CHAPTER - II
REVIEW OF LITERATURE

A brief account of some pertinent studies is being provided to understand the phenomenon of learning of scientific concepts and errors committed and misconceptions held by students. The achievement of students in science has been specifically studied in terms of school factors such as gender difference in achievement of science concepts, study habits, intelligence, stress and anxiety, scientific attitude, creativity, family environment, learning and thinking styles, etc.

2.1 ACHIEVEMENT IN RELATION TO SOME PERSONAL VARIABLES

The trend of the research endeavours looking into correlates of achievement shows that learning achievement of students has been studied mainly looking at personal characteristics of learners, both intellectual and personality related and also focusing on family background i.e. socio-economic status and home environment along with school related factors. The achievement among students at different stages of school education has been studied by researchers to identify its correlates.

2.1.1 Socio Demographic Variables

The results of a large number of studies like International Association for Evaluation of Educational Achievement (IEA) Study (Comber and Keeves, 1973), and National Assessment of Educational Progress (NAEP, 1979) support the fact that females underachieve in science in relation to males.

Based on the studies on the National Annual Examination in forms 1 and 2 held in government secondary schools, Falzon and Sammut (1976) found that the performance of girls in integrated science was much higher than that of boys.

Afif (1977) studied the effect of accommodating learning styles on students' achievement and found that male students had higher achievement gain scores than females.
Barua (1981) showed that boys and girls were not different with respect to intelligence and achievement.

Pandey (1981) studied the effect of socio-economic opportunity on educational achievement. The findings showed that an urban atmosphere was more conducive to better achievement than a rural environment.

Sharma (1981) investigated the factors related to academic underachievement of girls of secondary-schools located in rural areas of Haryana. He found that poor academic motivation, linguistic ability, planning of study work, adjustment and emotional insecurity contributed to underachievement of girls. The underachievers were significantly poor in their performance on all these variables.

Sarkar (1983) found that the home variables such as educational environment, income, spatial environment, social background, provision of facilities and parent – child relationship showed a significant difference between the high achievers and low achievers.

Puri (1984) studied the influence of environment as a factor to promote academic achievement among students. The results showed that the effect of environmental facility on both general academic achievement and achievement in English language was significant.

Shukla (1984) found that Socio-economic status was positively and significantly related to academic achievement. There was a tendency of better achievement of the children belonging to small family category. The structure of the family, whether joint or unitary had no significant differential impact on the academic achievement.

Smail and Kelly (1984) discovered that female and male students were approximately equal in science knowledge. However, males did better in physical sciences and on tests involving spatial ability and mechanical reasoning as compared to their female counterparts.

Misra (1986) studied the influence of socio-economic status on academic achievement of rural and urban high school students. The findings showed a positive relationship between socio-economic status and academic achievement of the students. The academic achievement of the rural students was lower than the achievement of the urban students. The results showed
that the academic achievement of girls was superior to the achievement of the boys.

Patel (1986) found a positive relationship between the achievement and socio-economic status. The results showed a positive relationship between the socio-economic status and the achievement of the students.

Paul (1986) found that the factors of home environment like recognition of the child, parental aspiration, parental affection, encouragement for initiative and freedom were found to bear a positive and significant correlation with achievement while punishments and anxiety for the child played an inhibitive role in the achievement of the child.

Upadhyaya (1986) studied the background factors that affect the academic achievement of the students directly and indirectly. The findings showed that the socio-economic status directly affected the academic performance. Poor results were due to strong effects of low socio-economic status through poor home environment and unfavourable school environment conditions.

Puri (1987) investigated the personality traits and self concepts of the underachievers along with the socio-economic status of their families. The majority of the under-achievers belonged to the lower socioeconomic groups. The underachiever girls were more group dependent, generally tense overwrought and frustrated.

Trivedi (1987) investigated the relationship between parental attitude, socio-economic status and academic achievement of intermediate students with intelligence held constant. The main findings of the study showed a significant relationship between academic achievement, parental attitude and socio-economic status. Students belonging to upper socio-economic classes showed better academic achievement than students in lower socio-economic status group.

Simpson and Marek (1988) found that students in small high schools had fewer instances of understanding and more instances of misunderstanding the concepts of diffusion and homeostasis than those attending large high school.

Darchingpuri (1989) examined the relationship among variables such as achievement in science, attitude towards science and problem solving
ability under certain conditions such as location, socio-economic status, parental education, occupation and typology of school among secondary school children. The findings showed significant relationship between scores on scientific attitude and achievement in science. High socio-economic status, family facility and type of school attended favored achievement in science, scientific attitude and problem solving ability.

Phalachandra (1989) analyzed that boys achieved better than girls on concept achievement tests and found that with higher levels of socio-economic status the concept achievement in science increased. However, parental education alone could not explain achievement in science, in a significant manner.

Giraudo (1990) studied the relationship between family environment and school performance among 5th, 6th and 7th grade students and indicated that there exists a relationship between family environment variables and a child's academic achievement.

Padhan (1991) indicated that socio-economic status of the students had no impact on scholastic attainment.

Reap and Cavallo (1992) assessed gender differences in relation to high school student’s acquisition of science concepts. They found that male students scored better than the female students.

Usha (1992) identified income level of father, educational and occupational level of father as best social correlates of achievement in physical science, whereas, home learning facility, family acceptance of the child, size of the family, parents sex bias in education, family achievement and order of birth identified the best familial correlates of achievement in physical sciences.

Ventura (1992) in his studies on gender, science choice and achievement found that the achievement of the girls at lower secondary level was at par with boys in Biology and Chemistry, but girls' achievement was slightly lower in Physics.

Addington (1997) studied effects of family climate on achievement in mathematics and suggested that parental involvement in student's academic lives has a powerful influence on student's achievement.
Uzat (1999) conducted a study to determine if there was a relationship between student achievement and school culture. He found that schools with higher levels of students' achievement possessed a more positive culture than schools with lower levels of students' achievement.

Kaul et al. (2000) concluded that parent education and occupational status have direct relationship with the achievement of students in mathematics and languages. There was no significant gender difference in language and mathematics achievement.

Lee and Smith (2000) explored that learning is higher in schools with higher levels of collective responsibilities and school size influences students' achievement.

McLaughlin and Drori (2000) studied the school level correlates of academic achievement. The major finding was that average achievement of the students in a school is related to school background factors (e.g. poverty, race), school organizational features (e.g. school and class size), professional characteristics and school climate.

Sweetland and Hoy (2000) supported the pivotal importance of school effectiveness in student achievement in middle schools.

Peecook (2000) indicated that home educational support had a greater influence on academic achievement in mathematics, science and social studies.

Chen (2001) supported the effectiveness of home environment and attitude towards mathematics as the more important and consistent predictors of mathematics achievement. The influence of peers, school environment and study habits had mixed inconsistent effects on mathematics achievement.

Kampourakis et al. (2001) investigated the basic physics and chemistry knowledge and patterns of achievement of secondary school students. The results showed that the mean overall achievement was low. The older students achieved higher than the younger ones. Boys achieved higher than girls.

Gupta (2001) Compared the performance of the boys and girls of class XI of different schools viz., private management run schools, missionaries run convent schools, public schools and state Government run model schools.
There was no significant difference in the performance of the male and female students in knowledge type test items.

Chand (2002) conducted a study on achievement of elementary school students in relation to school organizational climate and home environment. It was concluded that learning achievement of elementary school students was relatively better in Hindi as compared to mathematics and urban students had significantly higher learning achievement in mathematics than their rural counterparts.

Basappa (2003) found that socio-economic status had significant effect on the performance of students.

Devi and Mayuri (2003) showed that family factors were critically important for the achievement of residential school students and school factors contributed significantly to academic achievement.

Devi, Sonu (2003) concluded that there exists a significant relationship between dimensions of family environment and academic achievement of school students.

Misra (2003) tried to find out gender differences in science achievement. The results showed that the boys do not differ from girls with regard to achievement in science.

Singh Amita (2003) reported a significant positive relationship between family environment and academic achievement.

Sungur and Tekkaya (2003) investigated the effect of gender and reasoning ability on the concepts achievement and attitude towards biology. The results revealed that there was no statistical significant mean difference between boys and girls with respect to achievement and attitude towards biology.

Vijaypati and Rao (2003) studied the effect of gender and socio-cultural differences on achievement and found a significant gender difference in favour of girls in science achievement but no socio-cultural difference was found in science achievement.

Aseema and Gakhar (2004) studied the effect of gender on the academic achievement of the students. The findings showed that the rural students as well as male students scored high as compared to their urban as well as female counterparts.
Kalra and Pyari (2004) studied the role of family climate and family income on the educational achievement of students. The findings showed that the achievement of the students having favourable family climate was better than the group of students having unfavourable family climate. The achievement of the students was also found to be affected by the income status of the family.

Mehra (2004) assessed the students’ achievement in mathematics at the secondary level. Achievement in mathematics was significantly related to major learning environment and attitude towards subject mathematics. Urban students showed significantly higher achievement in mathematics, better learning environment and better attitude towards mathematics than their rural counterparts.

Shobhana (2004) conducted a survey to study the association between performance of students in written English and family related variables. There was a significant difference in both the competency - based achievement and the ability to use written English among the students’ in terms of locale of residence, type of school and medium of instructions. There was a significant association between the performance of the students in written English and different variables related to school and family.

Boo (2005) conducted a study on secondary school students to interpret everyday phenomenon involving light and sight. The results showed the better performance of female students in the study sample due to the fact that they were more careful in answering the questions.

Bajwa and Kaur (2006) conducted a study to find out the relationship of academic achievement with family environment and academic stress on students of class XI. The findings of the study revealed that there exists a significant and positive relationship between academic achievement and family environment, academic achievement and academic stress.

Orabi (2007) analyzed the academic performance and attitude of male and female students. The results showed that there was no significant difference between mean scores in the academic performance of the genders in the course. Average marks scored by students of either gender were almost equal.
Steinmayr and Spinath (2008) reported that despite equal cognitive ability, girls outperform boys in school achievement.

2.1.2 Psychological Variables

Abraham (1973) revealed that study habits do not influence significantly on English achievement.

Sandhu (1978) in co-relational study, reported that creativity and academic achievement in science subjects are positively related. However, when the effect of intelligence was partialled out, the two measures were not found to be significantly related, thereby, meaning that intelligence in comparison to creativity is more important in student's achievement.

Tiwari (1982) showed that science students in every class scored higher than students in other courses. There was a positive relationship between study habits and achievement among science students.

Sarah (1983) studied the attitude of high school pupils towards general science and its relationship with achievement in the subject. She concluded that the pupils' achievement was poor, in general and the attitude of the high school students towards science and science education was favourable but there was a wide disparity in their attitudes.

Bandopadhaya (1984) found that the pupils who had a favourable attitude to science possessed higher ability in mechanical comprehension and visualization of object in space. They were high achievers in physical science and life science.

Rajput (1984) concluded that intelligence affected the achievement of the students in mathematics significantly at all the three levels i.e. high, average and low. There was a superiority of the high intelligent group of students over the average and low intelligent group of students in their achievement in mathematics.

Dixit (1985) conducted a comparative study of intelligence and academic achievement of adolescent boys and girls and found that the intelligence test scores for the boys was higher than those for the girls, in case of the boys there was very high correlation between intelligence test scores and academic achievement; and in the case of girls there was an average correlation between intelligence test scores and academic achievement.
Kumari (1985) evaluated that the performance of high creative students was higher than that of low creative students. The performance of high creative students was greater through inductive strategy and that of low creative students through a combined strategy.

Mitra (1985) studied the relationship between the academic achievement and its correlates. The findings showed that intelligence was the most significant correlate of achievement, irrespective of the sex. Achievement motivation and extraversion positively and significantly correlated with academic achievement for both sexes, but lost their significant effect on academic achievement when intelligence was partialled out.

Sharma (1985) studied self-concept, level of aspiration and mental health which affects academic achievement among school going children. The main findings of the study were: Self-concept affects academic achievement and mental health is not related to academic achievement. High achievers have super self-concept on behavior, intellectual and school status and happiness and satisfaction than low achievers.

Lal (1986) observed that there was a significant and positive relationship between creative thinking and academic achievement.

Misra (1986) investigated the relationship of the intelligence and the academic achievement. The Samoohik Mansik Parikshan by Tondon was used to measure intelligence. The results showed a positive relationship between the intelligence test scores and academic performance of the students.

Patel (1986) during a psychological study of high achievers found that the better and greater the number of good study habits, the higher was the achievement. More time being given to difficult subject has influenced the passing or failing of the student in the subject.

Paul (1986) showed that the scientific curiosity, scientific rule and technology were the three factors described as instrumental for the high achievement of the girls in home science while dependence on utility and memory factors made achievement of girls low.

Singh (1986) studied some of the possible contributing factors to high and low achievers in mathematics of the high school students of Orissa. The achievement in mathematics was positively and significantly related with
intelligence, socio-economic status and study habits. The results revealed that study habits and interest were significantly correlated to achievement in mathematics. High achievers were more intelligent than the low achievers.

In an experimental study by Kamalanabhan (1987) the experimental group subjected to a multifaceted behavioural training programme consisting of 'relaxation' and 'assertive and study skill training', showed a significant increase in achievement when compared with the control group.

Aranha (1988) examined pupil achievement in science through master learning strategy. It was observed that the learning activities reduced rote learning and mastery learning in science generated group correlation rather than competition while learning.

Bhusari (1988) found a positive correlation between intelligence and scholastic achievement of scheduled tribe students in almost all the subjects. The coefficient of correlation between intelligence and mathematics achievement and intelligence and science achievement were at a higher level than the coefficient of correlation of intelligence with achievement in language and social sciences.

Darchingpuri (1989) showed significant relationship between scores on scientific attitude and achievement in science.

Irudayaraj (1989) found no significant relationship between science achievement and creativity of high school students.

Veeraraghavan and Bhattacharya (1989) in a study on school achievement analyzed that student's motivation has no relationship with school achievement.

Bala (1990) found a positive relationship between the study habits and academic achievement.

Chadha and Chandna (1990) reported a positive and significant correlation between creativity and intelligence, creativity and scholastic achievement and intelligence and scholastic achievement. There was a positive and significant correlation between intelligence and scholastic achievement but a negative significant correlation was found between creativity and scholastic achievement.

Devi (1990) investigated the effect of intelligence, neuroticism and locus of control on academic achievement and concluded that academic
achievement is positively correlated with intelligence and negatively correlated with neuroticism.

Kar (1990) reported a positive and significant relationship between the scientific attitude and achievement in general science among secondary school students.

Verma and Kumari (1990) conducted a study on students studying in arts, science and commerce stream in senior secondary schools of Delhi. The findings of the study suggested that there was a relationship between learning styles and academic achievement.

Kumar (1991) conducted a study to examine the teaching of general science and the development of scientific attitude in secondary school students in relation to achievement in general science. The findings showed the correlation between the science test scores of urban boys and girls.

Nelliappan (1992) found a strong relationship between the high and low learning environment of higher secondary biology students and their scientific attitude and scientific interests.

Astin (1993) found that stress levels had a negative correlation with achievement of students.

Singh (1993) examined the relationship between achievement, intelligence, anxiety and adjustment variables and found that low academic achievers differed significantly in their intelligence and test anxiety.

Niebuhi (1994) found the positive effect of motivation, relationship of school climate and family environment to academic achievement.

Bell (1995) suggested that stress experienced by individuals could have an influence on their academic achievement.

Sharma (1995) found that academic stress had a positive effect on the learning outcomes of secondary school students.

Sherrifrye (1998) conducted a study on academic achievement with respect to stress of pre-adolescents. It was found that academic achievement and stress were significantly related to each other.

Pittman (1999) conducted a study to explore the relationship among school student's acquisition of meaningful understanding of protein synthesis. Students were tested before and after protein synthesis instruction using a multiple choice assessment format and an open ended assessment format.
Analysis of the students generated analogies revealed the unique patterns in student's understanding of the topic.

Sarode (1999) found that socio-economic status, study habits and academic motivation exerted more influence collectively on academic achievement in case of science students than that of arts and commerce students.

Bandopadhyay and Ghosh (2000) found that the correlation between motivation and academic achievement for both the sexes was positive and significant and mental health and academic achievement (both in case of boys and girls) were also positively correlated.

Kaur (2000) found that academic achievement of students is different under high, average and low academic stress conditions. Mean achievement scores of low stress group is higher as compared to that of high stress group and low stress group achieved higher than the average stress group.

Aseema and Gakhar (2004) studied the factors of social stress, locality, gender and their various interactions that separately affect the academic achievement and reasoning ability of the students, on both male and female students studying in class X. The findings showed that the students with low social stress scored higher than the students having high or average social stress.

Mehra (2004) assessed the achievement of students in mathematics at the secondary school stage. The findings showed that the achievement in mathematics was significantly related to the major learning environment and attitude towards mathematics. The urban students showed significantly higher achievement in mathematics, better learning environment and better attitude towards mathematics than their rural counterparts. No sex wise difference was found in achievement of students in mathematics. The high scoring group of students' scientific attitude showed significantly higher achievement than their low scoring counterparts.

Shanmughadas (2004) showed that the achievement in social sciences was related to learning style and study approaches of pupils. There was a significant combined influence of approaches to studying and learning styles on achievement in social sciences.
Sirohi (2004) studied the under achievement of the students in relation to their study habits and attitudes. All under-achievers indicated deficiency in study habits. 98.7% of the underachievers tend to possess unfavourable attitude towards their teachers. 97.5% of underachievers had poor concentration.

James and Marice (2004) investigated the association between achievement in science, scientific attitude, scientific aptitude and some selected variables. There was a positive relationship between achievement in science and scientific aptitude whereas achievement in science and scientific attitude were not related. There was a significant gender difference in science achievement favouring girls.

DeBruyn (2005) designed a study to investigate the relationship between role strains and academic achievement. Four types of role strains were investigated: parent, teacher, school and peer. Parent and teacher role strains appeared to be negatively associated with academic achievement. Peer and school role strains were directly and negatively associated with achievement.

Manimekalai (2005) conducted a study to find out the correlation between achievement, motivation and scholastic achievement of girls. The results showed that there was a positive relationship between achievement, motivation and scholastic achievement of girls.

Gakhar (2006) conducted a test to ascertain the relationship between measures of learning, thinking styles, study skills and academic achievement of students from Punjab, Haryana and Delhi. It was found that there was no significant relationship between learning style, study skills of students and their academic achievement.

Stewart (2008) studied the individual and school structural effects on high school student's academic achievement. The results showed that school climate was important to successful student outcomes.

2.2 IDENTIFICATION OF ERRORS AND MISCONCEPTIONS

The errors and misconceptions among students at different stages of school education have been studied by researchers to enhance the level of learning.
2.2.1 Identification of Errors and Misconceptions in Learning of School Subjects

Tatsuoka (1984) examined various misconceptions committed by junior high school students in fraction, addition and subtraction problems. The results indicated that individual differences in applying different strategies and procedural skills varied more among students than expected. Many erroneous rules were committed by students who used them sporadically. Various error types (sources of misconceptions) cover almost all the levels of tasks involved in solving fraction problems. A close examination of the frequency distribution of the erroneous rules revealed that some errors tend to appear among students with high scores while others appeared only among students with low scores.

Mester (1986) identified a number of mathematical misconceptions among Hispanic students. He concluded that students often mistake the way in which an original price and a sale price reflect one another. Students often misconceive the independent nature of chance events.

Li (2000) studied the misconceptions of the sample of about six hundred Chinese students. The results showed that the students' understanding of the probability does not improve naturally with age, teaching plays an important role. The four main misconceptions in Chinese students were outcome approach, chance can not be measured mathematically, compound approach, and equiprobability, independent of school streams or background in probability.

Chen and Lin (2003) developed a diagnostic tool for diagnosing students understanding and learning difficulties in geometric optics held by junior and senior high school students. The results illustrated that the students' misconceptions about the image formation persists through out their schooling years despite the related scientific concepts have been encountered several times.

Tiley (2003) conducted a study to find out the misconceptions with decimal numbers concentrating mostly on the issues of the place value and decimal ordering. The results showed that there are some types of misconceptions which were held by pupils while dealing with decimal


numbers. The most common misconception appeared was 'decimal point ignored' where 0.125 was read as naught point one hundred and twenty five.

Bhise, Desetty and Patnam (2004) studied the common writing errors of elementary school children. The common writing errors made by the selected elementary school children were additions, deletions and substitutions, in addition to grammatical and punctuation errors.

Bataineh (2005) analyzed the compositions written by students to identify the errors made in the use of the indefinite article. Nine types of errors were identified in the substitution of a and an. The results revealed that all the errors were independent of the learners' naïve language.

Englebrecht et al. (2005) collected the data over one academic year from 3100 students in Michigan. Four concepts in geology were assessed i.e. rock cycle, surface processes, time and earth history and plate tectonics. The misconceptions identified were generally not widely held. The interviews provided an opportunity to remove uncertainty surrounding the occurrence of the misconceptions. The most frequently observed misconception in students was the water flows from water on to land.

Afamasaga (2007) analyzed the student errors which can enable to identify persistent misconceptions. Main findings suggest that students find solving word problems the most difficult followed by items on reasoning and operating with fractions and proportions while basic geometric, algebraic and numeric computation items were the easiest.

2.2.2 Identification of Errors and Misconceptions in Science Learning

Gunstone and White (1981) showed that many students could do well in examinations but used naïve ideas to account for certain daily events. They discovered that many students were unable to apply the relevant concepts to explain certain given situations.

Osborne and Cosgrove (1983) used clinical interviews which studied the conceptions of a relatively large sample of students to determine several misconceptions relating to the states of water and changes between those states. These misconceptions included the belief that the bubbles in a jug of boiling water were made of air, heat, hydrogen and oxygen or steam. They also asked about the source of water that condensed on a jar with blocks of ice in it. In addition to the accepted explanations, students also invoked such
explanations as the water passed through the glass, the coldness came through the glass to produce water and the coldness caused hydrogen and oxygen to combine forming water. The results indicated that over sixty percent of the 17 years old students held misconceptions with regard to the boiling of water and over forty percent students held misconceptions with regard to the condensation of water onto a jar of ice. They also found misconceptions about evaporation.

Arnaudin and Mintzes (1985) measured student’s prior misconceptions of human circulatory system in the form of frequencies at various levels. Student’s perceptions appeared to be tenacious, but confrontation strategies may assist fundamental paradigmatic shifts by students.

Clough and Wood-Robinson (1985) investigated common belief patterns among secondary school students about inheritance and noted the most prevalent misconceptions about genetics which occur at different age levels.

Fisher (1985) investigated a persistent error among introductory college biology and genetics students, namely those amino acids were produced by genetic translation (protein synthesis). Contributors to this misconception were revealed through multiple choice items and interviews.

Halloun and Hestenes (1985) surveyed the physics students at university level for the understanding of the concept of motion. They concluded that nearly every student used some mixture of concepts and appeared to be inconsistent in applying the same concept in different situations concerning linear and projectile motion.

Trowbridge and Mintez (1985) conducted a study to determine students’ alternative conceptions of animals and animal classification. The concepts examined were animal, vertebrates, invertebrates, fishes, amphibians, reptiles, birds and mammals. The comparison of the responses revealed that misclassification is consistent across the grade levels.

Tiberghian (1985) revealed students’ ideas of the kinetic molecular theory; many of these students had received formal instruction in the subject. He reported that children had an idea that heat is hot but temperature can be cold or hot and also that some of them thought that there is no difference
between heat and temperature. In addition, children thought that temperature will change during melting or boiling.

Ben-Zvi (1986) analyzed 10th grade students in Israel with a list of three properties of metallic wire and three properties of the gas resulting from the evaporation of the wire. A large number of the students did not make any distinction between the properties of the bulk and the properties of an individual atom. Majority of the students stated that the single atom obtained from the solid would have different properties than the single atom obtained from the gas. These students had misconception regarding the difference between characteristics of the macroscopic realm from those of the microscopic realm.

Cross et al. (1986) investigated university students' conceptions of the constituents of matter and conceptions of acids and bases. They found that the students knew more about acids than the bases and had a good knowledge of formal descriptive aspects, but they had inadequate conceptions of concrete phenomenon such as heat being released during an acid-base reaction. They noted that students found it easy to give examples of acids; the most frequently mentioned being hydrochloric acid, sulphuric acid, and ethanoic acids, but when asked to list three bases, most of the students could not name more than two. In addition, some students answered that pH was a measurement of the degree of acidity.

Furio et al. (1987) found that majority of the students incorrectly predicted the results of the mass change for the oxidation of iron.

Gabel, Samuel and Hunn (1987) asked the pre-service elementary teachers to draw diagrams of the results of various physical and chemical changes. The researchers found that some of the pre-service teachers had inaccurate ideas about the conservation of particles, the conservation of matter, the arrangement of particles with respect to each other in various states and the expansion of the atoms as they changed from liquids to gases.

Haslam and Treagust (1987) described a multiple choice instrument that reliably and validly diagnosed secondary school students' understanding of photosynthesis and respiration in plants. The consistency of student's misconceptions across secondary levels was observed and also a high
percentage of students were found to have misconceptions regarding plant physiology.

Treagust (1988) explained the use of diagnostic instruments for identification of misconceptions and identified misconceptions for covalent bonding and photosynthesis and respiration in plants.

Dreyfus and Jungwirth (1989) diagnosed the concepts of secondary school students about living cell as the basic unit of life. The results indicated the presence of misconceptions among students about cells. The analysis of the results described a distinction between conceptions, misconceptions, and non conceptions in terms of secondary school biology concepts.

A research was conducted by Amir and Tamir (1990) to define misconceptions about photosynthesis. A specially designed paper and pencil test was administered to students. The results showed that even though these students were familiar with the concept of limiting factors, they had trouble applying it in everyday life.

Anderson, Sheldon and Dubey (1990) studied the concepts of respiration and photosynthesis of college going biology students. The results indicated that students had many misconceptions like respiration is exhaling carbon dioxide and not understanding that plants manufacture their own food but thinking that plants get their food from nutrients in the soil.

Bodner (1991) identified the misconceptions of graduate students related to the concept of rusting of iron. He asked the students to predict the change if any in weight of the iron after rusting. The results showed that few students in his sample predicted that the weight of an iron bar would be less after rusting and some students predicted that the weight would remain the same.

Boyces and Stanisstreet (1991) indicated that the occurrence rates for the misconceptions vary with the student's prior learning level.

Hand and Treagust (1991) identified five key misconceptions about acids and bases among students. These misconceptions were: an acid is something which eats material away; an acid can burn you; testing of an acid can only be done by trying to eat something away; to neutralize is to break down an acid or change from an acid; a base is something which makes up an acid; a strong acid can eat away the material faster than a weak acid.
Hapkiewicz (1991) presented the demonstrations to help students to change their misconceptions about chemical bond breaking. Students' misconceptions about chemical bonds in both biological and chemical systems were identified to clarify the concept of chemical bonding.

Phillips (1991) has found some common earth science misconceptions among students. The common misconceptions were: the earth is sitting on something; the earth is larger than the sun; we live on the flat middle of the sphere; rain comes from holes in clouds; the earth is round like a pancake.

Westbrook and Marek (1991) examined students for understanding of the concept of diffusion. The results showed the differences among the grade levels in sound or partial understanding, misconceptions and no understanding of the concept.

Abraham et al. (1992) found that only two percent of the students had clear understanding of the concept of melting of ice. Thirty four percent of the students demonstrated misconceptions on this concept and sixty four percent of the students either left the question blank or had no understanding.

Griffith and Preston (1992) conducted a study to determine the misconceptions present in 12th grade students regarding the characteristics of atoms and molecules. Misconceptions were found in student's ideas about the structure, composition, size, shape, weight, bonding and energy of molecules as well as about the structure, shape, size and weight of atoms. Misconceptions regarding the size of the atoms were most pertinent. Much higher percentage of the students believed atoms to be alive.

Some common misconceptions about the concepts of light and sound were identified among the students by Hapkiewicz (1992). The findings showed that the common misconceptions were: loudness and the pitch of the sound is the same thing; sound can not travel through liquids and solids; colors appearing on the soap films and oil slicks are reflections of the rainbows; the size of the image depends on the size of the lens used to form the image.

Westbrook and Marek (1992) discussed the students' understanding of the concept of homeostasis. A number of misconceptions were detected among students and the number of misconceptions increased across grade levels.
Driver (1993) conducted a study to find out the misconceptions of students about the conservation of matter under physical and chemical transformations. The findings showed that many students could not apply the law of conservation of mass to chemical and physical changes. Nearly half of the students suggested that the weight of steel wool would decrease after burning and that the mass would change on dissolving sugar in water.

While studying about student's misconceptions about science, Lee et al. (1993) found that students have misconceptions in some of the areas like change of states, evaporation and macroscopic properties of atoms and molecules. One of the misconceptions among students was, molecules in ice are hard and frozen.

In a study by Abraham, Williamson and Westbrook (1994) on junior high school students, high school students and college chemistry students' understanding of the concept of conservation of mass, it was found that only eighteen percent of the sample had a sound knowledge about the concept.

Nakhleh and Krajcik (1994) investigated various misconceptions of secondary school students like understanding of acids, bases and pH concepts. The results showed that the students had following misconceptions: the pH is invariably related to harm and bases are not harmful; bubbling is a sign of chemical reaction; pH is a compound called phenolphthalein, a chemical reaction and a number related to intensity; acids are strong and bases are not strong.

Ross and Munby (1994) found that students had more understanding about acids than bases and had particular problems with the ionic nature of acids and bases.

Ebenezer and Gaskell (1995) looked at students' conceptions of solutions. Students had misconceptions in the concept of salt and water and also misconceptions were found in the concepts of recrystallisation and temperature.

Grayson et al. (1995) studied pupils' development of the concepts of heat and temperature. A number of misunderstandings were identified: objects at room temperature that feel different have different temperatures; objects could have a certain quantity of heat in them; objects could get hotter.
than their surroundings; the temperature of water could exceed the boiling point.

Odom et al. (1995) developed a two-tier diagnostic test to measure understanding of diffusion and osmosis of college biology students. Three general steps were used: defining the content boundaries, collecting information on students' misconceptions and instrument development. The results showed the misconceptions related to diffusion among students.

Huddle and Pillay (1996) investigated the misconceptions held by students at South African University. The students were required to balance an equation and determine the mole amount of each product. Only thirty eight percent of the students were able to successfully complete the question though ninety one percent students were able to balance the equation. They found misconceptions in regard to limiting reagents.

Graham and Peek (1997) studied understanding of some aspects of rigid body motion and in particular tried to expose intuitive ways of thinking among students. They identified the student's misconceptions about the understanding of rigid body motion and also identified the misconceptions of particle mechanics and these misconceptions can be carried forward to cause further problems with rigid body motion.

McCoy (1997) conducted a study in which a demonstration of actual reaction in which equilibrium was established and then manipulated was presented to students and then individual interviews were conducted to find out misconceptions. The misconceptions identified were: the reactions proceed in one way only; the inability to discriminate between chemical and physical changes' difficulty in application of information gained from the initial example to the explanatory analogy and to the new reaction. It was also reported that more concrete analogy was slightly more effective in demonstration of the abstract principle.

Marques and Thompson (1997) conducted a study to assess the understanding of students at the age of ten to fifteen years about the concepts of origin and nature of earth and the development of life. The results indicated a significant number of commonly held misconceptions.

Palmer (1998) measured the contextual errors in the diagnosis of specific alternative conceptions among year ten students. The results showed
the erroneous responses to be just under seventeen percent of the total responses.

Berthelsen (1999) tried to identify the student's na"ive conceptions in life science. Many na"ive conceptions were identified among students about plants, cells, ecosystem, heredity, evolution and vision and hearing etc. The findings showed that students' misconceptions were: plants, fungi, eggs and seeds are not living; only large land mammals are animals; respiration is synonymous with breathing; plants obtain their energy directly from sun; sunlight is a food; plants absorb water through their leaves; students are unsure about the hierarchy of atoms, molecules and cells. Cells are described as the components of many things including carbohydrates and proteins; stronger organisms have more energy; sexual reproduction occurs in animals but not in plants; asexual reproduction produces weak offspring. Sexual reproduction produces superior offspring.

Hapkiewicz (1999) identified the students' naive ideas about earth science. The common naive ideas were: students were unaware of microorganisms role as decomposers and recycling of carbon, nitrogen, water and minerals; clouds are "sponges" that hold water or bags of water than rain when they are shaken by wind or perhaps when they become cold or hot; gases are not matter because most are invisible; particles of solids have no motion.

Voska and Heikkinen (2000) developed a ten-item pencil and paper, two-tier diagnostic instrument, and used it to identify and quantify chemistry conceptions students' use when solving chemical-equilibrium problems. Eleven prevalent misconceptions about chemical equilibrium were identified with the help of the test.

Pachaury (2001) found the intuitive conceptions employed by the adolescents, about the respiratory organelles of two invertebrate animals. Five categories of the intuitive conceptions were formed and used. They are: plausible conjecture, juxtaposed conjecture, remote conjecture, physical object conjecture, no response. The findings of the study revealed that much higher percentage of students made plausible conjectures (skin, body and pores on the skin) about the earthworms' respiratory structures in comparison to the spiders' respiratory structures.
Henriques (2002) found some misconceptions about weather. Some of the common misconceptions were – students believe that the air we breathe and the oxygen are the same thing, not realizing that air is the mixture of many gases, and another common misconception was that many students believe that lightning never strikes in the same place twice.

Kousathana and Tsaparlis (2002) studied two types of errors i.e. random errors and systematic errors in the final upper secondary school students who were attending an elective chemistry course. The errors detected were categorized as: the equilibrium constant; stoichiometry; heterogeneous equilibria; the direction of a reaction which is not at equilibrium; gas equilibria and the ideal gas law.

McWilliam (2002) examined misconceptions particularly in the area of force and motion. Interview templates, containing concept and parallel questions and predicted responses, were designed covering frequently misunderstood area of force and motion. Structured interviews were conducted, using these templates, with mechanics and technology undergraduate students. The results revealed common misconceptions but more importantly indicated critical moments, the points where a student realizes that their apparent understanding is flawed, prior to conceptual change.

Tan et al. (2002) developed a two-tier multiple choice diagnostic instrument to access understanding of high school students' inorganic chemistry. The study showed that the grade ten students had difficulty in understanding the reactions involved in the identification of cations and anions, for example, double decomposition reactions and reactions of complex salts and thermal decomposition.

A case study was carried out by Senocak et al. (2003) in order to determine students' conceptions of heat and temperature. The results of the study demonstrated that students were more successful and willing to answers the questions related to everyday life than theoretical questions.

A study was conducted by Shook, Linda Jean (2003) to investigate the kinds of errors made on science tests by students of different gender and ethnic groups and changes of these errors between grades 6th and 8th. Errors were classified into three categories: mastery, visual interpretations and errors
caused by misconceptions. It was found that white students did better than African-American students in mastery error category and in misconception errors.

Demerouti et al. (2004) found that the 12th grade Greek students had misconceptions and difficulties on the following topics: dissociation and ionization, ionic equilibrium, neutralization, pH and buffer solutions.

Lin (2004) performed a study which involved the development and application of a two-tier diagnostic test measuring students' understanding of flowering plant growth and development. The instrument development procedure had three general steps: defining the content boundaries of the test, collecting information on students' misconceptions, and instrument development. The results of the test suggested that students did not acquire a satisfactory understanding of plant growth and development concepts. Misconceptions were identified through analysis of the items.

Ross (2004) studied children's misconceptions of animals as the concept, by interview of elementary junior high school students to name five animals and animals as a group. It was revealed from the response patterns that for defining the animal as a concept, students consider ambiguous and often conflicting pieces of information when classifying animals.

Senear and Eryilmaz (2004) developed a two-tier test to diagnose the misconceptions concerning electric circuits among students. It was analyzed that most of the students had many misconceptions. In addition, it was found that females had more misconceptions as compared to males.

Sarikaya (2004) showed that students had some misconceptions about the definition of the mole and Avogadro's number, which were based on the atom and molecule concepts. Majority of the students, instead of using the $^{12}$C isotope, defined these concepts as Avogadro's number of particles and $6.022 \times 10^{23}$, respectively.

Yen et al. (2004) examined alternative conceptions of reptiles and amphibians and the extent to which these conceptions remain intact through the elementary, junior and high school students. A multiple choice and free response instrument was administered to assess various levels of students' understanding of amphibians and reptiles. The results showed that most of the students were able to classify snakes as reptiles but few students...
classified sea turtles as reptiles, majority of the students' classified sea turtles as amphibians. More students were able to correctly classify frogs as amphibians than toads. In most instances, students correctly classified "Prototypical" representatives of two animal classes more readily than less exemplary representatives.

Burckin (2007) identified the preconceptions and misconceptions of students related to petroleum. The research showed a surprising number of misconceptions about petroleum. A survey was also conducted which reports the persistence of misconceptions related to petroleum into adults also.

Hancer and Durkan (2008) carried out a research to find out the misconceptions about the subject of "force and movement". Some of the misconceptions were: objects move with a constant speed under a constant force and if an object is not moving, there is no force affecting it. The rate of misconceptions was significantly different between older and younger class students. Although older students studied force and movement in previous year, they had the same misconceptions and same ratio as the younger students.

Klymkowsky and Gravin (2008) developed Biology Concept Inventory. Results indicated a striking lack of understanding on two questions related to randomness, even after three major's courses in molecular, cell and developmental biology at the University of Colorado at Boulder.

2.3 CAUSES OF ERRORS AND MISCONCEPTIONS IN LEARNING

Longden (1982) identified sources of misconceptions and learning difficulties by interviewing academically sound students who were having difficulty with genetics. The results indicated that misconceptions were related to nature of concepts used in genetics, such as frequent representation of meiosis by fixed inanimate stage diagrams and to instructional strategies.

Mester (1982) investigated mathematical misconceptions among Hispanic students. The results showed that their error patterns were nearly always the results of differences in language or culture. The numbers of unique errors among Hispanics resulting from linguistic difficulties were small.

Hibert and Wearne (1983) conducted a study on students conceptions of decimal numbers and found that pupils have some connection between the
decimal symbol and an appropriate referent and even if they are given a referent (heights of trees) many pupils do not believe that they are dealing with decimals.

Barass (1984) conducted a study on some misconceptions and misunderstandings perpetuated by teachers and textbooks of biology. The results showed a list of commonly encountered misconceptions/misunderstandings in biology related to the concepts of acellular and multicellular, respiration and photosynthesis, egestion and excretion and homeostasis and homeothermy.

Cho, Hee-Hyung et al. (1985) found high school biology textbooks as sources of misconceptions and difficulties in genetics to determine possible sources of misconceptions and related learning problems associated with genetics. Misconceptions were examined in the categories of: conceptual organization; conceptual relations; use of terminology; and mathematical elements.

Engel Clough and Driver (1986) found the misconceptions/conceptual frameworks among students for the concepts of pressure, heat and inheritance. The findings showed that students were using different alternative frameworks in response to the parallel questions and it was concluded that in many cases, students do not apply their conceptions in a way which a scientist would consider to be consistent. They noted the importance of context (or setting) of the question in determining an individual's responses.

Dreyfus and Jungwirth (1988) used the diagnostic evaluation to test the understanding of the concept of the living cell as the basic unit of life among the tenth grade students. They concluded that the students had misconceptions and they classified the students' knowledge as common knowledge, widespread lack of knowledge, inadequate alternatives and contradictions.

Pearson and Hughes (1988) examined the technical vocabulary of genetics as a source of error and confusion and reported misuse of terms in textbooks.

Lawson and Thompson (1988) diagnosed the misconceptions of seventh grade students about the concept of genetics and natural selections, with four cognitive variables: reasoning ability, mental capacity, verbal
intelligence and cognitive style. The results indicated that only the reasoning ability was significantly related to the number of misconceptions.

Mahapatra (1989) observed that children made a great deal of conceptualization on the basis of their observation of the day to day happenings in the environment and home situations. In this process they formulated alternative concepts about things, objects and events.

Kinderfield (1991) studied the misconceptions and errors of the students for the concept of chromosomes. He found that frequent misconception displayed by the students was that chromosome structure is a function of chromosome number or ploidy. This misconception was found to be more prevalent among the students of introductory genetics and as the potential source for inaccurate communication that it can generate within instructional settings.

Schmidt (1991) has identified the common misconceptions of students about the concept of neutralization. The results showed that the 'neutralization' label works as 'a hidden persuader' as the pupils are usually introduced to neutralization reactions through examples where strong acids react with strong bases to give a neutral solution and that creates misconceptions among students.

MASON and TOOLEY (1992) conducted a research on common misconceptions about decimal numbers and they diagnosed that the context that pupils use when dealing with decimal affects their understanding of the topic. The findings showed that the two most common errors were 'decimal point ignored' and the 'largest is smallest'. It was suggested to add context and visual aids to the problem so that the misconceptions are greatly reduced.

Kesidou and Duit (1993) conducted clinical interviews with 10th class students. The main misconception was that heat transfer starts and does not stop at once when temperatures have equalised. The main reasons for this kind of thinking was given as - the ease with which heat enters and leaves different materials varies, different materials attract heat or retain heat differently and the particles are not equally close to one-another they have different qualities and these ideas were based on everyday experiences and not on a scientific basis as taught in schools.
Lord and Marino (1993) surveyed students about the concept of theory of evolution. They found misconceptions among students and concluded that although nearly three quarter of the students said that they believe in the theory of evolution; most of them did not understand the mechanism behind it.

Gallegos et al. (1994) examined the pre-conceptions held by students on predator–prey relations and construction of food chains. The results showed that classification of herbivores and carnivores is based on students’ pre-conceptions of size and ferocity and due to these pre-conceptions students face difficulties at higher education levels in the concepts of food web and relationship with ecosystem.

Leach et al. (1995) researched on students’ learning and understanding of ecology. The results revealed that the concept of ecology was not found to be clear to the students. They found that student's ideas of the function of the ecosystem was not seen as an interrelated whole i.e. photosynthesis, respiration and decay were not viewed as cycling of matter in ecosystem.

Graham and Berry (1997) described a clear link between the development of students' understanding of force in the direction of motion's misconception or preconception. They proposed a model which showed that as students move from a view dominated by this misconception or preconception to a Newtonian view, they pass through a number of intermediate stages. They also showed that many students had not reached the higher levels of understanding; before they go on to consider application of Newton’s law.

Hardt and Paula (1997) examined understanding of electrical circuits among students. The results showed that both high school students and university students have misconceptions about direct current resistive electric circuits. Students tended to confuse terms especially current. They assigned the properties of current to voltage and/or for resistance.

Sanger (1997) identified the student’s misconceptions about electrochemistry and found the text books as the possible sources to misconceptions.

Palmer (1998) used a multiple choice instrument to identify the students who hold alternative conceptions about force and motion. Many
misconceptions were found and it was concluded that the contextual error was the factor which resulted in inaccurate diagnoses of alternative conceptions in students.

Rowland, Graham and Berry (1998) made an investigation of student's understanding of moments of forces to provide some indication as to the nature of intuitive ideas in this area. The results of the investigation showed three stumbling blocks in the conceptual understanding of moments of forces. The first stumbling block seems to contain problems where the forces applied were still acting vertically, but the points of application of the forces were not at the same horizontal level. The second stumbling block seems to either contain problems where the forces applied were vertical but there was no obvious sense of symmetry, or problems that represent a conceptual link between moments and rotation. The third stumbling block contains questions whereby the student had to recognize the line of action of the appropriate force and take note of the point of application of the force.

Tyson, Treagust and Bucat (1999) used a two-tier test, coupled with interviews from a case study, to explore student's understanding of what happens when reaction mixtures at equilibrium are disturbed. According to the findings, it did not appear that one explanation is better than the other, while language turned out to be a key factor, causing misinterpretations by students.

Debra (2000) explored the misconceptions and difficulties in acquiring metalinguistic knowledge. He observed twenty six mixed ability year eight pupils (12 years old) for two lessons a week over a period of a term with a close focus on grammar. The results showed a range of difficulties and misconception originating from different sources. These were broadly categorized under three headings: misconceptions acquired previously from teachers or text books, misconceptions promoted by the specific characteristics of English Grammar, misconceptions due to the cognitive demands involved in learning a metalanguage.

Eryilmaz and Surmeli (2002) estimated proportions of misconceptions about heat and temperature in terms of three tier test. The results have shown that the errors were due to mistakes, lack of knowledge and misconceptions.
In a study on the misconceptions and errors of students in naming the complex compounds conducted by Sindhu and Sharma (2004) it was found that some errors were due to lack of knowledge related to facts and concepts and some due to lack of knowledge of rules of nomenclature.

Hershey (2004) identified about fifty plant misconceptions and he categorised these misconceptions into five parts i.e. oversimplifications, overgeneralizations, obsolete concepts and terms, misidentifications and flawed research.

Ross (2004) identified the misconceptions among students with animals as the concept. He concluded that students consider ambiguous and often conflicting pieces of information when classifying animals. The sources of misconceptions may be the problem of linguistic transformation, misclassification and confusion among students.

In the purpose of assessing misconceptions of ninth grade students about simple electric circuits a three tier test was developed and administered to students by Haki (2005). Students gave a lot of wrong answers because of lack of knowledge but mostly misconceptions. Parallel circuit misconception was the most common misconception.

Kutluay (2005) developed a three-tier test for assessing misconceptions among students about geometric optics. The proportion of false positives and false negatives was estimated to be 28.2% and 3.4% respectively. The results showed that the proportions of misconceptions were observed to lessen gradually as the tiers of the tests increased one by one, due to mistakes and lack of knowledge while the proportions of the correct responses were observed to lessen gradually as the tiers of the tests were increased one by one, and were due to false positives and lack of knowledge.

Sanders (2006) conducted a study to find out the erroneous ideas about respiration. This study investigated teachers as the possible source of pupil’s errors.

Kucukozer and Kocakulah (2007) revealed secondary school student’s misconceptions about simple electric circuits. Data was obtained with a conceptual understanding test for simple electric circuits and semi-structured interviews. The most important findings appeared in the study were the misconceptions, which emphasized the idea of “no bulb lights on if the switch
is off” due to everyday language and the idea of “bulbs connected in parallel give better light than those connected in series” due to prior teachings.

Shaw et al (2008) analyzed the nature of student misconceptions in genetics, the possible sources of these misconceptions and potential ways to galvanize these misconceptions. The students’ answers were graded as complete answers, partial answers and unsatisfactory answers. Some common misconceptions held by students were identified.

2.4 EXPERIMENTATION IN CONCEPT LEARNING

Fredette and Clement (1981) interviewed the students for the topic of electricity. They noticed the short circuit misconceptions in the interviews. Afterwards, they followed three steps to probe their investigation. First, they administered the written questionnaire; second, the researchers conducted twelve additional interviews to obtain more insight into the depth of the conceptual difficulty; third, the researchers administered another but similar written test to ten engineering students who had completed a course in electricity and magnetism to observe if the misconceptions had been overcome after the course. It was concluded that it is difficult to overcome the misconceptions for some students even after the course.

Cohen, Eylon and Ganiel (1983) designed and administered a questionnaire to twelfth grade students. There were also two additional classes, one of which was eleventh grade and other was gifted ninth graders. The findings showed many misconceptions among students about the topic potential difference and current in electric circuit.

Adeniyi (1985) studied common misconceptions held by junior secondary school students in an environment related course. He reported that students possessed several alternative conceptions about food chain, energy flow and pyramid of energy and carbon cycle. He concluded that although some of the misconceptions might have existed before instruction, a few of them appeared even after instructions.

Dupin and Johsua (1987) identified French pupils' conceptions about direct current electricity. To be able to assess the effect of teaching they followed the evolution of the conceptions from the beginning of secondary school up to the fourth year of university. The findings showed that some of
the misconceptions can be overcome by teaching, however, some are resistant to change.

Griffiths et al. (1988) investigated the remediation of misconceptions through application of Gagne's hierarchical learning theory with stoichiometry, food levels and conservation of mechanical energy as target concepts. They found that there was no treatment effect on misconception, reported by students.

Hand (1989) administered a test based on five original misconceptions to a group of twenty four students, out of which some students had been taught more sophisticated ideas in a pure chemistry course, while others had studied a broad based science course. The results of the test showed that only students studying chemistry could answer basic recall questions correctly, while those studying biology did best overall.

Raman (1989) discovered the impact of remedial teaching programmes for the common errors committed by the students of standard XI in calculus under four categories i.e. entry behavior, perceptual, conceptual and computational in different divisions and percentage of errors were identified under each category. The findings showed that students committed more conceptual errors, entry behavior errors and perceptual errors.

Gurusamy (1990) attempted to find out the errors committed by students of standard IX in solving problems of geometry; and tried out the remedial package. It was found that students' errors were considerably reduced in the post test and the performance level of the students in the post test was high after the implementation of the remedial programme.

Licht and Thijs (1990) investigated alternative conceptions associated with Newton’s Third Law and found that pupils in higher grades were more consistent than those in lower grades. They concluded that contextual errors were lower amongst older students than younger ones.

Seymor and Longden (1991) explained the procedures, directed at isolating and identifying student's difficulties in comprehending the concepts involved in lessons about gas exchange and respiration. They indicated that pupils had deficient understanding of prerequisite concepts and tended to operate at the concrete operational level, whereas the highly abstract concepts being taught required a formal operational level.
Settlage (1994) tested the concept of natural selection among the students. He found some misconceptions. The results showed that the misconceptions were dropped to less than twenty percent on the post-test.

Trowbridge and Wandersee (1994) described and evaluated the use of concept mapping in teaching a college course on evolution. They determined that student's concept maps can improve learning. They identified a number of misconceptions among students and assessed the impact of concept mapping on students study practices and on student's understanding of course content.

Hartman (1996) conducted a pilot study to detect the misconceptions of biology students. The results showed that students had many erroneous conceptions of biology. Of the numerous problematic conceptions and misconceptions identified at the beginning of the anatomy and physiology, some were overcome and some remained by the end of the course. A few misconceptions were actually more common at post testing than pre-testing.

Hill (1997) examined the conceptual change through the use of student generated analogies of photosynthesis and respiration. There were eleven items and a three tier multiple choice instrument was designed to assess the common misconceptions. There was no significant change in performance between the pretest and post test administration. But the confidence in their responses about the two concepts had increased.

Maul and Berry (2000) studied the mathematical understanding of engineering students. The results showed that engineering and mathematics students have different concept images and that engineering students gradually adopt mathematical ideas into their engineering knowledge in a way which makes sense of them.

Linda and Angela (2001) developed a valid and reliable test instrument to identify students who hold misconceptions about probability. Results of the study showed many common misconceptions about probability and it was concluded that even students with formal instructions in statistics continue to demonstrate misconceptions.

Ozkam (2001) studied on remediation of seventh grade student's misconceptions related to ecological concepts and on environmental attitudes through conceptual change approach. The misconceptions identified through
an ecology concept test were related to the concepts of environment, ecosystem, decomposers, population and energy resources in ecosystem, food chain and food web. It was indicated that experimental group achieved significantly better than the control group.

Eryilmaz (2002) investigated the effects of conceptual assignments and conceptual change discussions on student’s achievement and misconceptions about force and motion. The statistical results showed that the conceptual change discussion was an effective means of reducing the number of misconceptions of students about force and motion. The conceptual change discussion was also found significantly effective in improving student’s achievement in force and motion.

Krause et al. (2002) identified students’ misconceptions in an introductory material engineering course. Results showed conceptual knowledge gain between 15% and 37% between course pre-test and post-test scores.

Li (2002) investigated the probabilistic misconceptions of Chinese students, and whether selected misconceptions could be overcome through a focused teaching intervention. It was found that, generally there was no improvement in the developmental level from grades six and eight, the two grades without any formal probability training. Grade twelfth students have a better understanding than the younger students. The results indicated that after the activity based short-term teaching program to grade eight students, the percentage of the correct answers increased from about fifty percent to about eighty percent.

Omer Geban et al. (2003) investigated the effect of conceptual change instruction on understanding of respiration of eleventh grade students. The results indicated that student’s science process skills accounted for a significant portion of variation in respiration concept achievement. The conceptual change instruction which dealt with misconceptions of students produced significantly greater achievement in the understanding of respiration concepts. There was a significant difference between the performance of females and males.

Cetin et al. (2004) investigated the effectiveness of using conceptual change text accompanied by small group work on 9th grade student’s learning
of ecology. The study covered the ecology concepts such as non living factors of environment: producers, consumers and decomposers relationship in matter and energy flow; symbiotic relationships, food chain and food web, cycle of matter, population, community etc. It was found that conceptual change oriented instructions explicitly dealt with students' misconceptions relating ecology. The students in experimental group attained better acquisition of scientific conceptions related to ecology than the traditional group.

In a recent study Demircioglu et al. (2005) investigated the effects of new teaching materials on achievement of students and misconceptions for the unit acids and bases. The results indicated that the students in experimental group showed significantly greater achievement in the unit and had more favorable attitude towards chemistry as compared to their control counterparts. Thereby, suggesting that conceptual conflict strategy produced better results, both in achievement and attitudes. The student's misconceptions in experimental group were less than the control group.

Sarikaya (2007) identified the misconceptions about concept of atomic structure and the misconceptions among the perspective teachers and students about the concept of atom. The perspective teachers and students from all the branches of science had misconceptions. It was found that the models were quite useful in teaching science and that the construction of knowledge would be possible if students played an active role in the learning environment.

Chandrasegaran, Treagust and Mocerino (2008) developed a two-tier multiple choice diagnostic instrument to evaluate the secondary school student's ability to describe and explain chemical reactions using multiple levels of representations. The teaching program proved to be successful in those instances where students were able to describe and explain the observed changes in terms of atoms, molecules and ions that were involved in the chemical reactions using appropriate symbols, formulas and chemical and ionic equations. Despite the emphasis on multiple levels of representation during instruction, fourteen conceptions were identified that indicated confusion between macroscopic and submicroscopic representations, a tendency to extrapolate bulk macroscopic properties of substances to the
submicroscopic level and limited understanding of the symbolic representational system.

2.5 OVERVIEW

The perusal of review of related literature provides a picture reflecting that student's learning and achievement is dependent upon conceptual clarification and mastery treatment of the knowledge.

The review of related literature pertaining to various socio-psychological variables under investigation provides certain indications that may be briefly summed up as under:

- The results of a large number of studies support the fact that females underachieve in relation to males (Affif, 1977; Sharma, 1981; Smail and Kelly, 1984; Phalachandra, 1989; Reap and Cavallo, 1992; Gupta, 2001 and Aseema and Gakhar, 2004). While the result of the various studies showed that males underachieve in relation to females in various subjects (Falzon and Sammut, 1976; Mishra, 1986; Vidyapati and Rao, 2003; James & Marice, 2004; Boo, 2005 and Steinamyr and Spinath, 2008), whereas some studies showed that males and females do not differ with regard to achievement and for some areas males had better achievement and in other areas females were better (Barua, 1981; Smail and Kelly, 1984; Ventura, 1992; Mishra, 2003; Sungur and Tekkaya, 2003; Orabi, 2007).

- Attitude has been identified as an important correlated towards achievement of students. Chen, Hui-Ling (2001); and Mehra (2004) found mathematics attitude to be related to achievement while findings of studies by Sarah (1983); Bandopadhyaya (1984); Paul (1986); Daschtingpuri (1989); Kar (1990); Kumar (1991) and Nelliappan (1992); Showed significant relationship between scores on scientific attitude and achievement in science.

- Some studies have shown that intelligence in general is a factor contributing towards achievement. (Sandhu, 1978; Rajput, 1984; Tiwari, 1986; Bhusari, 1988; Phalachandra, 1989; Dev, 1990; Chadha and Chandna, 1990; Singh, 1993). Some researchers have considered
study habits as positive correlate of achievement (Abraham, 1973; Tiwari, 1982; Patel, 1986; Kamalanabhan, 1987; Bala, 1990; Sarode, 1999; Chen Hui Ling, 2001, Sirohi, 2004; Gakhar, 2006), while Deshpande, 1984 found no difference in the study habits of students from high achieving and low achieving schools. While creativity and achievement was found to be positively and significantly correlated by Sandhu (1978); Singh (1983); Kumari (1985); Lal (1986); Manimekalai (2005). While Irudayaraj (1989) found no significant relationship between achievement and creativity. Negative correlation between creativity and achievement was found by Chadha and Chandna (1990). Whereas learning styles and achievement have some relation. This was shown by Aranha (1988); Verma and Kumari (1990); Shanmughdas (2004) while no significant relation between learning styles and achievement was shown by Gakhar (2006).

- Socio-economic status is the most commonly studied variable. Positives correlation was found between socio-economic status and academic achievement of students (Pandey, 1981; Shukla, 1984; Misra, 1986; Patel, 1986; Upadhyaya 1986; Puri, 1987; Trivedi, 1987; Darchingpuri, 1989; Phalachandra, 1989; Usha, 1992; Basappa, 2003; Kalra and Pyari, 2004). While according to other researches home environment plays a significant role in the achievement of students (Sarkar, 1983; Paul, 1986; Trivedi, 1987) and there was a significant difference between high and low achiever on the home variables namely, educational environment, income, social background, parental education, provision of facilities and parent child relationship etc. (McLaughlin and Drori, 2000; Peecook, 2000; Chen, Hui-Ling, 2001; Devi Sonu, 2003; Devi and Mayuri, 2003; Singh, 2003; Sobhana, 2004; Bajwa and Kaur, 2006).

- Some researchers studied the influence of environment of school as a factor to promote the academic achievement among students McLaughling and Drori, (2000); Mehra (2004), concluded that urban atmosphere was more conductive to better achievement than a rural
environment while Aseema & Gakhar (2004) found rural student high
achievers. Some researchers found that government, aided and
unaided institutions differ significantly in achievement. (Basappa, 2003;
Kumaran, 2003; Sobhana, 2004 and Manimekali, 2005). The
environment and organisational features of students has a significant
and positive relationship with achievement of students. (Gayani and
Aggarwal, 1998; McLaughlin and Drori, 2000; Peecook, 2000; Devi and
Mayuri, 2003; Kumaran, 2003; and Kalra and Pyari, 2004) and Stewart,
2008)

- Some researchers showed that stress influences student achievement.
Negative correlation between stress and student achievement was
found by Astin (1993); Kaur and Kanwalkpreet (2000); Malik and
Rehman (2003); Aseema and Gakhar (2004); DeBruyn, Eddy H.
(2005). While a positive correlation between stress and student
achievement was found by Bell (1995); Sherrifrye (1998) and Bajwa
and Kaur (2006). While some studies consider anxiety as a variable
affecting achievement. A negative correlation between anxiety and
achievement was indicated in the studies by Shanmugasundaram,
(1983); Paul (1996); and Singh (1993).

- Many researches were done in various subjects to identify the naive
ideas of students that can create learning difficulties for students and
ultimately causing low achievement. (Arnaudin and Mintzes, 1985;
Boytes and Stainstreet, 1991; Phillips, 1991; Driver, 1993; Lee et. al.
1993; Marques and Thompson, 1997; Palmer, 1998). Researches were
conducted to identify misconceptions of various concepts of physics
(Gunstone and White, 1981; Halloun and Hastenes, 1992; Hapkiewicz,
1992; Grahamand Peek, 1997, Chen and Lin, 2003; Hancer and
Durkan, 2008). Many researchers tried to identify the misconceptions
held by students for chemistry concepts (Osborne and Ccsgrove, 1983,
Clough and Wood Robinson, 1985, Ben-zvi, 1986; Cross, 1986; Furio,
1987; Hand and Treagust, 1991; Hapkiewicz, 1991; Bodner, 1991; Mc
coy, 1991; Ross and Munby, 1991; Griffith and Preston, 1992;
Abraham, Williamson and Westbrook, 1994 Nakleh and Krajcik,1994;
Misconceptions were identified for the various biological concepts by conducting studies by Fisher (1985); Trowbridge and Mintzes (1985); Haslam and Treagust (1987); Dreyfus and Jungwirth (1989); Amir and Tamir, (1990); Anderson, Sheldon and Dubey (1990); Westbrook and Marek (1991); Pachaury (2001); Ross (2004) and Yen et al. 2004 while Odom (1995); Berthelsen (1999); Tatsuoka (2000); and Tiley (2003) conducted various studies to identify the naive conceptions (ideas) of students about various mathematical concepts.

- Errors made by students were identified by some researches. These errors can affect the achievement of students (Raman, 1989; Kousathana and Tsaparis, 2002; Shook, Linda Jean, 2003; Bhise, Desetty and Patnam, 2004).

- Many researchers found various causes of misconceptions among students. Some studies revealed that misconceptions were related to the nature of concepts or the lack of knowledge of the concepts. (Longden, 1982; Hibert and Wearne, 1983; Engel Clough and driver, 1986; Mason and Tooley, 1992; Leach et al. 1995; Lord and Marino, 1993; Graham and Berry, 1997; Rowland, Graham and Berry, 1998; Eryilmaz and Surmeli, 2002; Hershey, 2004; Sindhu and Sharma, 2004). Certain studies concluded that misunderstandings/misconceptions are perpetuated by teachers like Barass, 1984; Kinderfield, 1991; Debra, 2000; Sanders, 2006). Textbooks were found to be the sources of misconceptions and difficulties by some researchers (Barass, 1984; Choo, Hee-Hyung et al. 1985; Sanger, 1997; Debra, 2000). Mahapatra, 1989; Gallegosetol, 1994 concluded that children made a great deal of conceptualization on the basis of their observation of day to day happenings. The results of some studies showed that misconceptions were due to the fact that students tended to confuse the terms. (Hardt and Paula, 1997; Chandrasegaran, Treagust and Mocerino, 2008). Overgeneralization was found to be the
cause of misconceptions by Hershey (2004) and Misclassification and Misidentification were found to be the causes of misconceptions by Fisher (1985); Chen and Lin (2003); Ross (2004); Language imprecision was found to be the cause of misconceptions by Mester (1982, 1986); Comins (1993).

• Experimental Treatment was given by many researchers to the students having misconceptions and concluded that it is difficult to overcome the misconceptions even after the course (Fredette and Clement, 1981; Adeniyi, 1985; Dupin and Johsua, 1987; Griffiths et al., 1988; Hartman, 1996; Hill, 1997). Some studies were conducted to discover the impact of remedial teaching programmes for correcting reducing the common errors and misconceptions (Hand, 1989; Raman, J., 1989; Seymour and Longden, 1991; Setlage, 1994; Berry, 2000; Li, 2000; Ozkam, 2001; Eryilmaz, 2002; Demircioglu, 2005; Sarikaya, 2007; Chandrasegaran, Treagust and Moscerino, 2008).

A large number of studies into students' alternative conceptions have occurred over past 40 years, with many of these studies investigating various aspects of science but few studies are in the field of biology and even fewer involved the topic environment. However, there is paucity of researchers in the area "errors and misconceptions in learning of scientific concepts" in Indian Context. Hence the present study is an endeavour in this direction to provide empirical evidence with regard to problems in learning of scientific concepts with objectivity and scientifically and also to identify the students conceptions and their understanding sources.

2.6 HYPOTHESES

• There will be no significant gender differences in pattern of errors and misconceptions and sources of errors and misconceptions on Concept Achievement Test (CAT) in science, committed by secondary school students.

• The rural secondary school students will differ from urban secondary school students in their pattern of errors and misconceptions on Concept Achievement Test (CAT) in science.
- The students with favourable scientific attitude will differ from students with unfavourable scientific attitude in their pattern of errors and misconceptions on Concept Achievement Test (CAT) in science.

- The students with high academic achievement will differ from students with low academic achievement in their pattern of errors and misconceptions on Concept Achievement Test (CAT) in science.