INTRODUCTION

In the last few years at ASERA two aspects of secondary school science education have been highlighted. One is the clarification of goals in science teaching. Fensham (1980) described new objectives for science teaching; Karplus (1980) described teaching for the development of reasoning. The other is the growing number of reports about students' understanding of science learnt at school. Almost without exception these reports contain rather disquieting observations about students' misunderstandings of basic scientific concepts. Osborne (1980) coined the term 'children's science', which he showed could be very different from the 'scientists' science' of textbooks and school curricula. Gunstone and White (1980) reported conflict between tertiary physics students' expectations of events ('learned science'), and their subsequent explanations of observed events ('real world science'). Using unfamiliar problems set in the real-world rather than traditional textbook knowledge, I have found that the majority of biology students entering tertiary studies are unable to recognize problems based on the concept of natural selection (Brumby 1981), or to provide scientific reasoning to identify if an unfamiliar object was alive, dead or non-living (Brumby 1982). Other studies with tertiary students (Baird & White 1982; West, Fensham and Garrard, 1981) show that basic genetics and chemistry concepts, although studied at school, have not been clearly understood.

Where does the problem arise? Novak (1976) attributes much to school teaching methods which still encourage 'right' answers, and to exams which primarily assess factual knowledge. These result in students memorising or rote-learning their work, rather than actively integrating new material with their existing knowledge, and applying it to relevant problems. This latter active form of learning has been called meaningful-learning by Ausubel (1968). Despite our growing concern about the implications of these results of science education research, students continue to spend hundreds of hours studying and 'doing' Science at school.

Due to tertiary selection procedures, some of the most successful secondary science students enter tertiary medical school. While working with the first-year medical students at Monash in 1981 on their understanding of basic biological concepts, I became aware of a curious gap in their explanations. It was not so much what they did say, but rather what they did not say, in attempting to solve unfamiliar biological problems. This paper presents these findings.

METHODS

Four divergent problems were given to the students during the year, in different formats:
1. **Mars Problem**

If you were on the first manned space-ship to land on Mars, what evidence would you look for to determine whether living organisms exist there?

(Written problem, written explanation, March, replacing normal lecture, n=150)

2. **Rock Problem**

If you were walking along the beach, and came across this, how would you go about finding out if it is alive, if it was once alive but is now dead, or if it has never been alive, i.e., non-living?

(Oral problem with greyish-green rock, student taped 'thinking aloud' and subsequently transcribed, individual interviews March-April, n=32)

3. **Nuclear Problem**

Recently there occurred a nuclear accident at the Three-mile Island nuclear plant, in America, and a considerable amount of radioactive material escaped into the surrounding environment.

If you were a doctor working at a nearby hospital, and were asked to join an expert committee to monitor the effects of this leak, what ideas would you put forward?

(Oral problem, individual written explanation, September, at beginning of normal lecture, n=121)

4. **Natural Selection Problem**

Explain briefly, but clearly, why a member of the medical profession should understand the process of natural selection. Give two examples of medical importance.

(10 marks, 11 lines)

(End-of-year Biology exam question, n=160, written by course lecturer)

Students explanations were analysed and categories subsequently formed.

**RESULTS**

The full categories of these problems are contained in Appendix 1. The absence of scientific experimentation or reasoning was strikingly obvious in problems at the beginning of the year.

1. In the Mars Problem, students focused on one answer, so results in Appendix 1 are percentages of students who answered in that category. Eleven students (7%) designed experiments which could reveal the presence of life:

'Whether the life processes that we know of, e.g., respirations or photosynthesis occur there. One approach would be to incubate a soil sample, labelled with radioactive nutrients and see whether radioactive CO$_2$ was evolved'.