makes no such appeal to law and thus cannot function in the same way. In order to illustrate the demarcation between science and non-science, I shall look at the alternative approaches to organic origins provided by contemporary evolutionary theory and so-called "creation science". I shall say that evolutionary theory and only evolutionary theory is genuine science and this fact can be seen by appeal to the criterion invoked above, specifically the reliance on natural laws.

Good Science, Bad Science, Dreadful Science and Psuedo Science. PHILIP KITCHER (University of Vermont)

Doctrines which scientists like to think of as firmly established are periodically challenged in ways that appeal to the public imagination. The recent vogue of "Creation Science" is only one of a number of twentieth century movements designed to reassure the gullible that uncomfortable pieces of scientific orthodoxy can be dismissed. In response to such assaults, defenders of science often try to label the opposition as purveying pseudo science. My paper is an attempt to show that this tactic requires more careful handling than is usually required. Once, there seemed to be a simple test for distinguishing science from pseudo science: genuine science is falsifiable, pseudo science is not. Many scientists have applied this test with gusto, using it not only to berate those maverick writers who secure a popular following for some crackbrained idea but their scientific colleagues as well. Unfortunately, the test is far too simple. As the "Creation Scientists" have taught us, it can be turned against scientific achievement that are rightly honored. There are great differences among good science, bad science, dreadful science, and pseudo science. These differences turn on a battery of tests (some of which articulate what was right in the simple idea of pseudo science as unfalsifiable), and they are differences of degree. When dreadful science becomes sufficiently egregious it earns the right to be called "pseudo science". Understanding the multi-faceted character of good science is important, not only for winning debates with misguided fanatics but also for avoiding simplistic and over-hasty resolution of internal scientific disputes.

Pseudo Scientific Thinking. PAUL THAGARD (U. of Michigan)

Past attempts to demarcate science from pseudo science on the basis of verifiability are now regarded as unsuccessful. This paper uses a broader psychological framework to question whether it is possible to distinguish scientific thinking from pseudo scientific thinking. It first describes a common type of pseudo scientific thinking which infers that objects or events are causally connected merely on the basis of their similarity. Illustrations are given from astrology, graphology and other pseudo sciences. However, not all pseudo scientific thinking is of this sort. In particular, so-called "Creation Science" uses patterns of reasoning that are very similar to scientific ones, and even astrology sometimes tests hyptheses. It is argued that in cases such as these an historical dimension is required to distinguish scientific and pseudo scientific thinking. Over time, practioners of a pseudo science fail to advance their theories despite competition from progressive alternatives.

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Understanding the Process of Transformation of Knowledge

Arranged by ARISTIDE H. ESSER (Association for the Study of Man-Environment Relations, Inc., Orangeburg, N.Y.) and WILLIAM GRAY (Massachusetts Department of Mental Health, Malden)

Mon., 30 May / LaSalle A

9:00 a.m. - 12:00 m.

Implications of an Ecology of Knowledge for Multicultural Synergy. JERZY A. WOJCIECHOWSKI (University of Ottawa).

Man behaves in the light of his knowledge. The man-knowledge relationship determines the evolution of mankind. Among the many problems which the impact of knowledge on man creates is the multiplicity of culturally determined bodies of knowledge (knowledge constructs). What in fact exists is not one body of knowledge, but a variety of systems of knowledge representing different visions of reality. The presumed homogeneity of the scientific knowledge construct cannot replace the cultural variety because science does not offer an exhaustive view of reality. This creates the problem of devising a method of transcultural communication and cooperation necessary for implementing the planetarization of humanity.

Culture as Social Foundation WILLIAM H. VANDERBURG (University of Toronto)

All throughout history, societies have interpreted their experience and shaped their relationships between their members and with the world into a coherent way of life by means of a culture. One of the remarkable things about these cultures is their extraordinary diversity. Apparently the way human beings are linked to reality is genetically determined at birth only to a very limited degree. On this basis a theory of culture as the social ecology of a society has been developed. Mental structures acquired from experience graft themselves onto those established genetically and the two become inextricably related. By building up models of the structure of our past experience, new insight can be gained into the way human beings are linked to reality and how a society by means of its culture establishes an artificial (that is, non-natural) order as the basis for social life. The research is aimed at showing how science and technology have become partial alternatives to traditional cultures by constituting the first universal subculture. The latter is transforming traditional cultures in very similar ways, causing a marked decrease in the diversity of human cultures. This has some important implications.

Heterogenism, Mutualism and Poly-ocular Vision. MAGOROH MARUYAMA (University of California Los Angeles)

The basic principles of biological and social processes are: increase of heterogeneity by interaction; and formation of mutually beneficial combinations among heterogeneous elements. Heterogeneity is basic, indispensable and desirable. These principles apply to cultural heterogeneity in the world and individual diversity in each culture. Similarly in binocular and poly-ocular vision, the differences between images enable the brain to compute dimensions which are invisible to all eyes. Different points of view are necessary and useful in computing dimensions invisible to all parties. The usual white-American and European assumption that similarities and consensus are needed for peace is a fallacy based on a homogenistic logic. Heterogenism is more scientific. Some of the African and Asian cultures are based on heterogenistic logics of mutual benefit and poly-ocular vision. We must foster heterogeneity, and develop the art and the science of making mutually beneficial combinations among heterogeneous cultures and individuals, such as have been cultivated in the Japanese garden design and floral design over many centuries. While European architectural and spatial designs are based on principles of unity by similarity, repetition, opposition, tension and extension, other cultures have articulated the principles of heterogenization, connectedness and convertibility in art as well as in practical matters such as job rotation of workers in factories, and policy decision processes.

Generating Emotions in Computer Systems. BRIAN R. GAINES and MILDRED L. SHAW (Centre for Man-Computer Studies).

The use of close person-computer interaction to extend our knowledge processes is one of the most significant applications of computer technology. However, whereas person-person communications are rich and subtle with information being carried at many levels, person-computer communications is currently single-level and simplistic. A wide variety of

Gaines, B. R. and Shaw, M. L. G. (1983). Generating emotions in computer systems. In Abstracts of 149th Annual Meeting of the American Association for the Advancement of Science, pp. 103-104.

techniques are being developed to open up the window between the person and the computer and allow both parties to the interaction to become more responsive to the other's processes. In this paper we analyse techniques for building into computer systems the equivalent of human emotions through which so much of our response to information is normally expressed. The theoretical foundations of our work are based on a model of inductive inference using a notion of "surprise," coupled with Kelly's model of emotions as generated by the violation of "core" constructs. The work is illustrated with applications to database and expert systems.

Microprocessors and the Third World. PAUL TRACHTMAN (Smithsonian Institution).

Microprocessors have been proposed as a powerful new technology that could be used rapidly to transform Third World societies, enabling them to "leapfrog" the industrial revolution by developing new information industries that require smaller investments of capital and energy.

Many of the pathologies that have resulted from transferring industrial technologies to Third World societies during the last few decades have been seen as "unforeseen results," or "side effects." The breakdown of traditional agriculture after the introduction of hybrid seeds, fertilizers and mechanized equipment, with resulting decline in the quality of the diet and lowering of public health, is an example. My purpose in presenting this paper is to attempt to foresee some of the "unforeseen results" that could accompany the transfer of computer technology to the Third World.

While it is possible for microprocessors to be the catalyst for rapid economic development in the Third World, it is also possible for the computer to be a chimera, one of those Greek monsters with a lion's body, goat's head and dragon's tail, bringing only further destruction of traditional societies and even greater economic dependence on the developed world. Associated issues, problems and possibilities will be discussed.

Science and Technology in the Service of Pluriculturalism. ARISTIDE H. ESSER (Assn. for the Study of Man-Environment Relations) and WILLIAM GRAY (Massachusetts Department of Mental Health)

Knowledge transfer and technology transfer must be carried out with regard for the existence and preservation of pluriculturalism in order to prevent dysfunctionality, for the senders and recipients of any knowledge are cultural beings. Even if a culture free transmission mode were possible, cultural beings would have to impose a cultural meaning on the supposedly culture free symbols, otherwise Brain/Behavior/Environment system forming, as described by Esser, could not take place. The Emotional-Cognitive Structure Theory of Gray relates scientific and technological creativity to particular personality shaping and individual experiences in the personal life history, such as Einstein's in the patent office and his subsequent exploration of simultaneity. The search for usable knowledge takes what is "known", and through a "window shopping" process transforms it to the "knowingly known". Thus the life experience and the cultural background serve as the nutrient bed for scientific knowledge. Scientific/technological and cultural evolution thus become linked in a co-evolutionary process allowing for the humane evolution of pluriculturalism. Examples from corporate cultures will be given.

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Philosophy of Science: Current Research and Implications for Science Education

Arranged by HARVEY SIEGEL (Sonoma State University, Rohnert Park, Cal.)

Tue., 31 May / Cadillac A

9:00 a.m. - 12:00 m.

Can Scientific Method Be Taught? D.C. PHILLIPS (Stanford University).

In order to teach scientific method, it first has to be known what this method is. In the past, science educators received helpful advice on this matter from scientists and philosophers - who, although they may have disagreed, were sure at least that there was a method there to be taught. Recent influential work in philosophy of science, however, suggests that there is no such thing. Where does this leave the science educator? Is their task, perhaps, the rather vague - but no doubt important - one of fostering critical rationality in their students? Is this sufficient preparation for their students to understand and pursue science?

Relativism, Rationality, and Science Education. HARVEY SIEGEL (Sonoma State University).

Recent philosophy of science has been preoccupied with two interrelated questions. First, is scientific knowledge relative, as Kuhn, Feyerabend, and perhaps Winch and Wittgenstein hold? Second, are the methods and procedures of scientific activity rational? If so, in what sense?

In this paper I shall explore these issues with an eye towards their ramifications for science education. In particular, I shall argue that, while scientific knowledge is not relative, contrary to Kuhn et.al., it would nevertheless be a mistake to conclude that science should be taught as if it offered certain, "absolute" conclusions. Rather, science education should emphasize pluralism and fallibilism, which suggest that scientific knowledge is neither certain nor relative.

Second, I shall argue that a central aim of science education (as well as the rest of education) is the development in students of the skills and dispositions of critical thinking. That is to say, science education should strive to develop the rationality of students in matters scientific. To do this, science education must incorporate insights gained from philosophy of science and epistemology concerning scientific methodology. In addition, science students must come to understand that scientific method, which focuses on scientific reasons, is itself subject to rational assessment and improvement.

The Theory-Ladenness of Science Teaching Objectives STEPHEN P. NORRIS (Memorial University of Newfoundland).

In 1958 N.R. Hanson upset much thinking in the philosophy of science with his negative response to the question, "Do Kepler and Tycho see the same thing in the east at dawn?". Observation, Hanson claimed, is theory-laden. Hanson's impact was supplemented and extended by P.K. Feyerabend and T.S. Kuhn, among others, offering an alternative to the logical empiricists' school of philosophy of science. This paper treats its relevance to the prediction and explanation of how science teaching objectives (whatever their basis) are perceived by those in various educational groups. Specifically, the following question, parallel to Hanson's, is addressed: "Do science curriculum developers and science teachers see the same thing in the objectives of a science curriculum?". As Hanson's question, this question too is answered negatively.

Evidence is presented which supports the negative answer and also indicates the type of difference in perspective which teachers and curriculum developers have. It is proposed that the difference is due to deep psychological and conceptual differences arising from the different understandings and the different roles which teachers and curriculum developers have. In short, objectives for teaching are theory-laden. This is used to argue that any attempt to make teacher-proof curriculums, itself an offshoot of logical empiricism, will not erase differences in perspective, which in turn will hinder the implementation of curriculums as intended by their developers.

Science Education and Moral Education. MICHAEL MARTIN (Boston University).

In this paper I argue that science education and moral education are mutually relevant to one another, that a good science education is relevant to moral education and conversely. Using a conception of science education developed in my book Concepts of Science Education and