THE CHANGING STRUCTURE OF KNOWLEDGE

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[Traces the history of the concepts of the universe of knowledge as a dynamic continuum, the basis of its classification, the modes of its development, the fundamental categories, the facets, their rounds and levels, the notational devices developed, new main classes etc. as manifested in the writings of the Indian school of thought in classification.]

Formation of Classes

In 1937, Ranganathan published his Prolegomena to library classification, in which he explained the theory upon which his CC (=Colon Classification) was based. This theory is basically a certain conception of the pattern or structure of knowledge. The pattern described in 1937 is relatively simple, and his later analysis has made it progressively more complicated. The first part of this paper gives a brief outline of the way his views have developed.

11 Characteristic

He starts with a “universe” of entities (concrete and conceptual existents). Each entity has many attributes, and some of these can serve as characteristics for the division of the universe into groups or classes. In the Prolegomena, he laid down that attributes usable as characteristics should be relevant, ascertainable and relatively permanent.

12 Ranking

The groups so derived can then be ranked to give a helpful sequence in array. In the Prolegomena, the following principles of ranking were put forward: quantitative, developmental, spatial, temporal and canonical (conventional). In the Elements, these principles were set out more fully as: decreasing extension, increasing concreteness, evolutionary, chronological, geographical, increasing complexity, and canonical.

13 Seminal Mnemonics

The use of “seminal mnemonics” also effects ranking in array.
Ranganathan formulates sets of related concepts, which are ranked in the following sequence:

1. Fundamentals, preliminary, person, nomenclature.
2. Structure, morphology, parts, form, constitution, sources.
3. Function, physiology, activity, syntax, method, analysis, technique, transformation, distribution, interpretation.
4. Fault, pathology, social ills, disease, transport, interlinking, synthesis, hybrid.
5. Fluidity, liquid, sap, blood, ocean, control, beauty, energy, light, organic, environment.
7. Personality, magnetism, ontogeny, composition, growth, produce, value.
8. Management, organization, testing, equipment, fitness.

14 Modulated Chain

Each group is itself a fresh "universe" susceptible of division by another characteristic. Successive division by a train of characteristics gives rise to a chain of classes, which should be appropriately modulated. The meaning of "modulation", though clear enough to intuition, is not easy to define.

15 Main Class

In the practice of classification, the original universe to be divided is one of the main classes, defined by Ranganathan as "the fairly homogeneous, conventional regions of knowledge, which together form the first order array of classes which are mutually exclusive and totally exhaustive of the field of knowledge" (General theory). His later analysis recognizes other "original universes"; (1) canonical subdivisions of a main class, (2) "amplified" classes—i.e., main or canonical classes expounded according to a particular system of thought, or studied within specific boundary conditions.

2 Facet

Ranganathan next suggests that any such original universe can be divided by more than one train of characteristics, each train giving rise to one facet of the universe.
21 Fundamental Categories

The facets encountered in the field of knowledge are all manifestations of five fundamental categories—Time, Space, Energy, Matter and Personality. In any original universe, an Energy facet is always manifested, and either Matter or Personality. Time and Space do not necessarily appear. Each category may serve as a "proxy" to any of those which follow it in the order listed above. The most helpful sequence in which the facets are to be cited in a specific subject is the reverse of this sequence.

22 Rounds

The categories of Energy, Matter and Personality can be manifested more than once within a given original universe. The first Energy facet can introduce a second "round" of the Personality and Matter categories, the second Energy facet which follows can introduce a third round, and so on. Time and Space can figure only in the last round.

23 Levels

Even within any one facet, further levels of complexity are evident. The Time facet is dissected unidimensionally into a series of conventional time intervals, but there is sometimes need to indicate a stretch of time which overlaps these conventional divisions. The Space facet is dissected two-dimensionally into conventional geographical areas, but other groupings must be allowed for, in which the areas grouped are not necessarily adjacent (disjunctive incidence): for example (1) countries grouped round a certain sea, (2) climatic zones, (3) areas with common social, industrial, religious, etc., characteristics, (4) empires, (5) international associations. Physical features also cut across the conventional groupings.

The Energy category, Ranganathan postulates, is subject to no such complexity. He suggests that it can manifest itself only as a single array of terms in any one facet. Personality, however, exhibits levels—the whole personality may be subdivided into parts or organs, these in turn into sub-parts, and so on. Ranganathan has not as yet revealed any complexities in the Matter facet, which may figure as a "constituent" of personalities.
3 Dynamic Continuum

The above description of the structure of knowledge is static. But Ranganathan stresses that the universe of knowledge is not static: “It is a dynamic continuum. Its structure is therefore ever changing. Hence it is not sufficient to know its structure at the present moment. We should also understand its mode of development” (Depth classification, page 174).

31 Modes of Development

He has indicated five modes of formation of new specific subjects: (1) by the laminating of terms from different facets within the same original universe, and (2) by the loose assemblage of terms from different original universes; new terms are introduced into the structure by (3) the denudation of a class to form a sub-class, by (4) the dissection of a class to form an array of subclasses, or by (5) the interpolation of a new term in an existing array. This kind of development goes on continually.

32 Periodical Reorganization

As such changes accumulate in a particular main class, it becomes necessary to re-organise the ranking of terms in particular arrays, or even in a whole facet. Further, it becomes necessary to reshape the facet formula of the class. Ranganathan conjectures that such adjustments may occur once in a generation. Lastly, it is less frequently necessary to establish a new main class (Classification, Coding, and machinery for search).

4. Notational Devices

The pattern of knowledge displayed in a scheme of classification is preserved and mechanised by its notation. The particular notational devices used by Colon to preserve the pattern described above may now be enumerated.

41 The ranking of classes in an array is preserved by the use of the ordinal numbers 1 to 8. If more than eight classes are to be accommodated, the “octavizing digit” 9 is introduced to give further co-ordinate classes 91 to 98, 991 to 998, etc.

42 The numbers 1 to 8 are reserved for terms in the array which attract considerable literature; the second, third, etc., octaves are used for terms less frequently encountered.
“Amplified” classes are accommodated in the “last” and “penultimate” octaves. The “last” octave is formed by the use of a group of digits (the capital letters) which is higher in ordinal value than 9. The “penultimate” octave is formed by this alphabet introduced by the “octavizing digit” 9. The effect of this device is to place the “amplified” classes at the end of the array in which they occur. The last and penultimate octaves are also used for linking on other facets, and for simple alphabetical subdivision.

The formation of chains of classes is mechanized by making the ordinal numbers into decimal fractions.

The arrangement of the different facets into which a main class can be divided is effected by introducing each of them by a digit which is lower in ordinal value than 1: Time and Space by a full stop, Energy by a colon, Matter by a semi-colon, and Personality by a comma—the last having the highest ordinal value of the four. Time is distinguished from Space by using capital letters instead of numbers for its first array.

The intervals of Time which overlap conventional divisions are indicated by linking the limiting dates with an arrow, which lies below the numerals in ordinal value.

Disjunctive incidence in Space is indicated by adding, after the term which is to be “disjointedly” divided, an introductory of either lower or higher ordinal value than the digits which normally follows it in the conventional divisions. Thus the dash (which lies below 1 in value) is used to introduce the mother country of an empire, and capital letters (which lie above 9 in value) introduce the common subject characteristics found in an area. The symbol .1, the World, in the Space schedule has no “normal” divisions, as the continents are represented by other digits in the first octave. The numerals may therefore be used after .1 for disjunctive incidence to introduce groupings around seas, climatic zones, compass zones and physiographic regions.

The sub-levels of Personality are introduced by the Personality “indicator”, a comma. Confusion of the various levels does not result if each sub-level only occurs when its parent level is present.
491 Lamination is effected by the facet indicators. Since they are of lower ordinal value than class numbers, it is possible to link on any facet to any term in the schedule of another. The Time facet may be linked on directly, and since its first digit is a capital letter it forms the last octave of the array to which it is linked. Facets from another main class may be linked on by the main class digit, also a capital letter. The varied uses of this last octave device (see paragraph 3 above) may cause confusion.

492 Loose assemblage is effected by introducing the second main class by a digit lying below the numerals in value—the zero or colon.

493 The anterior common subdivisions in Colon specify "approach materials"—bibliographies, encyclopaedias and so on. They are introduced by the lower-case letters, which are lower in ordinal value than all other digits, and are anteriorizing.

5 Appearance of New Terms

The remainder of this paper will discuss in more detail ways in which the structure of knowledge, as envisaged above, is subject to change. The pattern can be represented by the following diagram, in which A, B, C, D represent main classes (phases), 1, 2, 3, etc. represent facets, and a, b, c, etc. are individual terms in each facet.

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    A  |  C  
---+---+---
1  | 2  | 4  |
 a | f  | m  |
    |    | q  |
    |    |
 c | g  | n  |
 d | h  | p  |
    |    |
 e |    | s  |
    |    |
    |    |
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The original structure is represented by the two phases A and C, each with three facets (1, 2, 3 and 4, 6, 7), each facet containing three terms (a, c, d, etc). The arrows represent later additions, which are of several kinds. These are discussed below, using the convenient terminology of Ranganathan.

51 Addition. This is the simplest way in which a new term can be introduced into the structure—it is added to the list of terms in an
existing facet, as shown in facet 1. If it is desired to insert the term in a particular filiatory order, it must be made possible either to extrapolate the list (as at \( e \)), or interpolate (say at \( b \)). An example of addition occurs in the fourth edition of the Colon classification: to the earlier list of terms in the Utility facet of Agriculture (decoration, feed, food, stimulant, drug, etc.) three more have been added (adhesive, manure, vegetable).

52 Dissection. If the terms in a facet are arranged in a hierarchical, classified order, new terms may arise which are subdivisions of an existing class, which is thus dissected (as at \( v \)). For example, the same Agriculture schedule of Colon now divides the earlier term Loam into five kinds of loamy soil: sandy, silty, clayey, sandy clay, and silty clay.

53 Interpolation in chain. In a hierarchical classification, in which a class \( v \) is divided into sub-classes \( vw, vx, vy, vz \), it may be helpful to group together, say, \( vx \) and \( vy \), and a term naming the group must be interpolated in the chain of classes. An example is given by Bliss in his Bibliographic Classification. Telegraphy and Telephony were originally sub-classes of Electrical Technology. When to these two were added the further terms Radio-telephony and Television, it became helpful to group these four terms and to interpolate between them and Electrical Technology the term Electrical Communication. A rather different example comes from the fourth edition of Colon, which has made allowance for various groupings of main classes: Physical Sciences, Humanities, Social Sciences, etc.

54 Formation of new facet. In this case, new subjects occurring in a main class are found to include a new category of terms for which provision has not been made, so a new facet must either be added (as at \( 8 \)) or interpolated (say at \( 5 \)). For example, in the schedules applicable to Mining in the earlier editions of Colon, no provision was made for the inclusion of the substance mined. This has been remedied in the fourth edition by the insertion of a Substance facet.

55 Formation of new main class. There may be need for the insertion of a complete new subject field, which has either not been provided for in the classification, or has been provided for in other
ways. The new class may once again be added (as at D) or interpolated (say at B). An example from the fourth edition of Colon is class 9, Preliminaries, which, though it includes material from the old class 9, Generalia, has been so reconstructed as to form in effect a new class.

The creation of a new main class which had previously been contained in another class is exemplified by Animal Husbandry in the same classification. This had previously been listed as one of the Useful Arts.

It is possible that the multiplication of "differential facets" in a schedule is a sign that an existing main class is in fact heterogeneous. For example, Colon class D, Engineering, includes the following terms, among others, in its Work facet:

- Building
- Irrigation
- Mining
- Road Transport
- Rail Transport
- Bridges
- Water Transport
- Air Transport
- Transport Vehicles
- Mechanical Engineering
- Heat Engineering
- Electrical Engineering.

Each of these terms (and its sub-divisions) has its own particular Part facet applicable to it but not to the other terms, and one of them (Mining) also has a special Operations facet which does not apply to the others. The various sections of Engineering seem, in fact, to be incipient main classes. The same is true of the Useful Arts in Colon.

A more profound need for the creation of a new main class arises from the development of new subjects. Another example may be quoted from Bliss: "Bacteriology has developed from the study of Bacteria, an item in Systematic Botany. But it has been applied in many fields — Pathology of Man, of Animals, of Plants, Agriculture, Horticulture, and even Chemistry, especially the Fermentation Industries. It has extended to comprise protozoan (and other) micro-organisms", and has become in effect a distinctive main division of Biology.
56 **Dissection of composite terms.** The representation of a specific subject is achieved by combining two or more terms drawn from the classification schedules. Three forms of composite term may be recognised.

561 Auto-bias: In this case, two terms are drawn from the same facet, to form a compound such as \( t-u \). For example, in the Organ facet of Medicine (fourth edition of Colon), there occur the terms 134, Leg, and 82, Bone. The “bones of the leg” are represented by the compound 134-82.

562 Lamination: This name is given by Ranganathan to compounds formed by the combination of two or more terms from different facets in the same main class, such as \( p:s \). Numberless examples can of course be cited, such as the Colon combination L18:477 for “head wounds”.

563 Assemblage: By this Ranganathan means the combination of two or more terms drawn from different main classes, such as 1.p. For example, D6,9M142, Composing Machinery, combines the terms D6,9 (Machinery) and M142 (Composition).

Each of these composite terms may need to be treated as a unity and dissected into sub-classes—leg-bones into tibia, fibula, etc., the various types of head wound; and composing machines into monotype, linotype, etc. These new terms cannot be added at a single point in the original structure—they stem from existing compounds.

57 **Reconstruction of schedules.** Once a set of classification schedules has been prepared, new terms will be accommodated as far as possible by the methods already described—addition to or dissection of existing facets, the formation of new facets or main classes, and the dissection of composite terms. But the continued insertion of new matter may eventually enforce a more fundamental change, in which certain existing terms disappear and a new pattern is introduced. Various possibilities will be discussed.

571 Compound terms become simple. The need for such a change is already evident in the discussion of subsection (6)—the
complexity introduced by the dissection of composite terms. Consider, for example, the term “Chemical Analysis”. When in 1903 an obscure paper appeared on “New adsorption phenomena and their application in biochemical analysis”, it would naturally be classified (in a system such as is here described) by linking Analysis and Adsorption. This composite term now has a single name, Chromatography, and may be divided into flowing chromatograms, frontal analysis, displacement analysis, electrochromatography, partition and paper chromatography, and so on. To continue to represent the subject by a clumsy composite term is very inconvenient, and it is preferable to use the single term, “Chromatography” as a subdivision of Analysis.

The general method of dealing with the simplification of a composite term is therefore to subordinate it to one member of the compound (in this example, Analysis). The problem then remains, how to reveal the existence, in the new “simple” term, of the other element of the compound (Adsorption). Bliss solves this by a cross-reference from the suppressed term.

572 Simple terms become compound: It may happen that a group of terms, which are originally regarded as constituting a single category or facet, are later seen to belong to two or more facets which it is helpful to distinguish. An example is given by V.S. Moghe from the Medicine schedule in Colon (Depth classification). In the Organ facet, under Stomach, we have the terms listed at (1). These may preferably be divided into two schedules for Region (2) and Organ (3):

(1) Gastric secretion
    Gland, gastric
    cardiac
    pyloric
    Orifice and valve
    Orifice, cardiac
    pyloric
    Valve, pyloric

(2) Cardiac
    Pyloric

(3) Orifice
    Valve
    Gland
    Secretion
573 Much more drastic reconstruction may be required if examination shows that an existing facet is a heterogeneous mass of tenuously related terms. For example, it has been pointed out in an earlier paper that the Problem facet of chemistry in Colon is “a jumble of all the themes traditionally labelled chemical with the exception of systematic organic and inorganic chemistry. Side by side lie particular kinds of reactions between molecules, the internal structure of molecules, particular types of molecular mixtures, procedures for investigating molecular structure, procedures for separating molecular mixtures, and so on” (Review of Documentation, volume 19, Pp. 87—91, 1952).

In another paper an essay in reconstructing this material has been made (Abgila, volume 3, Pp. 11—24, 1953). The Problem facet has been replaced by four facets,—State of Matter, Action, Operation and Property. Two effects are noted: terms which are simple in the existing Colon schedule become compound in the modified one, and certain terms are removed altogether from this group of facets and are placed in the substance facet.

6 Conclusion

The outstanding characteristic of knowledge is its ceaseless development and change. It is added to, it becomes more detailed, more profound, wider in scope, and more intricately interconnected. Each of the theoretically possible modes of reconstruction discussed here has been exemplified in practice, and there are no doubt other modes of change which have been overlooked. An historical analysis of such changes would again emphasise that the structure of a classification needs to be as flexible and as hospitable to new terms as possible. At the same time, both history and the practical examples in this paper warn us that complete reconstruction may sometimes be necessary.