \frac{\sigma_1}{\sigma_i}
\]
\[
\beta_{14.235} = \frac{b_{14.235}}{\sigma_i} \times \frac{\sigma_4}{\sigma_i}
\]
\[
\beta_{15.234} = \frac{b_{15.234}}{\sigma_i} \times \frac{\sigma_5}{\sigma_i}
\]

The "beta weights" give the relative weight by which each independent variable contributes to the dependent variables, independently of the other factors.

\(R^2\) of the multiple regression equation may be expressed in terms of beta coefficients and the zero order r's.

Thus, 
\[
R^2_{(2345)} = \beta_{12.345} \times r_{12} + \beta_{13.245} \times r_{13} + \beta_{14.235} \times r_{14} + \beta_{15.234} \times r_{15}
\]

\(R^2\) of the multiple regression equation gives the proportion of variance of dependent variable attributable to the joint action of independent variables. From the \(R^2\) values obtained percentage of variance of dependent variable attributable to the joint action of
independent variables also can be calculated. Similarly $\beta_{13,245} \times r_{13}$, $\beta_{14,235} \times r_{14}$ and $\beta_{15,234} \times r_{15}$ each give percentage of variance of dependent variable attributable to the action of that particular independent variables.

V The Coefficient of Multiple Correlation 'R'

The multiple correlation coefficient 'R' of the variable $X_1$ and variables $X_2, X_3, X_4$ and $X_5$ is given by

$$ R_{1(2345)} = \sqrt{1 - \frac{\sigma_{12345}^2}{\sigma_1^2}} $$

in which, $\sigma_{12345}$ is the standard deviation of the variable $X_1$ when the effect of the variables $X_2, X_3, X_4$ and $X_5$ are held constant.

The coefficient of multiple correlation indicates the strength of the relationship between one variable and two or more others combined with optimal weights.

The Significance of Multiple 'R' is interpreted in the same way as the simple correlation coefficient 'r'.

VI Analysis of Variance (Best and Kahn, 1999)

The analysis of variance (ANOVA) is an effective way to determine whether means of more than two samples are too different to attribute to sampling error.

The one-way analysis of variance consists of these operations;
1) The variance of the scores for the groups are combined into one composite group, known as total groups variance ($V_t$).

2) The mean value of the variances of each of the groups, computed separately, known as within groups variance ($V_w$).

3) The difference between total groups variance and within groups variance is known as the between-groups variance ($V_t-V_w=V_b$).

4) The F ratio is computed.

$$F = \frac{V_b}{V_w} = \frac{\text{between - groups variance}}{\text{within - groups variance}}$$

**VII Partial Correlation (Best & Kahn, 1999)**

Partial correlation is used to remove the effect of one variable on the correlation between two other variables. It is calculated using the formula,

$$r_{12,3} = \frac{r_{12} - (r_{13})(r_{23})}{\sqrt{(1-r_{13}^2)(1-r_{23}^2)}}$$

**VIII Multiple Classification Analysis**

The results of regression equation is adapted to Multiple Classification Analysis table. The table contains adjusted and unadjusted means of biological concepts corresponding to different categories of independent variables with corresponding $R^2$. The unadjusted mean is calculated from simple regression equation using the specified independent variable. The adjusted mean of Biological concepts is calculated by using the multiple regression equation by
fixing the independent variables at their mean except the variable taken into consideration. The adjusted $R^2$ is taken as the square of partial correlation between Acquisition of Biological concepts and the variable under consideration by partialling out the other independent variables.

### 3.9 SUB CATEGORIES OF THE INDEPENDENT VARIABLES

In the present study the whole sample is categorised into three for every independent variable studied. This division is based on the scores of the sample for the independent variables. Thus the division is as high, medium and low scores of 800 subjects for the 4 independent variables were used to calculate the mean and standard deviation.

Taking $M$ as the mean score and $\sigma$ as the standard deviation 800 subjects were categorized into three for every independent variable. Those who scored above $(M + \sigma)$ for an independent variable belong to the high group. A subject who scored below $(M - \sigma)$ was categorized as belonging to low group. Those subjects whose scores fall between $(M + \sigma)$ and $(M - \sigma)$ belong to the medium group. Thus three sub categories are there for each independent variable as given below;

- Intelligence - High - Low - Medium
- Attitude towards Science - High - Low - Medium
By making use the statistical techniques mentioned above analysis of data was done, the details of which are presented in the next chapter (Chapter IV).