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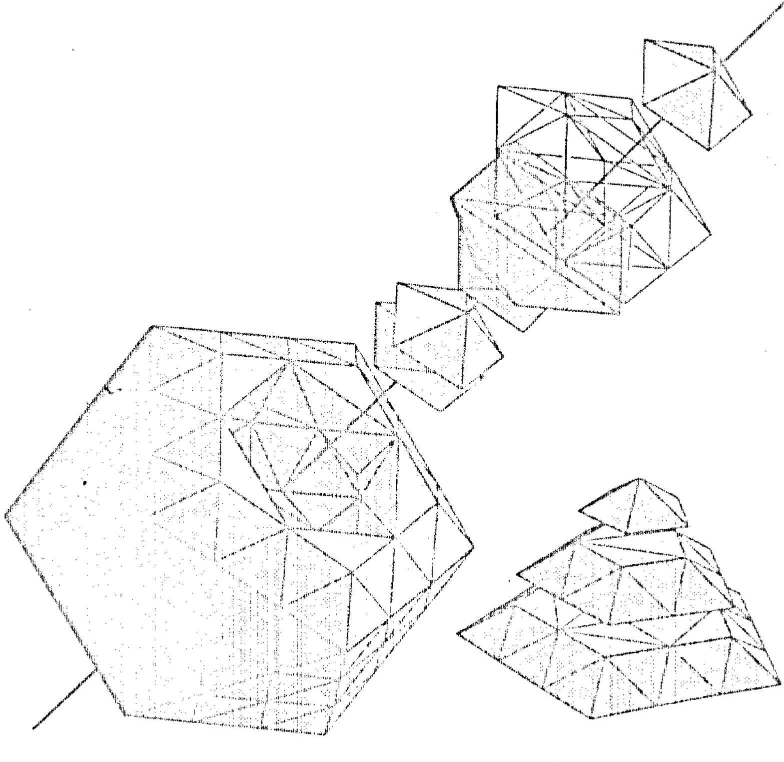

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A REPORT ON PROGRESS TOWARD AN ISIS-SYMMETRY INTERTAXONOMY

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INTRODUCTION

Among the first tasks of a new professional society is to define what it is all about. This must be focused at a level of detail to which each individual member-worker can relate. The definition of the work of the society is especially important in the interdisciplinary case, where the membership shares no common disciplinary vocabulary. In this case, a common skeleton must exist or be created, one which allows members to relate their work to one another. In fact, the very reason for forming ISIS-Symmetry (ISIS-S) was to take advantage of the wonderfully symbiotic contributions from work from disparate areas related through *symmetry*.

The first order in providing this skeleton for interdisciplinary sharing is the creation (and support) of a taxonomy for the society[*1]. At minimum, such a taxonomy will be useful for indexing papers, works, etc. in a bibliographic sense. It may well also provide a basis for a common vocabulary to examine the relationships among different individual disciplines. In that case, interdisciplinary value would be added to the dialogue about and the rationale for ISIS-S . The benefits of participation in ISIS-S would be greatly increased. New perspectives may emerge.

The need for such a taxonomy was raised in Budapest in 1989. 'A project area' was proposed, and a board position established related to the scientific questions surrounding the problem. The project was announced in the Journal (Goranson, 1990).

Some parallel efforts are underway in a similar international, interdisciplinary forum, so some initial thinking has been done. These initial thoughts were presented in Hiroshima as a proposed starting point for the project (Goranson, 1992). They are summarized in this report.

NATURE OF TAXONOMIES

Normally, a taxonomy for a discipline is not so much a project involving ideas as it is an accounting process. This is so because each individual discipline develops a fundamental set of concepts, uses a language (including shorthands, often mathematical) to express those concepts, and adopts certain elements of a worldview. In such a case, taxonomic controversies are few as the system evolves from the same consensus that forms the basis of the discipline.

Such taxonomies are normally simple in structure for three reasons:
– no formal process was considered in their development;
– they reflect the historical development of categories, for example, a subdiscipline is classed under a 'parent' discipline if its history derived from that parent.
– the underlying 'world view' is sufficiently robust to allow the taxonomy itself to be weak*2.

For these reasons, the simplest taxonomic structure is also the most common. Everywhere one turns, one finds hierarchical taxonomic structures. In textual form, these are 'indented' lists, often using tabs and/or some labeling scheme to show which is the parent entry and which is the child. In graphical form, these take the form of 'tree' structures which more clearly show levels and dominance. The indexing system used by Mathematical Reviews (which indexes this journal) is of the indented type, shown here generically in tree form.

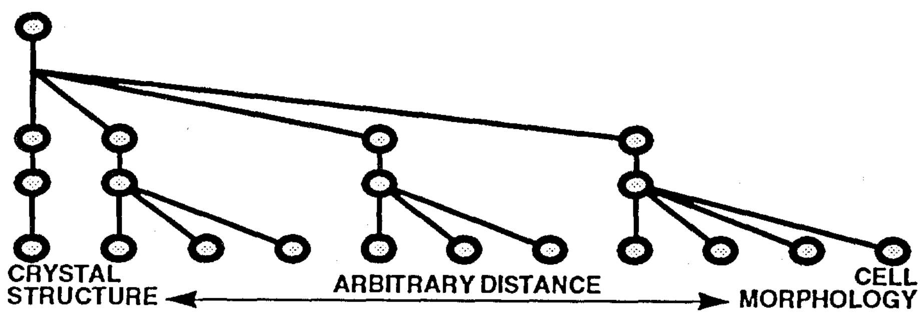


Figure 1

When one computerizes indexes and their taxonomies, the mechanics must be made more formal if they are not already sufficiently so. For example, the need to digitally store hierarchical indices has spawned a set of formal mechanisms of the 'indentured' type (similar to 'indented'). In this family, specific rules are developed as to what properties (or components of the 'world view') are inherited by the child, when the influence stops, how deep it goes and so on.

Such formal considerations are made necessary by the recent progress by the information science community into taxonomic considerations. As a result, new insights about how concepts are represented have emerged. These principles can be loosely considered as a new science of taxonomies, or more properly: 'Category Theory'. (See Asperti, 1991 for an introduction). The taxonomic principles depend heavily on concepts of symmetry and incidentally may be of significant utility in helping ISIS-S members understand one another.

THE SPECIAL NEEDS OF ISIS-S

ISIS-S is an interesting case. The disciplines represented within the society do not share a common parent science (at least not in historical times). There is no default consensus world view or shared language. The opposite is the case; maintaining the diversity of worldviews is the point. But this places the burden of providing a lowest common denominator for intercourse on the taxonomy.

A hierarchical breakdown of disciplines will not do for ISIS-S . Any one researcher may feel comfortable breaking disciplines into certain parents and children. But the distance between any two entries is somewhat arbitrary and the result will be seen as unacceptable to others. Figure 1 shows an example. It may be common practice to classify some crystallographic work deep within the physical sciences and similarly to place an example activity of cell morphology under the life sciences. Yet the analytical tools of certain workers may be much closer than the distance infers.

Is there a taxonomic methodology which would capture the similarity of the two disciplines? Could it indicate the linkages from individual workers which may share a common theoretical basis while maintaining differing applications? Could the many linkages contained therein be united under one common set of principles? Could those principles be the principles of symmetry? Finally, would it be possible for future researchers (or philosophers, theoreticians, indeed artists) to glean new insights into the fundamental (i.e. symmetric) principles which underlie the taxonomy?

ISIS-S CAN LEVERAGE NEW RESULTS

I believe that all of these questions can be answered in the affirmative. My confidence comes from taxonomic studies sponsored under international aegis on a similar problem. (Petrie, 1992, especially in the nine contributions of Goranson, define the problem and project.) In that case, the problem deals with the problem of common indexing, via computer, of the thousands of disciplines which must be coordinated in a large, complex industrial enterprise. Examples are semiconductor or aerospace enterprises.

This interdisciplinary work is well resourced and involves many bright minds and institutions. New results have emerged, some in fundamental new practical techniques. It may be no surprise to ISIS-S that a fundamental principle of such efforts involves symmetry. It appears that those techniques are applicable to the ISIS-S problem, resulting in a remarkable proposal: to use principles *of* symmetry to index work related *to* symmetry.

In particular, three techniques from this project can be put into service for the ISIS-S taxonomy. Each of these is briefly discussed below.

FIRST TECHNIQUE: A FEDERATED TAXONOMY

A guiding principle of the ISIS-S taxonomy project is the eschewing of creating yet another discipline, with its unique taxonomy. Instead, the ISIS-S taxonomy should allow the taxonomies of each individual discipline to be eminent. In such a case, the ISIS-S taxonomy would *federate* the taxonomies of the individual disciplines involved.

'Federation' is understood here as a special kind of synthesis, where the individual sources are preserved and are unconstrained. The federation mechanism is a unifier which allows concepts to be expressed in a neutral form. The most useful characteristic of a fully federated index is that each user can fully express the whole index in his/her own system.

As an example, our previously mentioned crystallographer has a set of indices and related tools to express the world; the molecular biologist another set, perhaps quite different. An unacceptable approach to enhancing the interdisciplinary dialogue is to force each to use a third, 'lowest common denominator' system.

A much better way is to provide a federating mechanism which maps or transforms perspectives, even concepts from one system into another. In this case, each individual uses the worldviews which are natural and the tools which are efficacious to the discipline.

Federated systems are much more challenging to create than traditional trees. It appears that two underlying mechanisms are required: A shared, higher unifying principle and a 'technology'[3] to support the transformation process of one system to another. The ISIS-S project has the former in *SYMMETRY*, and the latter in the condition of proliferating personal computing.

The first use for the federating, or *inter*taxonomy will probably be to index journal contributions. Nearly all of the disciplines involved in ISIS-S which have such indices, have automated tools for reference management. So the 'source' indices are already to a large extent computerized.

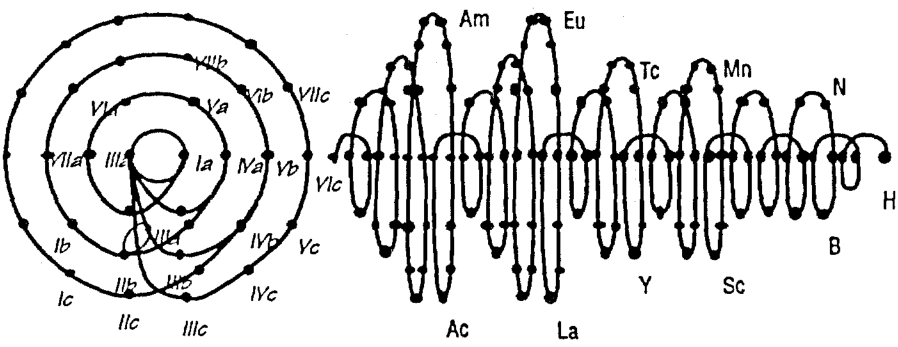
It is also presumably the case that most persons likely to find an intertaxonomy useful will have access to a computer. It is the in the nature of the society to be distributed globally. One would expect electronic media, such as the email journal, to be more preferred for many ISIS-S members.

SECOND TECHNIQUE: METASTRUCTURE

Methods of *abstraction* are fundamental to understanding. When one abstracts according to a structured system, he/she can reason in the abstraction in order to gain insights into the primary situation. It appears that all useful abstract systems have an internal structure. One could term this a 'physics', a 'grammar' or a 'mathematics', depending on one's background. The challenge of *federation* therefore depends on discovering an underlying, global structure of these individual structures.

This structure of structure, or *METASTRUCTURE*, would form the basis of the federation mechanism of an intertaxonomy, so is of especial interest. A simple example of metastructure is indicated in the figure 3. A (US) national laboratory has crystallographers and molecular biologists collaborating on a project. They were in need of common computerized models that both could use.

Among the problems encountered were profound differences in as fundamental a concept as the periodic table of elements. Each discipline had specific properties of the periodicity which were emphasized. But this difference in emphasis was sufficiently substantial to make the models distinct in structure. Resulting models from the system could not be related and the collaboration was threatened. Figure 2 schematically shows the two views*4. Note the fundamental differences in structure.



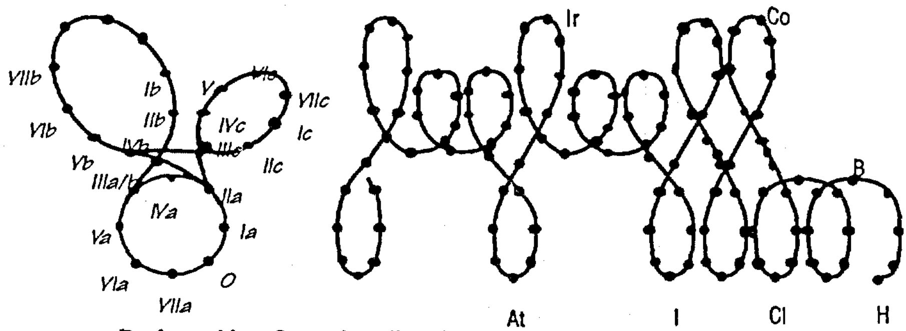


Figure 2: Two periodic tables.

There were also many other discipline-specific twists in this area, each peculiar to a different group of researchers and resulting in a 'different' periodic table. The solution was to devise a structure of these structures. (The method used is indicated by the number, types and relationships of the 'loops' shown on the left.) In a sense, this metastructure was a periodic table of periodic tables. At the same time, it contained all of the information of the various views.

Symmetry appears to be the only practical mechanism for creating and understanding these metastructures. (von Fraassen, 1989 is representative of the best presentations in this vein.) However, in considerations of symmetry, the application of metastructure is more straightforward than in the general case of metaphysics. This is because the *form* of the sources emphasizes the symmetric principles which can be leveraged for abstracting to a higher structural level. The most accessible use of this principle is Haresh Lalvani's work where polyhedral structures are used as an organizing mechanism for *types* of polyhedral forms. (Lalvani, 1982 and 1992 are representative of his work in this area.)

THIRD PRINCIPLE: LATTICES

The final basic technique proposed for use in the taxonomy project is the *CONCEPT LATTICE*. The idea originated in the set and group theoretical branch of mathematics (Wille, 1987); formally speaking, the technique defines the structure of relationships which themselves can be structures of relationships. As such, it can provide a theoretical foundation for a metastructure to federate individual taxonomies.

But the technique is useful for another reason: apart from the mathematics, it provides an intuitively accessible way of visualizing relationships, much like the 'tree' diagram of Figure 1, or the richer type of Figure 2. The approach has special power when the symmetry of the lattice is regulated. If this is done, all of the important properties of the lattice can be described *and easily seen* in terms of symmetry characteristics.

Figure 3 shows a simple concept lattice as an illustrative example. This type of lattice is directional, though many other, more powerful, types exist. Each of the four directions imparts a property, as shown by the four arrows. The lattice shows the same relationships as the table shown in Figure 4, a simple characterization of ten (fictitious) source taxonomies.

The ten rows of the table denote ten example disciplines. Row one might be a library discipline. The note indicates that this may be an ISIS-S contribution related to the properties of 'classifying classification'. This paper is an example. Row #7 is noted as a contribution on the symmetric properties of stained glass design (a personal interest of this reporter).

The first three columns show whether a property is held by one of the ten or not. A marker indicates yes; for example the study of stained glass work (row #7) emphasizes the use of intuitive methods, whereas row #6 does not. (It may be a more pedantic discipline or contribution.) The fourth column is more sophisticated. It shows, in crude sense, degree. An entry of 1 indicates some degree of the property – 2 shows twice that degree. So that the taxonomy paper (row #1) emphasizes intuitive access to the internal mechanics of the work to twice the extent that the fictitious contribution of row #7.

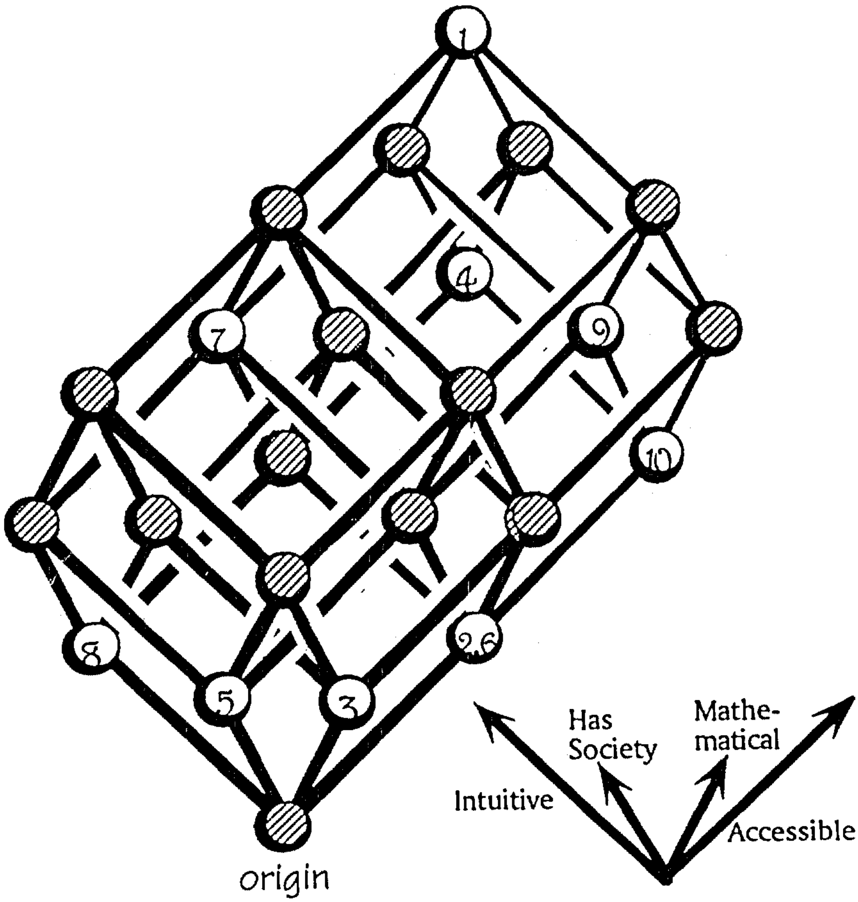


Figure 3: A simple concept lattice.

Turning to the lattice, one begins at the bottom. Moving in a direction bestows the property of that direction (shown by the four 'arrows'). So moving one unit in the direction of 1:00 denotes the property of 'using mathematical techniques', the same as the third column in the table. An entry of '3' at this node, shows that row #3 has that property and no other. Note that the notion of two levels of degree from column four shows in the lattice as a doubling of the basic cell.

In this simple example, the lattice appears to be a more complex system than the table. But in meaningful situations, the number of rows and columns is very large. And the table would require many dimensions. For example, there is a relationship (in our example) between whether the discipline *uses* intuitive methods (as in designing stained glass), and whether the discipline (as in understanding stained glass effects) emphasizes intuitive access. As a result, tables would have to be many dimensioned with additional tables to show column-to-column relationships.

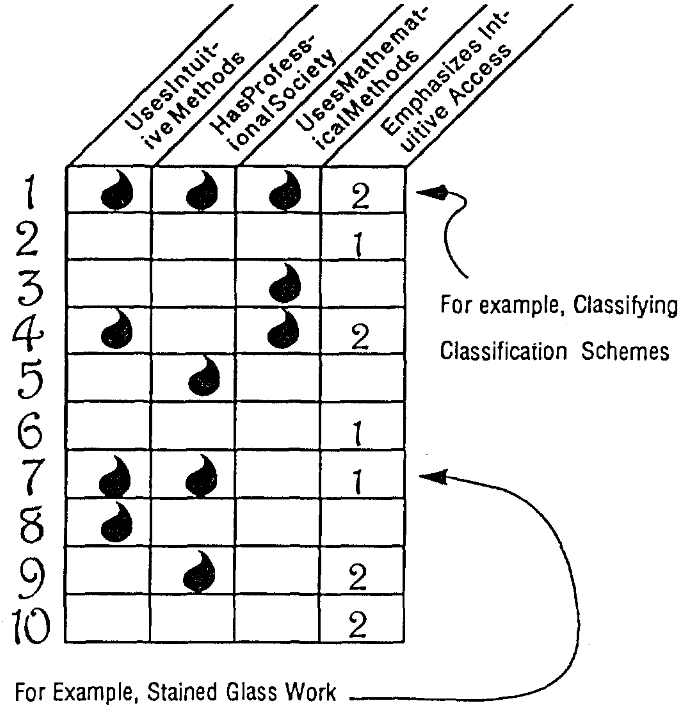


Figure 4: A table view of the lattice relationships.

As the situation represented grows more complex, the lattice does not, and therein lies its power. Every entry and property can be formally characterized by a few, fundamental symmetry properties. It is also the case that tree representations, tables and other conventional representations can be extracted from the lattice. In a practical sense, this means that the stained glass artist could have the entire lattice represented in whatever simple tree structure he or she is used to. This satisfies the requirement for federation.

Lattices used by Sirius-Beta for similar representation applications use techniques not shown in the example: the lattices are infinite and have multiple dimensions (internal to the machine); the lattices are dynamically linked among differing symmetry types; and new 'intersymmetries' are extracted for special shortcuts.

NEXT ACTIONS

These three techniques are proposed as a beginning dialogue toward an ISIS-S intertaxonomy. It is hoped that reaction to the proposal will prompt some response, and initiate the project as an activity within ISIS-S. In a future report, we will provide an example drawn from recent ISIS-S contributions.

REMARKS

*1 Another required task is to coherently recount the intellectual history behind the shared ideas. Note Nagy careful surveys (Nagy , 1990).

*2 Another perspective is that the formally considered elements of the taxonomy are kept vital in the world view, and the discipline's indexing systems is a mere artifact (as are the papers, etc.). In either case, attention is not paid to the explicit formal basis of the taxanomic system.

*3 The term is used here in the most general sense to include: spoken language, the printed word, diagrams and mathematical tools as well as more conventionally described technologies.

*4 The schematic representations are derived from Mazurs (1957), a study in alternative representations of the periodic table.

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