

Student Reading # 3**Science Is Conceptual Modeling**

Words, words, words! They shut one off from the universe. Three quarters of the time one's never in contact with things, only with the beastly words that stand for them.

—Aldous Huxley

Words are key elements in our mental and *expressed* models, the latter being any external representation of a mental model. When you speak or write a sentence, you are building a syntactical model. Each word stands for an object, relationship, or characteristic. The relationships among the words correlate with relationships in the objective world. In a simple sentence like “John loves Jill,” every word has a meaning and the order of the words expresses a different relationship than “Jill loves John.”

Each word represents a *concept*, which is your total idea of a person, place, or thing. In the sentence above, “love” has certain connotations. I could get some idea of your conceptual model of love by asking you to write down everything you can think of that is associated with it. These associations characterize your idea of love. No two people would write exactly the same things and, in fact, even closely related people might express far different models.

Conceptual models are the bricks and mortar of our mental models. Much of what you are doing in school is delineating and labeling new ones. You delineate conceptual models through their relationships with other models. It's instructive to watch a very young child learn. When he first learns the term “mama,” he may apply it to all women. As his mental model matures, he learns that mama only refers to one person, but he may resist the idea that there are other mamas in the world. Gradually he comes to understand that mama can refer to any woman with a child as well as his own specific mother.

This process of model maturation occurs no matter what age we are, and what we are learning. For the sake of communication, we agree upon the labels we give our models. “Dog” represents the same animal for all English-speakers. The label “2” evokes the same thing as “two” for most civilized people.

These labels and symbols represent *phenomena*, things that we perceive in the physical world, as well as things we conceive of and wish to represent. They are not the things they represent, and this is important to remember. We don't truly know something if we can't conceive of the model and target behind the word or symbol. One reason some students have difficulty with equations is that all they see are the symbols.

The ability of the human mind to create models from words is truly amazing. No computer can emulate it. Computers work much faster, but almost all programs use algorithms to function: that is, they follow a set of fixed rules. The brain is able to learn and retain information in the form of images and it can operate upon those images. It can create a model out of words to describe those images. Furthermore, it creates its own rules as it goes along. No computer can do this with the proficiency of the human brain.

In our lifetime, we create thousands of conceptual models, all tied together in an intricate network of associations. Some mental conceptual models are very large, with many associations. Your mental model of your school and all that is in it is quite large now, but it will probably shrink after you graduate and other models become more important in your life. The brain, like all computers, is limited in its capacity.

To save time and space, the mind organizes our mental models hierarchically. Some models are larger and more important than are others. These models are selected and united by strong associations that form the rules and principles governing your actions and your worldviews.

Science introduces you to a lot of new and unfamiliar terms. Each term is associated with a conceptual model. Before science came along, the world seemed to humans to be a much more uniform place. Science by its very nature creates new concepts—new models of things that were not recognized before. The explosive growth in the number of new models over the past several centuries has led to increasing specialization, not just in the sciences, but elsewhere as well.

Today, no one person can know all of the models in all areas of science. The broad domains of science typical in high school (biology, chemistry, physics, and the Earth-space sciences) have become less meaningful in professional science, where the domains are blending, and then fracturing into specialized studies. Today, scientists in different specializations may not be familiar with one another's models.

Any given conceptual model is independent of the label that is put on it. Russian labels for many concepts are different from American ones. The concepts (in science at least) should be similar. Similar but not the same, of course. A conceptual model only exists—only has meaning—in our minds. We may create a model of it with images, words, numbers, and symbols, but that model means nothing without our interpretations. And those interpretations are invariably going to be somewhat different.

So in fact, there is no one model of any shared concept. There are as many models as there are people, usually with a certain agreement on major (core) characteristics. You and I would probably agree that a certain kind of animal is a cow, but our total conceptual model of cows might be considerably different. You and a nuclear physicist might agree on the most basic characteristics of an electron, but be worlds apart on the specifics.

Scientists are no different from other people. Scientific models may seem firmly established to you, because you see and learn one model. But the models you learn in science class are often highly simplified. They only approximate the greater complexities of the full models. The attributes of the full models may vary from scientist to scientist. You should not be surprised when you come upon different models of the same phenomenon in the literature you read. A model is always an approximation of its target.

For Discussion

1. Write the following sentence on paper: "A crippled old pine tree stood in the open field." Now visualize the scene. In your mind, find correspondences between each word and something in or about the scene.
2. Expand your mental model into a one-paragraph description, adding features. Compare your model to someone else's. Are they the same?
3. Select any model you see in the room you are in. What is the model representing about its target? What things in the target are missing in the model?