mathematics such as conservation of number, mass and volume, classifications, and sequencing by size. Later, studies of situated cognition in mathematics learning (e.g. Lave, 1988; Nunes, Schliemann, & Carraher, 1993) not only emphasised the importance of context but also directed further attention to content. In science, studies of students’ beliefs mushroomed (Pfundt and Duit, 1994, provide a bibliography of several thousand studies).

The initial studies in science were descriptive, in which researchers reported elucidations of students’ beliefs. They uncovered many instances where students’ conceptions were at odds with scientists’ portrayal of the world, and often where they differed from what they had been taught in school. The next phase of research was to see how alternative conceptions could be displaced by the scientists’ portrayal. This proved to be much more difficult than the researchers had imagined. Even when students acquired the scientific explanation, they often kept their original contradictory beliefs as well (Brumby, 1979; Gunstone, Champagne, & Klopfer, 1981). In some contexts, such as formal school tests, they could respond with the scientific view, while in less formal out-of-school contexts they would rely on the earlier belief.

Content-general principles for change in belief, such as the much-cited statement of Posner, Strike, Hewson, & Gertzog (1982) that it requires dissatisfaction with the present belief and that the new belief must be intelligible, plausible, and fruitful, did not lead to practical methods of intervention. It is not easy, for instance, to make people dissatisfied with an ingrained belief that must have been suiting them quite well for a long time.

The difficulties that researchers experienced in their attempts to bring students’ conceptions into line with those of scientists stimulated interest in how alternative beliefs form in the first place. Although differences exist between theories of early learning, such as those of Carey (1985) and diSessa (1988), all accept the obvious principle that children form their ideas through interactions with the physical world. Play, in which they push, pull, drop and throw things, gives them notions of force and motion. Other experiences lead them to ideas of solids and liquids and gases, of living and non-living, and of plants and animals. Of course social transmission also has an effect. Parents, other adults and older children, stories and television, all present the child with interpretations of the world that might not be scientific.

A point to note is that topics vary in their openness to both experience and social transmission. White (1994) attempted to codify this variation by defining dimensions of content. One dimension is how open a topic is to common experience, and another is how abstract it is. White argues that students are less likely to come to the classroom with beliefs about topics for which they have had little experience or that are abstract. White’s theme is that where a topic stands on the set of dimensions should influence how it should be taught, and how alternative conceptions might be addressed.

White’s analysis is a step towards a sophisticated appreciation of subject matter and its teaching and learning. It deals with an important question: Is each topic idiosyncratic, or are there principles that apply across a number of topics with similar properties? The chapters in this section carry the sophistication further not only by providing positive evidence about that question, but also by opening up
another important issue: Does conceptual change require a different type of knowledge that enables learners to see a subject and the topics within it in a new way? Though all four chapters bear on both questions, that by Stavy, Tsamir, and Tirosh is more directly concerned with the idiosyncratic nature of topics, and those by Limón, Leach and Lewis, and Merenluoto and Lehtinen more with knowledge that leads to a new perception.

2. IDIOSYNCRACY VERSUS HOMOGENEITY OF TOPICS

I criticised above early research for treating content as homogeneous rather than as a variable that should affect the method of teaching. It would, however, make teaching even more difficult than it is if topics were totally diverse. That would require researchers to investigate every separate topic to discover, and then to try to counter, the alternative beliefs that students are likely to hold about it. Consequently one would hope that even if content is not psychologically homogeneous some regularities exist and can be found. That is, there is a half-way position, a balance between uniformity and individualistic chaos.

Regularities lie behind Piaget’s stages of operational thought, where conservation is a general principle that applies to several quantities. They also appear in diSessa’s (1988) phenomenological primitives and in Bliss and Ogborn’s (1994) prototypes. In proposing that “a small number of intuitive rules…direct our responses in many situations”, Stavy, Tsamir, and Tirosh make it clear that they, too, intend to identify “phenomenological primitives”. They mention four that their research is to focus on, and provide details about their study of one, the notion that more of one variable will be accompanied by more of another, or as they put it more succinctly, ‘More A, more B.’

In diverse situations Stavy et al. found that many students implement the More A, More B rule. This is useful for teachers to know, since there will be many topics where the rule will lead to fallacious expectations, interpretations, and beliefs. Alerted to this, teachers would be prepared in advance to head off error. Teaching to counter More A, More B might be an explicit part of the curriculum, with students learning about situations where the rule does not apply. Some such situations are important in themselves. An example is where people take excessive quantities of analgesics or other medicines in the belief that the more they take the better the effect. Not so important, but an example that interests me personally, is a belief I once had that the more I knew about a subject the more I would feel that I understood it; I now appreciate that after a certain amount of knowledge is gained, an appreciation can grow that one’s understanding is less complete than one had thought. It is interesting to see More A, More B thinking occur in a topic so different from the examples that Stavy et al. describe.

3. KNOWLEDGE THAT SUPPORTS NEW PERCEPTIONS

Many authors (e.g. Fensham, 1988) have discussed the tension between teaching science to produce future scientists and teaching it to produce a generally informed