# Knowledge Organizers of Cell Biology

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As the scientific pursuit progresses, the number of technical terms in sciences is always on the rise. However, the use of knowledge organizers, more or less, remain constant. Knowledge organizers consist of (1) the types of concepts (Metatypes) used in knowledge (2) types of relations used to relate the concepts (Relation types) and (3) logical connectors and quantifiers used to express the knowledge.

Representing common sense knowledge using these minimal knowledge organizers is highly challenging, and often impossible since generalizations of common knowledge may not always work. However, much of scientific knowledge uses a small subset of our natural language since scientific language is highly conventional and formal. Our attempt is to represent already well organized scientific knowledge using Knowledge Representation (KR) methodology. The problem of representing knowledge of exact sciences like physics and mathematics is seemingly easier than not-so exact sciences like biology. The ontology of biological sciences is not as clear as other branches of science. In this work, we attempt to introduce our methodology for representing the knowledge of biological sciences. This exercise also helps us to explicate the structure of biological knowledge.

How can this methodology help us in science education? In science education, we expect the students to learn the concepts of science. According to a study conducted by us, students come across about 4000 concepts in the domain of biology, (excluding the names of all the species of plants and animals) upto higher secondary level of education (Thulasidas and Nagarjuna, 2001). However, the knowledge organizers required to understand these terms are not only constant but few in number. Our hypothesis is: if during the course of science education students are trained to think and study the world using knowledge organizers, *meaningful learning,* in contrast to rote learning, as explicated by Ausubel (Ausubel et. al., 1978), takes place. With this understanding when we explored for a set of required knowledge organizers for science (or for the domain of biology) from the literature, we could not obtain any such set readily available. This indicates that there is a need to develop an authentic set of knowledge organizers for use in science education. Our research objective is to fill this gap.

Representing anatomical details is more or less straightforward, since this knowledge can mostly be represented using *class inclusion, spatial inclusion, part-whole relations* (Winston et. al., 1987). But much of the core biological knowledge is contained in physiology, molecular biology, developmental biology, ecology, etc. Representing this knowledge in KR terms is often challenging. Based on our earlier analysis of biological terms, most significant knowledge of this field is expressed in terms of concepts that describe processes, states, or stages, and cycles. We make an attempt to explicate the general structure of these sciences to arrive at a definite KR for physiology. Since cell biology is a good representative for much of biology, we chose this area.

Many educational researchers have found it useful to adopt a network representation format for explicitly representing knowledge structure. There exists various methods to represent knowledge such as—concept map, knowledge Vee, Concept Circle Diagrams, SemNet, Conceptual Graphs. After analyzing the concept mapping methodology, we identified several problems on the basis of our knowledge organizers. These are discussed in an article, *Towards Principled Approach of Concept Mapping* (Nagarjuna and Kharatmal, Unpublished Paper). We find the conceptual graphs approach by Sowa (Sowa, 1984) is highly instructive and we plan to make use of this technique for representing scientific knowledge. Based on our understanding, we developed a model of KR and an application that can be used to undertake the task. The software application called GNOWSYS (Gnowledge Networking and Organizing SYStem) (see URL in ref.) is developed which helps to construct the set of organizers of scientific knowledge. An introduction to the Knowledge Organization (KO) model of this application will be discussed. In this work, we shall describe the methodology followed to construct the set of knowledge organizers using GNOWSYS for science education and illustrate the method for the domain of cell biology. We shall indicate how this methodology can be used in understanding the structure of knowledge, measuring cognitive significance of concepts, generality-specificity

index of concepts, defining learning paths based on cognitive dependency relations, comparison of novice-expert's cognitive structures, etc.

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