TwoOldGuys™ Study Guides
BI114 Biological Concepts for Teachers
Chapter 1. Introduction
1.2. Life Defined

Based on Indiana's Academic Standards, Science, as adopted by the Indiana State Board of Education, Nov 2000.
Numbers refer to the age-appropriate grade-level for the content.

Review

An important characteristic of science is to define our terms and to state our assumptions to assure that both the writer and the reader are in agreement concerning what the words mean and concerning what assumptions apply to the discussion. Arguments and conclusions (Theories) advanced must be logically consistent with the assumptions. Yet we remain prepared to reconsider any theory, and even to abandon it, in the face of new facts or new theories. Theories must be testable, so must make predictions of observable events which can be verified through repeatable experimental proof.. However, ideas are of no value unless they are communicated in logically and grammatically correct style. Science is, then, merely a means by which we can acquire new knowledge.

Characteristics of Life

This entire topic has to be "discovery" because we, as scientists, have no definition of Life.

Since this is a biology text and we have established the requirement to define our terms, we need first to define life before we attempt to study it.

After a review of a rather large number of introductory Biology textbooks over several decades, the author has concluded that the task of defining Life must be nearly impossible. To date, no textbook authors seem to have successfully developed a simple definition of Life, but resort instead to a 'definition by enumeration,' in which the definition consists of an enumeration of the characteristics shared by living organisms. Following the pedagogic approach to definition by enumeration, we need to note the similarities among living things and the differences between living and non-living things as we develop our own enumeration of the characteristics of Life in age-appropriate stages.

Kinds of Living Things
grades K: - 3:
Game: '20 Questions'

To get the children thinking about the kinds of things in their environment rather than just about the things in their environment, we could start with the familiar game, 20 Questions. The idea of the game is to guess what an object is starting only with its classification. In one variant of the game, the person who is "it" selects some object and, without saying what the object is, declares it to be either: "Animal, Vegetable or Mineral." The other players are allowed to ask no more than 20 true-false questions in order to guess what the object is. A normal result of attempting to play this game with older grade school children (grades 5 to 8) is to cause arguments about the assignment of the object to the chosen category. However, we want to redirect this argument to a discussion of the process of assigning objects to the categories. Implied in the rules of the game is the idea that all objects in the universe can be grouped, or classified, into three fundamental categories: Animal, Vegetable, Mineral. For many non-scientists, this classification

scheme forms the basis of their concept of the organization of the things in the universe. Although there are objects that do not easily fit into any of the classification units (taxa, singular taxon), these people may resist changing their theory of the universe in spite of the exceptions to the classification. Scientists, on the other hand, *do* change their theory of the universe to adjust for those objects which cannot be easily classified. On an intuitive level, the 20-Questions taxon which is the most obvious is 'Animal,' especially as it differs from 'Mineral..' As an exercise in similarities and differences, you (or your students) could develop a list of similarities [compare] of Animals as Living Things, especially those which are also differences [contrast] between Living and Non-Living Things or Mineral. Typical entries may include the following:

- move
- eat
- drink
- sleep
- breathe
- grow
- "poop"
- reproduce [usually older students only]

We can tentatively accept this as a reasonable definition by enumeration of Life. All familiar Animals do exhibit the characteristics named above, but Minerals do not. However, when we consider Plants [Vegetable in 20-Questions], the characteristics of Life as we just defined them do not apply very well:

- move.
  - Minerals definitely don't.
  - Animals definitely do.
  - Plants don't really do this.
- eat.
  - Minerals definitely don't.
  - Animals definitely do.
  - Plant roots absorb minerals.
- drink.
  - Minerals definitely don't.

- o Animals definitely do.
- o Plant roots absorb water.
- sleep.
  - o Minerals definitely don't.
  - o Animals definitely do.
  - o I don't think Plants do.
- breathe.
  - o Minerals definitely don't.
  - o Animals definitely do.
  - o Plants absorb carbon dioxide [CO_2] through leaves.
- grow.
  - o Minerals definitely don't.
  - o Animals definitely do.
  - o Plants definitely do.
- "poop."
  - o Minerals definitely don't.
  - o Animals definitely do.
  - o I don't think Plants do.
- reproduce [older students only].
  - o Minerals definitely don't.
  - o Animals definitely do.
  - o Yeah, Plants do.

We now have an acceptable definition of Life for grades K through 3. It should be noted that we have changed "Animal, Vegetable, Mineral" to "Animals, Plants, Non-Living." Another assumption implied in the 20-Questions classification scheme is that this method of classifying objects moves from the complex Animals to the simple Minerals, and thus Plants are less complex than Animals but more complex than Minerals.

CLASSIFICATION OF OBJECTS.

I. Animal
II. Plant [Vegetable]
III. Non-Living [Mineral]

grades 2: - 3:

'Improved' Classification of Objects, or Things

We can challenge the 2nd grade and up mind to consider whether Plants are more like Living Animals or Non-Living Minerals. In the above exercise, I listed 8 characteristics that my students (grades secondary to college) have been likely to suggest, based on previous classroom trials. Of these, Animals exhibit all eight; Minerals exhibit none. Plants are generally listed as exhibiting five. However, for the other three (move, sleep, "poop"), a closer examination reveals that Plants:

- move, in that leaves and flowers in some plants actually open and close; and some plants [Cottonwood Trees] even 'fan' their leaves to cool off.
- sleep, in that they exhibit a distinct day/night cycle of activity.
- "poop," in that they discard toxic substances, usually as crystals, inside parts of the plant.

Even ignoring the last three, it seems reasonable to conclude that Plants are more like Animals than Minerals, so we should divide all things into two rather than three categories: Living and Non-Living. For the purposes of Biology, the Non-Living taxon includes only minerals [although in Physics and Chemistry there will be more taxa in this group]. The Living taxon includes, at this age group, two taxa: Animals and Plants. This arrangement places some taxa at different rank. The highest rank is Living/Non-living, and the lower rank is Animal/Plant. Continuing the concept of rank, we can introduce yet another, even lower rank by dividing Animals into Mammals, Birds and Bugs (which is consistent with my observations of a distinction made by many non-scientists).

CLASSIFICATION OF OBJECTS.

I. Living
   A. Animal
      1. Mammals
      2. Birds
      3. Bugs

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B. Plant [Vegetable]
II. Non-Living [Mineral]

grades 3: - 6:

    As the children become more familiar with the variety of living things, we need to expand their classification system to account for this variety. This age group should be aware of additional animal, such as lizards and snakes, frogs, fish, insects (bugs) and spiders, and worms. It is reasonable to expect these students to be aware of some lower taxa of plants, such as flowers and weeds, pine trees, ferns, and perhaps moss. We should also ask if our definition by enumeration of Life has to be revised to explain the new facts or assumptions reflected in the expanded classification system, but at this point, I shall leave that question for you to ponder. What we do not have to do to 3rd to 6th grade students is insist that they follow the *same* classification system we expect of college students. Perhaps this should be worded more strongly: 'what we must not do to them...'

CLASSIFICATION OF OBJECTS.
I. Living
    A. Animal
        1. Mammals
        2. Birds
        3. Lizards (Reptiles)
        4. Frogs (Amphibians)
        5. Fish
        6. Insects & Spiders
        7. Worms
    B. Plant
        1. Flowers
        2. Pine trees (Conifers)
        3. Ferns
        4. Moss
II. Non-Living

grades 6: - 8:

    Although this version is labeled 'Complete,' you as the teacher need to know that it is neither complete nor accurate. Compared to the college level version this is still rather simplified. Again, it is important that we do not expect the students to follow the same classification system we would expect of college students. There are some subtleties in the college level classification system that are beyond the cognitive development of the 8th grade mind. The important addition here is the names of the ranks of the taxa: Kingdom, Phylum, Class, …

Having added the assumption that our classification categories [taxa] can be sub-divided, we are obligated by scientific methods to reconsider our definition of Life to determine if it should be revised. Although few, if any, scientists would revise the definition of Life to accommodate the added taxa, the question should be presented, allowing the 6th to 8th grade students to develop a new definition of Life. There arises another interesting [remember my definition of 'interesting'] question: if our definition of Life is adequate to explain all known Life on this Planet, must we change the definition to include Life on other planets? Another way to word this question (as a simpler question) is "How will we recognize Life if we find it on some other planet?" Especially among the 7th and 8th grade students who watch science shows on TV and read science magazines, lively discussions of this question will sometimes (but not always) occur if the teacher makes it a classroom exercise in scientific thinking.

'Complete' Classification system
       I. Living
          A. Animal Kingdom
             1. Vertebrate Phylum
                a. Mammal Class

    b. Bird Class
    c. Reptile Class
    d. Amphibian Class
    e. Fish Class
   2. Insects & Spiders Phylum (Arthropod)
   3. Segmented Worms Phylum (Annelid)
   4. miscellaneous other phyla (worms, jellyfish, sponges)
  B. Plant Kingdom
   1. Flowering Plant Phylum (Angiosperm)
   2. Conifer Phylum (Gymnosperm)
   3. Fern Phylum
   4. Moss Phylum
  C. Fungus Kingdom
  D. Protist (protozoa and algae) Kingdom
  E. Bacteria Kingdom
 II. Non-Living

Life: the Short List

grades secondary: - college:

  In an effort to develop a true definition of Life, rather than a definition by enumeration, I have been working on reducing the characteristics in the list to the least number which are necessary and sufficient to describe Life. The following table is the current version of that effort:

CHARACTERISTICS of All Living things	
Homeostasis	
	Consume matter and energy from environment
	Release matter and energy to environment
	metabolism
	growth & repair
	response to stimulus
	adaptation to environment
Death	
Reproduction	

Based on this list, we could suggest as a tentative definition of Life:

Life: "any complex, self-maintaining [homeostasis], and self-replicating [reproduction] system which is subject to death."