Ray Paton, Mary Meyer

Introduction

The representations and interpretations of knowledge are crucial to the pursuit of science. They are not only central to education and the communication of the subject matter but also to the practice and evolution of the subjects. Furthermore, as there is still no single all-pervading approach to science so there is no single way of communication within or between emerging areas of knowledge. Maybe we could be reminded of the comments of two notable twentieth century scientists on this subject. For example, Ilya Prigogine noted:

> "... the world is richer than it is possible to express in any single language. Music is not exhausted by its successive stylization from Bach to Schoenberg. Similarly, we cannot condense into a single description the various aspects of our experience. We must call upon numerous descriptions, irreducible one to the other, but connected to each other by precise rules of translation (technically called transformations)."
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> Prigogine (1980), p51.

In a similar but maybe more graphic manner Freeman Dyson suggested that:

> "... there is no such thing as a unique scientific vision ... science is a mosaic of partial and conflicting visions ... If we try to squeeze science into a single viewpoint ... we are like Procrustes chopping off the feet of his guests when they do not fit on the bed"
>
> Dyson (1995)

Although there is no single way to construct, interpret or represent the scientific enterprise there are ways of exchanging ideas and gaining insights on one domain of study through coming to a richer understanding of other domains. A variety of representations and interpretations persist and there are close interrelations between some of these especially through visual media and analogy.

The contents of this volume could have been organised in many ways around a number of topics. In the end we have decided to order it into four groupings - representations, biomedical domains, retrospections, and cognitive domains. The first group of papers is collected together around a theme of general issues regarding representation and cover mathematical, statistical and conceptual representations (Ehresmann and Vanbremeersch - Parker-Jones and Pilkington). From here issues related to the representation of time in biological systems are introduced (Matsuno) and then follows a number of other papers on bio-medical themes. This is concluded with a retrospective and reflective account of the history of medical practice (Dioguardi). Three papers then follow that maintain the theme of retrospection, professional practice and time. The last of these (Lund and Paton) also deals with issues of brain and mind around which the next three papers (Harre - Erdi and Tsuda). The final paper (Meyer and Paton) draws together a number of themes in relation to multidisciplinary research. In order to provide the reader with an overview we shall now discuss the contributions (based around authors' abstracts).

This special volume begins with a paper by **Andree Ehresmann** and **Jean- Paul Vanbremeersch** that deals with the topic of Memory Evolutive Systems (MESs). These have been developed from a mathematical model, based on Category Theory, and are applied to open autonomous hierarchical systems as found in biological and social systems. MESs can provide a framework in which to study the formation, representation and interpretation of knowledge. The authors note that an MES can acquire pragmatic or conceptual knowledge through the coordinated action of a net of competitive internal patterns of agents, called coregulators (or CRs). This knowledge is not rigid, but is adapted to different situations subject to an appropriate choice of some parameters.

Ehresmann and Vanbremeersch's paper leads us to some issues regarding mathematical representations and interpretations which is taken up by **Ronnie Brown** and **Tim Porter.** The main theme of their article are to show how the abstraction processes of mathematics allow for hierarchies of structure in which a process such as a comparison becomes an object and so allows for methods of comparison to be compared. What is more a representation of an object need not be unique, and the comparison of representations is important for our understanding and use of an abstraction process.

The next paper by **Ronnie Brown** is a mathematician's reflections on the works of a collaborator, John Robinson, who happens to be a sculptor. The aim of this article is to raise questions on the place of art in the investigation of Knowledge: representation and interpretation. To this end, we examine symbolism in the context of the Universe Series of Symbolic Sculptures by John Robinson. Brown also briefly discusses the place of symbols in an evolutionary context.

The paper by **Sallie Keller-McNulty** and **Mark McNulty** describes statistical representation as the science/art of using data to describe the world around us. They argue that statistical representation is based upon the fundamental concept that data consists of structure plus noise. There are numerous ways of constructing statistical representations. The methods discussed here include tables, graphs, and models. The proper representation depends upon the nature of the data and the particular issues being addressed. A combination of methods is often appropriate. The challenge facing the statistician is using the noisy data to learn about the underlying structure.

The paper by **Christine Parker-Jones** and **Rachel Pilkington** is concerned with the representation of concepts again using a visual approach. The authors report on work with medical students in relation to the acquisition of critical thinking skills to support diagnostic reasoning. Their paper examines the use of Concept Maps as an aid to learning whilst interacting with a simulation of calcium metabolism. Simulations can be particularly useful in providing a meaningful context in which students can both acquire conceptual models of complex systems and practise diagnostic reasoning. However, work with simulations can be shallow and their full potential for learning may not be realised unless students are supported with appropriate active tasks and scenarios. Concept Maps also provide useful insights into the completeness and consistency of students' mental models following interaction with a simulation model.

Koichiro Matsuno's paper is the first of a number of contributions with a distinctive biological or biomedical emphasis. The issue he addresses concerns the microphysical level of biological systems and he argues that the representation of the activity of experiencing in the empirical world is a formidable task. An internalist account of this level is presented in which the „activity of experiencing" is about the concrete particulars addressed only in the present progressive and in the present perfect tense. Representation will come to be conceivable if the concrete particulars addressed in the present perfect happen to be identical with those addressed also in the present progressive tense. Unless the present perfect tense is equated to the present progressive in the present tense, there would be no representation. Nonetheless, there is a possibility to think of a representation under the condition that it can frequently be updated. From the internalist perspective, short-lived representations can be appreciated when there is an understanding and view of the present tense.

David Goodsell's work brings together the disciplines of molecular biology and visual representations in an imaginative and influential perspective on the complexities of packing and interaction at the molecular level. He notes that biological molecules are too small for direct imaging and so synthetic images are used for the study and presentation of molecular structure. Three basic types of such images are widely used, each using different fictional elements to display

contrasting aspects of the structure namely, bond diagrams spacefilling diagrams and ribbon diagrams. Goodsell discusses how the widespread, and nearly exclusive, use of these three types of diagrams has influenced the course of biomolecular research and the perception of molecules in the popular media.

Lev Beloussov discusses two alternative versions of interpreting the developmental events in biological systems. The first regards development as a set of highly specific steps each of which is caused by a unique special force, or an "instruction". In this version, nothing outside the rigidly determined chain of events is presented, and the ultimate aim of a researcher is to produce a list of specific instructions. The second version is centred around the idea of an extended spatio-temporal continuum (morphogenetic field). Any developmental trajectory is now considered to be the function of this continuum's geometry. Within the context of this alternative we review the classical embryological data related to inductive phenomena and embryonic regulations. The contours of a morphogenetic field theory are sketched.

The paper by **Philip Maini** provides an interesting link between the work of an embryologist (Beloussov) and a physician (Dioguardi) - both of whom are seeking to employ mathematical constructs in their work. Maini notes how one of the main immediate challenges in the biomedical sciences is the synthesis of the vast amount of data now available at the molecular and cellular levels for development, regulation and repair. This, in turn, requires an understanding of the interaction and coordination of a myriad of complex inter-related processes occurring on very different spatial and temporal scales. Mathematics provides the obvious language in which to develop and interpret these interactions, and a number of mathematical models have already been proposed to account for certain observed biological and medical phenomena. Here, we consider two areas of modelling, namely spatial patterning, and wound healing, both sharing the common underlying processes of cells creating and responding to signalling cues.

Nicola Dioguardi looks at the development of the practice of Western medicine by dividing it into three epochs. The first epoch is characterized by the belief (episteme) in a certainty that is derived from a transcendental faith. During the second epoch, which began in the Baroque period and there was a belief that was based on the certainties derived from faith in scientific research. The third and present epoch is increasingly characterised by an episteme whose essence lies in uncertainty due to the complexity highlighted by technology. The scenario of the death of the "nineteenth century" physician at the end of the second millennium is not only characterized by the occurrence of scientific revolutions since it is enriched by the new organisation of medical practice. Dioguardi argues that the mental torpor induced by specialisation has produced a kind of intellectual isolation which, in the case of late twentieth century medicine has reduced the enjoyment of theoretical speculation as a means of *fertilising* the pragmatic theories of medicine,

and has led clinicians to lose much of their aptitude for synthesis. What is more, this has restricted the curiosity of the physician to go deep into what is known leaving small space for looking over the bounds of the unknown.

The article by **Martin Perl and Mary Meyer** is a retrospective on the former's experience as an experimental physicist. It is addressed especially to young research scientists. Perl reflects on almost 50 years of experience in experimental science to pass on what he has learned. His lessons are presented as maxims and illustrated by the experiences that led to their formation. Perl's focus is on the researchers as integral part of the experiment; for example, his first maxim is that the experimenter must take account of his or her personality and temperament in selecting experiments. Some of his main lessons are presented as key and recurring maxims. This paper is based on Perl's Nobel Prix 1995 paper, "Reflections on the Discovery of the Tau Lepton", and supplemented by excerpts from his presentation, "Reflections on Experimental Science", which was given to an audience of mainly young scientists at Los Alamos National Laboratory on June 29, 1999.

Laura McNamara's paper is an ethnographic study of shifts in constructions of time among nuclear weapons experts at Los Alamos National Laboratory. It frames the Laboratory's weapons experts as members of a community of practice organised around the production of confidence in the American nuclear stockpile. Throughout the Cold War, this community's activities were patterned by several interlocking cycles, including the arms race, cycles of weapons acquisition, and most immediately, a local experimental cycle in which the community designed, engineered, and tested prototype devices. This local experimental cycle also served as a site for the renewal of the community and its knowledge, as novice experts acquired skills and abilities and seniors reinscribed understandings about how weapons work. However, these cyclical rhythms broke apart as the Cold War ended, leaving the weapons community without the design-and-test cycle as a central point of social organisation. The paper argues that in the wake of these changes, local references to time emphasise a shift from cyclical rhythms of renewal to a more linear understanding of time, in which time has become a force for ageing and decay.

The paper by **Charles Lund** and **Ray Paton** reports on work that is concerned with the development of meaningful communication between an expert practitioner in psychotherapy and trainees, especially within the context of supervision. In order to facilitate this communication a dialogue has been established between the expert and a hermeneut; the latter being concerned with the characterisation of complex domains of knowledge. The challenge of this ongoing study is to analyse some of the key concepts in the psychiatrist's domain of expertise with the result of developing a visual metaphor for helping to integrate and clarify these concepts.

The next three papers develop the cognitive theme. **Rom Harre's** paper addresses issues of binding the cognitive activities of human beings into a coherent conceptual system with the neurological basis of these activities within the domain of cognitive science. He argues that the problem is partly due to the complexity of the relationships that must be set up between a naturalistic analysis of discursive practices such as remembering, and the brain mechanisms by which they are accomplished. The transition from human activity to neurological hypothesis can be accomplished by a second step of modelling in which standard cognitive models are revised by the use of connectionist architectures, to provide a foundation for plausible neurological hypotheses. The argument is set out in the context of the psychology of remembering.

Olaf Sporns examines the ways a nervous system goes about balancing the seemingly opposing requirements of extraction from sensory inputs and generation of coherent internal states. The need to quickly and reliably to extract important features from sensory inputs is accomplished by functionally segregated (specialised) sets of neurones, e.g. those found in different cortical areas. The need to generate coherent perceptual and cognitive states allows an organism to respond to objects and events, and represents conjunctions of numerous individual features. This is accomplished by functional integration of the activity of specialised neurones through their dynamic interactions. Empirical and computational studies suggesting that changes in functional connectivity may underlie specific perceptual and cognitive states involving the integration of information across specialised areas of the brain offer new insights into the linkage between neural dynamics and cognitive synthesis.

Peter Erdi and **Ichioro Tsuda** apply hermeneutics, the art of the interpretation, to brain theory. The relevance of concepts of hermeneutic processes and hermeneutic devices to brain theory are explained. This paper is the emergent result of a series of long conversations between the authors who first met in 1983 on a train towards Schloss Elmau, where the Synergetics of the Brain conference was organised by Hermann Haken. The paper is presented in a dialogical interpretative form.

The volume concludes with a paper by **Mary Meyer** and **Ray Paton** that addresses challenging problems of representation, interpretation and integration of knowledge to many emerging and established disciplines that must make use of the transfer of ideas, ways of thinking, and practice. An experimental approach, called ECLECTIC, is introduced to help tackle some of these problems. Like the knowledge domains it seeks to address, ECLECTIC is an evolving approach that not only reflects its history (i.e., the background of people applying it and the domains to which it has been applied) but also anticipates and is sensitive to future areas of multidisciplinary knowledge. This paper and indeed this volume of papers are concerned with many issues that have to be faced as domains of knowledge evolve.

Editorial Notes

The reader will be aware that the authors come from many different disciplines and also there are a number of papers with authors whose first language is not English. It has been a deliberate editorial policy to edit papers so that they are readable but not to change the style or mode of the presentation to any standard format. What is more a single convention to the writing of English (e.g., U.K. or U.S.A.) has not been followed so for example, spelling and paragraphing conventions reflect country of origin.

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References

Dyson, F. (1995), "The Scientist as Rebel", in Cornwell, J. (ed) *Nature's Imagination The Frontiers of Scientific Vision*, Oxford: OUP.

Prigogine, I. (1980), *From Being to Becoming*, San Francisco: W. H. Freeman.