Bare Bones Ecology

Energy Handbook

The Flow of Energy Through the Ecosystem

This book is for EC

Proteus . . . believed that the universe emanated from God eternally, like rays from the sun . . ." [1]

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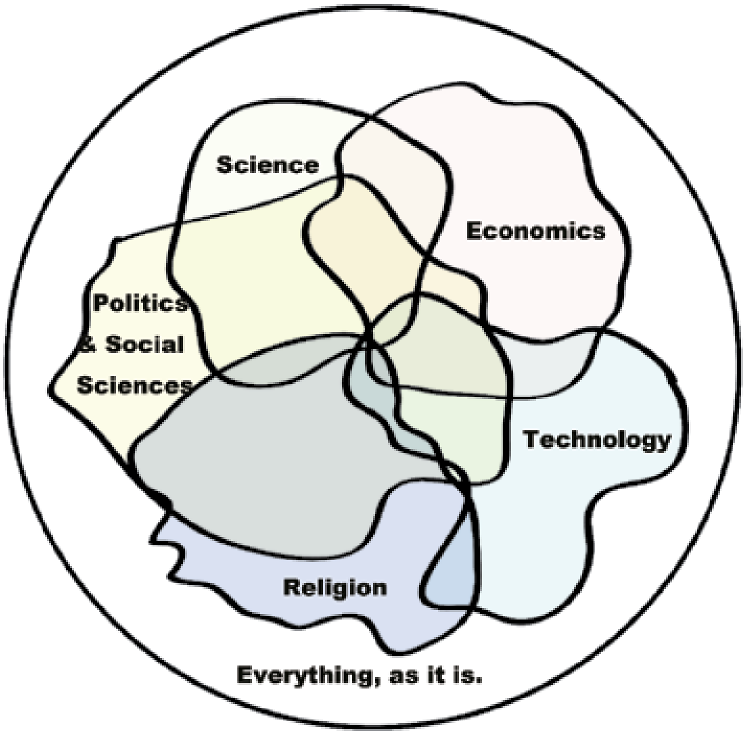
The flowing river never stops
And yet the water never stays the same. (Hojoki, Kamo-no-Chomei)

Introduction - Science and The Creation



Did The Creation make the flower, or did the flower, and all the billions of other living things, give rise to The Creation? Or what? Standing next to the flower and looking up or back -- or down -- we do not exactly know. With the Buddha we know that "all of life is loss." We know this because we have lived, or maybe because the Bible, and the Koran tell us so, or maybe we know it because of the evidence of science that we must die so that The Creation may live. We don't know for sure if science can look perfectly back, or forward, but science does know a lot about how The Creation functions right now. This is important to all of us, because anything that is alive can die if the time comes when it can not maintain a viable balance among its many vital functions. And right now the living earthly part of The Creation is struggling to keep its balance, even while our knowledge of the sciences is being ignored.

I am convinced that we all really need the same things. We live inside exactly the same Creation -- the thing that exists all around us and is discussed by serious thinkers everywhere: to name a few, Historian Karen Armstrong,[1] Prof. Wendell Berry,[2] Scientist James Lovelock,[3] Philosopher Paul Woodruff;[4] religious philosopher Huston Smith[5] and his compatriot Joseph Campbell.[6] And Francis Collins.[7] And you. And me. But I know that we also have differences, so to find a universal starting point I turned to Huston Smith for a definition.

In his book, "Why Religion Matters,"[5] Professor Smith says The Creation is: "Everything, as it is." OK. It's hard to disagree with that. The Creation is "Everything." An excellent starting point for discussion of the Biology of the Ecosystem. The ecosystem is an earthly part of what The Creation is.

Next, we probably can also agree upon the idea that we human persons did not create The Creation. So definitely there is a difference between The Creation, which is not human, and us, who are human. The Creation is bigger than human; it is bigger than all of us together. We did not create it, and it does not depend upon us for its existence. We, and our wars and our corporations and technology, we are only human, nothing more. The Creation is too much for us to understand. In my opinion, this should be the deepest expression of our faith, for all of us, to believe that The Creation is whatever it is, and we humans do not understand everything about it.

But human kind does want to understand The Creation. It's our nature. Even though we know that no individual human person will ever understand everything about The Creation, still we do keep trying, and so we humans, by our normal nature, ask questions. What is The Creation? How was it created? How does it funcion?

In fact, if you think about it, most of what one hears in schools, and places of worship, and in conversations of all kinds, and even on TV, are questions about some little bit of The Creation. Everyone has questions about The Creation, and, good questions can lead to good answers. So over the centuries of human time we humans have found many answers, and several important but different ways to study The Creation. And the different ways of asking our questions give us different answers. Not better necesssarily, or worse. And all the answers add up to more than any one method of inquiry could understand. Philosophy, for example, or religion, take us along different avenues of inquiry, while mathematics is thought by some to represent the language of the universe at its most basic level. And science has another set of tools, based in the scientific method of evaluating measurable facts.

Science is the method I know most about. Modern basic science is the study of measurable facts using the scientific method. The scientific method is one way to study "everything, as it is." This does not mean that science is a better way than mathematics or philosophy or religion. But science can deal very effectively with measurable data, and we need to respect this tool if we want to appreciate the factual, measurable laws of nature that permit survival of the ecosystem and ourselves within it.

What is Science?

My definition of modern basic science is: the study of measurable facts using the scientific method. This is not the popular idea of science. However, basic science is fundamentally different from technology, so I get fussed when people lump them together. Technology uses the information discovered by basic science to make things for people; while science studies the basic laws of nature that nobody can control, with or without technology. Like gravity, for example. So, technology is controlled by people; and we can change it any time we want to, but basic science studies the reality of the universe that nobody can control. In the "game" of staying alive, like any other game, it's very important to know what we can control and what we can't. For this, technology is of no help, but basic science can make the difference between life and death, and the scientific method is a powerful tool.

Dr. Lee Smolin is a physicist who is highly trained in the use of the scientific method to develop good hypotheses. A hypothesis is an opinion or educated guess that we present in a way that can be tested using the scientific method. The word hypothesis does not mean the idea is wrong. It is more likely to be right if the science is properly developed using the scientific method.

Dr. Smolin describes the scientific ethic as follows:[8] I describe the method further in the sidebar and define it above.

"In science we have an ethic. We argue from evidence based on publicly available information. When you become a scientist you agree to be bound by that, even if the evidence goes against your own theory." In other words, basic science is not about winning. Scientists really do enjoy getting the accurate answers, even if they must change their own belief system to do it.

Sometimes readers misunderstand that a published scientific paper "proves" whatever the author of the paper presented for discussion. I grit my teeth when someone suggests that published scientific opinions are the same as proven facts. Publication of data is only one step of the scientific method (described in the sidebar), and the method of science is to disprove false ideas, not to prove right ones.

Another problem some people have with science is "statistics." We know that statistics are often misused, but it is not true that good statistics "lie." Good statistical analysis is an important tool for scientists in the interpretation stage of the scientific method. The challenge is to do the analysis properly and well. That is one important reason for peer review of scientific papers before they are published. The work of every scientist is open to review by other scientists who know equally as much about the topic. And it is open to review by everyone. There is no reason to leave this task entirely to scientists. We all can learn the basic principles of statistics and at least triage statistical reports as to whether or not the statistics make sense.[9] And if we want to know more we can contact the authors. We need not allow ourselves to be victimized, either by refusing to believe any statistics, or by believing whatever sounds good. Statistical analysis, if done honestly and properly, helps us to understand relationships that we otherwise could only guess about.

Good scientists know that the scientific method does not tell us what is a true fact. The great power of the scientific method is that it tells us what is not a fact. Scientists assume that a hypothesis, is wrong until it is confirmed by competent people using the scientific method. If the new knowledge turns out to be predictive of reality, then the scientists begin to to have increasing confidence in the interpretation. In the case of global warming, for example, multiple scientists in many fields of expertise were convinced of the reality because of the consistency of all their results. In fact, they were convinced about 10 years before the media would even discuss the issue. And before that, the same thing happened when AIDS was discovered. We lost ten years to denial, when we could have been dealing with the problem.

Sidebar-What is a Fact?

Probably there is no good definition of a "fact," and yet no other word suits. I will therefore refer to "measurable facts" for realities that can be measured and do not change. Measurable facts are, for example, the temperature of pure water at sea level when it freezes. Good science is based in measurable facts. For this reason, good science is predictive. That means it will be just as true tomorrow as it is today and so we can predict what will happen when we use the information. We can trust that it will always be true within the conditions of the system being measured. Airplanes fly because the technology (engineering) of airplanes uses measurable facts about gravity and the way air flows across the wings, and so on. If facts actually keep changing, as I have been told a number of times, then airplanes would fly sometimes and not fly other times. Oh, well, of course they do but the times when they don't fly, it's not because the measurable facts changed.

The most commonly used example I hear about changing facts is: "The earth used to be flat and now it is round." Now you know that is just a silly game to avoid talking about issues. The fact is the earth is more or less round, not flat, and it certainly did not change from flat to round. People changed. Words can change. However, people did not make The Creation, and whatever people say or believe will not change it. Whatever it is, it is a fact, and basic science is our best shot at factually understanding what it is -- including what is the ecosystem and what it needs to function properly.

Measurable facts are a critical component of the scientific method -- therefore of science. It is important, even in everyday life, to understand the difference between the disciplines that rely on measurable facts -- science, technology, engineering -- and disciplines that use the methods of inquiry and persuasion that are part of the liberal arts, such as philosophy, religion and art, including literature. Any person who wants to help solve our social and biological problems will naturally want to be reasonably fluent in the problem-solving tools of both the liberal arts and of science, because these different tools study different "windows on reality"[5] (See diagram on page 1).

If we are to maintain a reasonable quality of life for humans, we need to understand what is true and what is not true about the ecosystem in which we live. More importantly in this day of biological challenges to the living ecosystem, we need to know what we can do and what we can not do with technologies -- what forces have more power than we have. There is no point wanting something that is physically impossible. There is always a way, if we stop fighting battles that can't be won and begin to figure out answers that could work within the reality of the whole ecosystem and our little part of it.

And while we are on the subject of facts -- anecdotal fuzzy bunnie stories are not scientific; metaphors are not factual. An anecdote or a metaphor can soar on the wings of Jonathan Livingston Seagull, but they do not belong in a discussion of science, because they create more confusion than they dispel. Science is not about unique observations or Jonathan Livingston Seagull, or spirituality. Art, philosophy, spirituality, religion are sometimes fun, and sometimes comforting or enlightening, and sometimes a way to sell books. But there is no reason to make-believe that these parts of our lives are science, as though we were ashamed to claim them for what they are -- lovely unmeasurable realities.

Sidebar-The Scientific Method

1. Someone has a question. For example. It seems warmer inside the city than at my house. I wonder if this is generally true? You will hear the word "null hypothesis." A null hypothesis is a question worded so it can be answered by a yes-or-no experiment: "The average temperature in cities is the same as the temperature outside cities." The next step is to try to see if the null hypothesis is false (because it is very difficult to prove that anything is always true).[9]

2. Now the person must devise an experiment. Experimental design is an important skill. The good basic scientist wants to know the truth, her goal is not to sell something but to understand something. Therefore, she designs the experiment (as best she can) with no bias or preconception. To do that, she will make sure that all conditions of the experiment are the same except the one(s) she wants to measure. For example, if she is comparing temperature in the city with temperature outside the city, she will take the temperature at the same time of day, and in the same conditions of wind and shade. Thus she "controls" all the variables except one.

3. She then takes the measurements. She must do exactly the same experiment on different occasions, enough times for the result to be statistically significant. Usually that would be at least 100 measurements at each location.

4. She then writes up the results in proper format. Results are reviewed by her peers (other people who are trained and experienced in the same field of study) to make sure the experimental design, the background discussion, and the statistical evaluation are correct, and that the discussion of the resuslts is logical according to what science already knows. Usually the peer reviewers spend time and effort helping to evaluate the data, or the presentation, so that the paper, when it is accepted for publication, is as good as it can be. This is because the goal of the basic scientist is to use the facts to discover the reality, and the reputation of each scientist, the one who does the research and the one who evaluates it, depends on accuracy and valid interpretations.

5. The paper is then published.

6. The process of basic science is not finished when the paper is published, because one paper is only one step in getting together all the information needed to grow our scientific understanding. After publication of an individual's research, other scientists will be inspired to wonder in new ways about the same question and devise their own experiments. If enough people ask well designed questions in the field, the accurate answers will gradually emerge.

If we want to be effective activists, parents, voters, citizens, or if we just want to maximize our personal power in any situation, we need to pay attention to the difference between science and other disciplines, so that we can get the maximum benefits from all of these important fields of inquiry. We should not limit our spirituality, art, or emotionality by tying them to measurable facts — fake or real. On the other hand, we will never solve factual problems unless or until we are willing to face the facts -- measurable facts -- that we do understand -- and deal with them factually.

Biology is the scientific study of facts about life and living things and how they function.
Ecology is the scientific study of facts about the living ecosystem and how it functions.
An Ecosystem is a the largest living thing on earth. The definition of life is below this sidebar.

This sidebar is not science. It's real enough, but not science.

In a doomed effort to regain my youthful health and vigor, I set up an exercise bike in my living room. I can sit on the bike, let my muscles do their thing without interference from my brain, while listening to the heartbeat rhythms of taiko drums and trying to think of nothing. Inside the room it's only me, the bike, and the ancient, insistent rhythms.

Outside the window is a fence. I think of that fence as defining level one of my life. Level one of my life is me, myself and my stuff. My little car, at least when I'm in the US, my computer, the music, and my camera. All of these come with me, even outside the fence. We are me.

But outside that fence, staring at me through the window, are the horses for which I have responsibility. They are dependents. Part of my family. They are also part of level one, a small circle centered on my own self-ness.

Beyond that first fence another fence separates me and mine from our closest neighbor. I can't see the neighbor from my window, but she has occasionally come to my rescue in times of need, as have many people in this small town. So that must be part of my self. I wouldn't be here without them. It is the next higher level of life -- the human community of which I am a part.

Across the neighbor's back pasture, as my legs and arms and the taiko drums carry thoughts toward outer realities, I see a broad green pathway up the hill and into the trees and then straight into the sunrise. Where does that pathway go? It goes someplace, or maybe no place -- or maybe every place. Even all the way to the broad, green fields of Sado Island, where the children wrap bandanas around their heads to practice the very taiko rhythms that come out of my speakers. From their generations -- from their hands -- to my ears. I yearn to be there -- and here -- and then I realize I am here -- and there. Whenever I choose to believe that all my brothers and sisters all over the world, altogether and at the same time, are level two of my self, then I can live in the reality of level two.

But it's not easy. Level one keeps interfering. Sometimes I don't pay enough attention, and other times I can barely see beyond it. Once in a while I can bring it truly to life for a time, if I don't think too much as the sun rises over the trees behind the neighbor's pasture.

Gazing at that pathway. Not a person on it, I imagine what if everything disappeared from the face of the earth that is not a person or an animal. Those things are not me. Not the trees and the bugs and spiders, or the grass. Or are they? Without the whole network of the earth ecosystem, there would be no me -- no us. No living levels at all. So that must be level three. Level three of my life, the whole earth ecosystem, is just as much me as the exercise bike, the muscles, that pathway that leads across my neighbor's pasture into the trees and then the rising sun beyond.

So it seems that I am not really me. Or rather me consists of all the levels. Any part of any level that rejoices or believes, or cries or is in pain, or withers from the lack of rain or freezes under a layer of snow. All of that is me, and I want very much to be fully me -- to live the reality of my life. To be whole. I do not want to destroy or neglect any part of my self.

> When I published the above on my blog, I got the following answer from IW.
>
> "God inhabits all of the dimensions of our lives however we define them. That inner dimension, which you describe as self, is what makes us unique. It is made up of our core values, beliefs, and self concepts. God is in the mix for me here. These are the things that are ingrained in us in a number of ways. We are often unaware of how they were developed. They affect our behavior in countless ways. The Holy Spirit was sent to help us in every dimension of our lives. God is in the mix."

I don't know. I can't understand any living level higher than three. To me, the rest is mystery. But however the earth ecosystem -- that is life -- came to be, I don't think we should destroy it, and we do know some facts that can tell us how not to upset the balance of the network of life.

What is Life?

It's always difficult to define things we don't fully understand. Things like God, or good, or love or life. But it's worth a try because we need to all know what we are talking about when we use these words. A life form, as we know it on earth, is an entity that has the unique property of being able to respond to its environment in such a way that it can stay alive and reproduce its own kind. The living thing does this by using its own self-contained information system (this is directed by its genetics) to communicate with its insides and outsides, so that it can continually flow organic energy through itself to do the work of staying alive, and continually recycle the materials (atoms and molecules) that its body is made of.

We know life is part of "The Creation," the universe -- "everything as it is." It's not the biggest part and not one of the most mysteriously tiny parts, but somewhere in the middle of the hierarchy. We know the hierarchy of the universe is organized so the bigger parts are made up of the smaller parts. Galaxies are made of solar systems; solar systems are made of planets; living things and nonliving things are made of molecules and atoms; atoms are made of subatomic particles. Every level of the hierarchy has special properties and characteristics. The special property of living things is the ability to respond to their environment, using their own genetic information, to direct all the necessary activities of being alive, and the ability to reproduce themselves for the next generation.

A "unit of life," is one living thing. You are a unit of life; so am I. We can look around and see units of life all over the place, from the pesky fly in your kitchen to the bacteria in my pond to the nematode worms in the earth itself. The most basic unit of life is the cell. Basic unit means the cell is alive, but if we examine the things it's made of -- they aren't alive. They do life processes in the cell, but outside of the cell they don't do much of anything. The cell is the smallest or we should say simplest sort of living thing.

The largest, most complex, unit of life on earth is the whole earth ecosystem, and it stays alive in the same way that all living things stay alive. At the most basic level, we life forms must: (1) keep organic energy flowing through our selves to do the work of living (that we will discuss in this book); (2) cycle and recycle the nonliving materials of which we are composed (that will be discussed in the next Bare Bones Ecology book); (3) transmit through all the generations the information that directs the functions of life and is carried in the genes. We will discuss information flow in the next book.

Life itself is not quite the same thing as a unit of life. In order to maintain life itself, through time, every individual living thing must sooner or later die. But so long as the balance between life and death of individual organisms is maintained within the ecosystem, then the whole ecosystem can continue to nurture its life and our lives indefinitely.

The Creation
http://factfictionfancy.wordpress.com/2009/10/26/biology-for-real/

The Creation (everything, as it is) is organized so that the smaller things are functional components of the bigger things. Functional components means they have jobs to do that are important to the whole bigger thing. For example, the solar system is a part of the universe, the living earth is a part of the solar system; we are a part of the living earth; our cells are a part of us, and so to atoms and beyond. The technical term for this is "levels of organization." I spent about four years trying to explain levels of organization to people until finally I understood that everyone already knows about levels of organization, just by living in them, but they thought I was talking about something more complicated because of using a technical term. So you already know that our universe and everything in it -- cars, houses, us -- is organized according to levels of organization, more complicated things are made from less complicated things. We will talk more about it later. In the meantime, these are the most important facts to remember about the levels that are most important to us:

A. The most important fact about the universe.

The Universe (and therefore everything in it) runs by "Laws of Nature." Some people think Laws of God. Whatever we think does not change the laws, so we can use either term so long as we explain what we are talking about. The natural laws are things like gravity, time, energy relationships, cause and effect, and other realities that mostly are studied by the science of physics. We do not have the power to change anything about the universal laws. We can't even observe very much of it, though the sciences of astronomy, physics and mathematics keep learning more. So, the most important fact of the universe is that we must conform to universal laws of nature if we are to survive. For example, unless you have considered all the natural laws that relate to gravity and flight you should not jump off any tall buildings. Some things are simply facts of life that we must accept.

B. The most important fact of life.

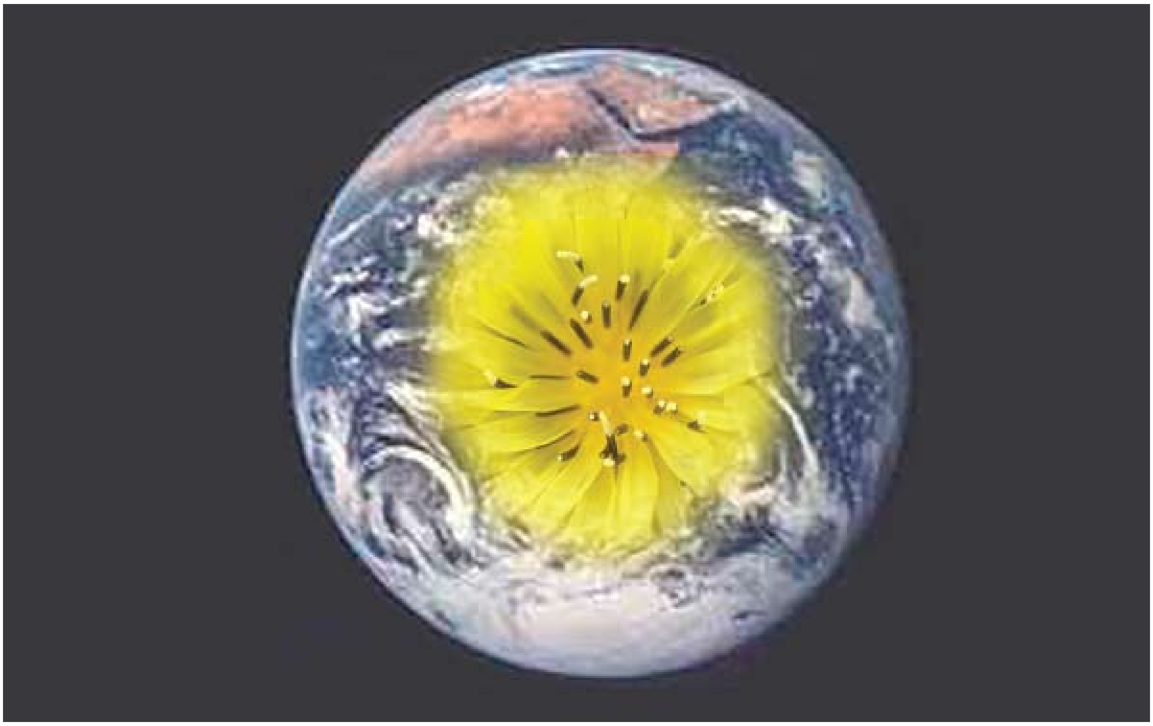
All of life is about keeping our balance within the hierarchy of the universe. For our personal lives we require balance in our bodies and in our communities. For life itself to exist, there must be balance within the living earth ecosystem, including a balance among the three most basic requirements of all living things, which are listed on the next page.

C. The most important fact of human life.

Human life must conform to the natural laws of energy, gravity, the hierarchies, cause and effect, etc, that are laws of the whole universe. We can not do whatever we want to do. Our special human power is the ability to understand the difference between a fact and an opinion and a belief -- and the freedom to choose our behaviors. Our beliefs and opinions can not change facts. The Dalai Lama said:[10] "If scientific analysis were conclusively to demonstrate certain claims in Buddhism to be false, then we must accept the findings of science." And again, in the field of philosophy, Paul Woodruff echoes many religious assertions when he states:[4] "To be reverent is to take care never to play the part of god or beast."

The Ecosystem

http://factfictionfancy.wordpress.com/2009/11/12/the-ecosystem/



Can a giraffe in Africa have anything in common with an acacia tree in Australia and a jellyfish that lives in the ocean? Yes, of course, they are all living things. Everyone is aware of the enormous differences among living things, from one-celled bacteria to the whole earth ecosystem. When you see the beautiful blue earth from space you are looking at the largest unit of life as we know it, the whole earth ecosystem. The unique characteristic of living things is their ability to balance all the processes that are required to stay alive -- within themselves and between themselves and their environment. You, as a living thing, can name many of these processes: breathing, eating, metabolism, urination, and many you don't even know about -- thousands of processes must be continually balanced by your body to maintain your life or any life. We can organize these processes into the three most basic requirements of life:

1. Energy flows through all living things. Energy is the ability to do work and work is described as moving or changing in an "uphill" fashion, or growing more complicated. Clearly one characteristic of living things is their complexity, growth and movement. So they require energy to be alive.

2. At every level, living things must regulate interactions with the materials in the environment and recycle materials such as oxygen, nitrogen, carbon and hydrogen and more. These are the elements that living things are made of.

3. All these interactions are too complicated even for a computer to keep track of, but somehow the living organism finds a way. For this it requires a continuity of information through the generations.

The three most common misconceptions about science (based on comments I have heard at book clubs, the Sunday morning café, comments on my blog, and TEA parties, etc.), are:

1. “The facts keep changing.”

No Sir, we covered that in the sidebar “What is a Fact,” but the bottom line is, if the facts kept changing we could not have science and if we did not have science we could not have technology and if we did not have technology we could not have -- well you know what all technology can do.

2. “We should go about our lives and leave the ecosystem alone.”

No Ma’am. We can not separate ourselves from the ecosystem because we get all our energy (and other things) to be alive from the ecosystem. We are as much a part of the ecosystem as your eye is a part of your body. Even when we die we remain an integral part of the ecosystem. It is impossible to leave it alone.

3. “We must live within the amount of power that is provided by the sun.”

No Sir. What keeps us alive is food; we can not eat sunlight. Food (for us and for our cars) is organic molecules. Plants make organic molecules. Therefore, we must live within the amount of organic molecules (food) that can be made by plants. To do that, we must help to keep the whole ecosystem healthy so it can continue to produce our food (and other things) that we need to stay alive. We can not make the ecosystem do these things. The ecosystem *does* these things to keep itself alive. What we must do is stop preventing the ecosystem from doing its job of staying alive.

Chapter One - The Flow of Energy

http://factfictionfancy.wordpress.com/2009/11/15/chapter-three-energy/

"What the world needs now is energy ... What if that energy comes from an energy company?" This quote is from an advertisement that Chevron is playing on public radio. It is one of the slickest lines I have ever heard, never saying anything that isn't true but making sure we end up believing some things that are not -- well -- let me say this. No community can lie to itself and survive. This book is not funded by any energy company. It is dedicated to us and to the true scientific facts about how life functions, so that we all will be in a position to help to defend our community from slick.

First of all, nobody can create energy. The first law of thermodynamics is one of those universal natural laws that we can not change. The first law of thermodynamics states that the energy of a system can not be created or destroyed.

We do require energy. Energy is the ability to do work; work is done for example, when anything moves uphill or becomes more complex. This is easy enough to visualize. We can not make a car without doing work. The work of the assembly line puts the car together. It falls apart by itself. If we stop fixing it -- well there is one in my back yard you can have for free. Things don't need energy to become disorganized. Energy is required to do the work of making things more complicated or stopping things from falling apart into smaller bits. This is a natural law of the whole universe.

Second, no company can give us energy without using up more energy than they generate. The second law of thermodynamics tells us energy can change from one form to another, but it can not change from a "lower" energy type to a "higher" type. Your energy company can not make more energy, and it is running out of oil, gas and coal because we can not make more. They know this. If you want the statistics, check out Lester Brown's web site. He has been collecting good data for decades.[14]

So much for slick; now let's review how energy functions to support the very highly organized lives of our ecosystem.

Life Requires Energy

http://factfictionfancy.wordpress.com/2009/11/15/chapter-three-energy/So much for the bullshit; now

Of course every minute of life pulses with change, growth and movement, and that is work. This chapter is about the energy necessary to do that work. It is organic energy, as described below and as studied using measurable facts, and easy to see in the dog across the page. We also know that the universe is vibrant with other kinds of energy that we can not study using modern basic science. However, the important message of the science of ecology, described as succinctly as possible here, is what we do know factually. The physical life of the ecosystem, as of your own body, requires a consistent balance between the light energy that the ecosystem uses to generate organic energy, the organic energy that is required for survival on earth, and the heat energy that is released when organic energy is used up doing the work of life. The organic energy for our life comes from the food we eat. Of course, we also get other good things from food, but this section is about energy.

Personal Opinion! Sometimes people want to argue about their various experiences with energy. That kind of argument makes me cranky. (Actually, more often they don't want to talk at all and that makes me even more cranky.) Yes other forms of energy exist that science can not measure. Furthermore, we probably sometimes use the same word "energy" for phenomena that are different from energy as science understands it. Phenomena that can not be measured can not be studied using the scientific method. That doesn't mean they aren't real; it also doesn't mean they are real. It simply is not relevant to our factual knowledge of the ecosystem, and I don't see the point in arguing over things we don't understand if we are ignoring critically important facts that we do understand. Surely there is no shamanic or religious or New Age tradition that would relieve us of our responsibility for stewardship over the welfare of mother earth, and our responsibility to understand the measurable facts about her needs, so that we can know which of our behaviors are helpful and which equally well intended behaviors actually are making things worse.

Dog Found

Our Life Energy Comes from Food

Food is the source of energy and materials for our bodies; food is the energy source for all plants and animals and almost all other organisms. Food is also the energy source for the entire ecosystem; the energy that supports life comes from food, and food is made of organic molecules.

All the energy that we need to run our bodies and most of the energy we use to run our machines comes from plants and other organic things. Organic things are those that are or formerly were living things or part of living things. These living things include cells, organisms, ecosystems and organic molecules. Organic molecules, in chemistry, are molecules that contain carbon. Most carbon compounds are made by organisms, and mostly they are proteins, carbohydrates, nucleic acids (DNA and RNA) and lipids -- and a few other molecules. For example some of the vitamins and smaller molecules that are necessary for life.

You already knew that. You know that you would not have muscles without proteins; you would not have parents and children without DNA and RNA that carry the code of life from one generation to another. You may think you have too much lipids in your body, but if you remember the dog on the previous page, you would not want to change places. And as for carbohydrates, you can eat them unwisely, but if you had none at all, then nothing would happen inside your cells because carbohydrates carry a primary source of energy for your life. Organic food molecules are made of atoms (carbon, hydrogen, oxygen, nitrogen and others) that are the building blocks of your body. All these atoms make up your structures, and they are joined together and kept together by energy bonds.

Energy bonds of organic molecules, and inorganic molecules such as water for example, all follow the same rules of chemistry. There are a great many different sorts of energy bonds -- strong bonds, weak bonds, bonds with odd names, and we do not need to know all that. To avoid talking about ideas we don't need, I will take the unusual liberty of referring to the energy contained in the energy bonds of food as "organic energy." If you want to know more, you could probably find a university level biology book or chemistry book,[11] or you can find information on the web. For the bare bones, we need to know that chemical energy bonds are the energy that keeps molecules from falling apart, and that they are very specific. Each specific kind of atom makes specific sorts of bonds with some other atoms.

And it's very important to understand that organic molecules are made by plants. The plants take the various atoms and join them together, using energy they can capture from the sunlight. This "fixes" the energy in a big organic molecule that we can use as a source of energy to run our lives. Then they can use the organic molecules to get the energy they need to stay alive.

Animals do not make organic molecules from sunlight. We can rearrange organic molecules, and take energy from food to make new molecules, but we can't make organic molecules without using more energy than we generate. To get our energy, we must eat organic molecules.. Then we digest them. Digestion is a part of metabolism that is described in more detail below, but the metabolism of all organisms uses the energy stored in organic molecules. The molecule is broken apart, and the energy from the bonds is transferred to a different kind of molecule that has a specific function in the body. This is also a part of metabolism.

Energy Levels - A Question from our Blog Readers
http://factfictionfancy.wordpress.com/2009/11/22/energy-levels/

"What do you mean by high energy and low energy? Isn't the sun made of nuclear energy?" The sun is actually made of matter: mostly very hot hydrogen. Which produces light and heat energy by nuclear (fusion) reactions. So the sun is indeed a source of several kinds of high level energy including light. However, we can not eat nuclear or light energy. We need organic energy. Plants can use light energy to make organic molecules. If you want to look up the second law of thermodynamics on the web, another reader sent a fine reference, written by a chemist. http://secondlaw.oxy.edu. He thinks that the second law is: "The biggest, most powerful, most general idea in all of science." Probably he is right, but let's not only think of a basic natural law as an "idea." Whether or not we perfectly understand them, the laws of thermodynamics are real.

The second law says that "high energy" (we could say more concentrated energy as they do on the web site) can change to low energy but not the other way around. The web site uses the example of a hot frying pan that can release its heat energy but can not get it back again without someone doing the work of adding energy back into the system by turning on the burner. Higher-level energy is released from the chemical bonds of the burning gas and transferred to the frying pan as heat energy.

To determine which is a higher or a lower form of energy, we observe behaviors. If a type of energy can change into a different type of energy, then the first is a higher form and the second is a lower form. Gas, coal or oil contain organic energy. When they are burned, the bond energy is released as heat energy.

So we know which type of energy is higher energy by observation. Another way to observe is to see what kind of energy is given off when a substance degrades (for example what kind of energy is given off spontaneously as the sun burns). Energy types include:

Nuclear
Light
(that plants can use to make organic)
Electrical
Heat

Light energy can not spontaneously revert to nuclear; heat energy can't change back to either light or nuclear energy unless someone adds energy to the system. This is why energy companies can not "make" energy. There are other forms of energy. We particularly focus on light energy because plants use it to make organic energy that drives the ecosystem. The ecosystem is uniquely able to capture the energy from light, that it then uses to create organic energy. Our food.

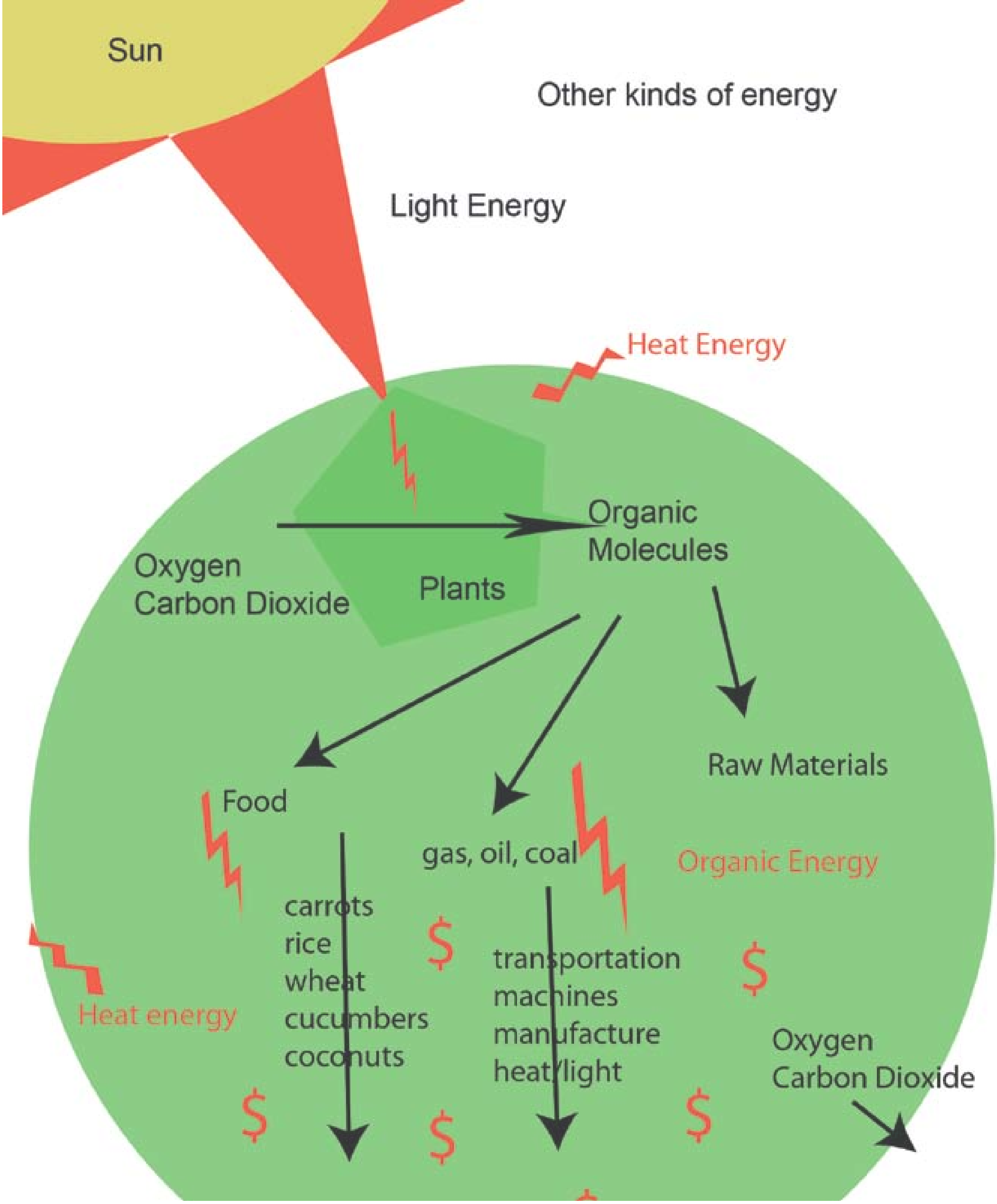
Almost all the organic energy required by the whole ecosystem is made by plants, or it was made by plants at an earlier time in history. Oil and gas and coal are fossilized organic compounds that were originally made by plants using energy from the sun.

You also know that all things eventually decay or fall apart unless something is holding them together. Sometimes it takes a very long time, like a mountain might grow because of energy from a volcano. Then, when the volcano energy stops, the mountain gradually falls down. For another example, any plant or animal will decay after it dies. Cells, when they die, can no longer do the work of maintaining their tiny round shapes, making new molecules needed to do the various functions of life, and they fall apart. And even molecules, like proteins, carbohydrates and etc., will eventually come apart if there is no energy to hold them together. It takes energy to grow or move; without energy, things fall apart. Most of the cells in the whole world, including yours, are using organic bond energy from their food right now -- processes within the cell move the energy away from the molecule that is coming apart and use it to energize other cellular processes required for growing, moving, catching more food, running away from enemies, and making babies -- whatever they need to keep their species and their ecosystem alive.

Energy Flows Through the Ecosystem Or Nothing Happens, Not Even Life

"Flows through" means that it comes in one way and basically "runs downhill" until it is all changed to a lower form, and then goes out another way. Energy can not be created or destroyed, but it can change its form, and when it changes its form it can do some work. So, light energy comes into the ecosystem (into green plants). This high energy light is used in the process of photosynthesis to bond together smaller molecules to make bigger organic molecules. Some of the energy is stored in the organic molecules, while the rest is changed to a lower energy form, that is heat. We people can not use light or heat as a source of food (organic energy). We can't eat light, we can't eat heat; but we can eat organic molecules such as meat (protein), fat (lipids) and carbohydrates. Then of course we use (metabolize) the organic energy as our digestion breaks the big organic molecules into smaller molecules thus releasing the energy bonds that were holding them together. Most of the energy for life in the ecosystem comes from organic molecules that are created by plants using the energy of light.

If we use up all the plants to make paper to put in your mailbox -- if we eat more plants than the earth can grow -- if we burn up more organic molecules than the ecosystem can make -- we are unbalancing the flow of energy through the ecosystem. The ecosystem does not stay alive by growing forever bigger like a cancer; the ecosystem is the balanced living earth. Energy flows to it from the sun, is captured by plants that can make organic molecules, and is distributed through the ecosystem -- through all its levels of organization -- as food. The organic energy is gradually changed into heat energy as it is used to energize the processes of life. To stay alive, the ecosystem must maintain the balance among all these processes. It must be able to balance the input and the outgo and the waste products with each other as the energy flows through all the living things of the whole ecosystem. The right amount of energy is stored in organic molecules by the plants so that the plants and animals and other creatures all have the energy they require to stay alive. The right amount of energy is used up -- enough to keep the organisms alive, but not so much that the plants are destroyed. The right amount of heat energy is the byproduct. Just enough heat energy to maintain the environment necessary for life -- but not so much that would upset the balance of the materials (water for example, and oxygen and carbon dioxide) that cycle through the ecosystem or to upset the temperature or other environmental conditions that are necessary for life.



"What does that have to do with us people?" someone asked
http://factfictionfancy.wordpress.com/2009/11/19/what's-that-go…do-with-people/

I gave a longish answer on the web, but for now let's just consder the most basic fact of economics. Money comes from resources. The resources of the earth ecosystem are limited and we are running out.[12] We can print all the paper we want, but that will not change the relationship between resources and money. Technology can not change natural laws; so it's good to understand the natural laws.

When someone interrupted the train of logic to talk about money, we were discussing the energy of life that is contained in large organic molecules.

Molecules are Composed of Atoms joined together with Energy Bonds

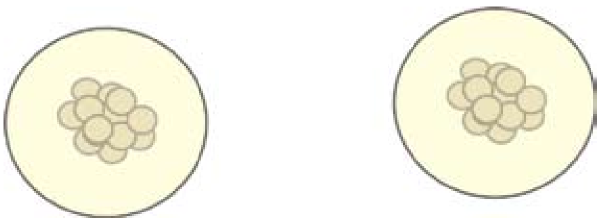
http://factfictionfancy.wordpress.com/2009/12/12/molecules-are-…posed-of-atoms/

At least this is a useful way to think of these entities that are so small and at such a relatively low level of organization that we (meaning the physicists, I don't try, I only want to know how they function) can't see, touch or imagine precisely how they function. But we can make a model that describes the things we know about how they interact with each other and with their environment.

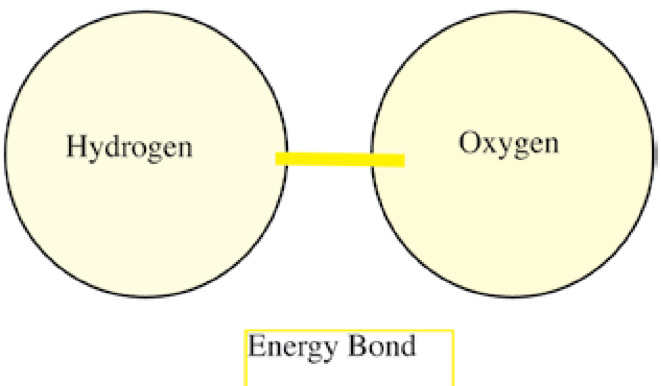
OH-NO-chemistry

Atoms are made of mass and energy. Mass means they have weight (where there is gravity) and volume. On earth there are a little over 100 different kinds of atoms that are discussed in a lovely recent photo book by Grey and Mann.[14] In case you want to know more.

Each different kind of atom has a different mass. The mass of an atom can be thought of as protons and neutrons that make up the internal portions of the atom. Protons have positive energy that attracts electrons. Electrons have negative energy charges that make up the outer portion of the atom where it can come in contact with other atoms. (These negative energies are somewhat similar to minute units of electricity). Atoms with more protons are heavier, and they also have more electrons because the opposite charges attract each other. Different kinds of atoms can join together, according to their different electron energies. If the energy attractions are strong, then atoms can make energy bonds between themselves to form molecules.

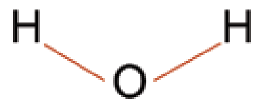


A molecule is two or more atoms joined together by energy bonds. The following diagram is one way to describe an energy bond.



One molecule of water, for example, is two hydrogens joined with one oxygen by energy bonds.

One molecule of carbon dioxide is one carbon atom joined with two oxygen atoms (symbol is CO_2). Three molecules of water would be symbolized as $3H_2O$. Carbon atoms are C, Nitrogen is N, etc.



Energy bonds are not random. The innate energy characteristics of a particular kind of atom determine if it will bond and how it will bond with other atoms. This is another of those laws of nature that humans can not control. We can change atoms around -- we can bombard them and break them because we have powerful technologies, but we can not change the nature of the energy interactions. Energy interactions happen according to the second law of thermodynamics, and that's all we need to know to appreciate how energy is captured in the form of energy bonds and transferred from place to place throughout the ecosystem. We don't need to know all about the chemistry and physics of atoms and molecules to understand that living things are able to control the release of energy from the energy bonds and use it to do the work of living.

Metabolism

http://factfictionfancy.wordpress.com/2009/11/26/metabolism/

Isn't it interesting that so many cultures have historically honored or revered the sun as the source of life -- and then science found that the sun is indeed the source of the energy for our green plants and so for the life of the entire earth ecosystem? And we know the flow of energy through the ecosystem is accomplished by metabolism of organic molecules and by organisms eating other organisms and then metabolizing the organic molecules. Better yet, we know how metabolism functions to use the energy from the sun to make those organic molecules.

According to Webster's Handy College Dictionary, metabolism is: "The chemical process of absorbing food." The computer says: "the ongoing interrelated series of chemical interactions taking place in living organisms that provide the energy and nutrients (that is food) needed to sustain life." These definitions are OK, but I don't like either and it is easy to find books, videos, and all sorts of information about human physiology that tell us how we eat and absorb our food and get rid of the waste products. All these resources tend to be so focused on humans, as though the whole process is all about us, that many people imagine, as did primitive peoples, that food is magically provided for us on this earth and the only thing we need to do is find it and eat it. This is so far from the reality that we are threatening the health of the ecosystem by our voracious finding and eating.

The incredible beauty of the living process is the way in which green organisms convert the light energy into the energy bonds that they use to make big organic molecules that then circulate throughout the ecosystem as food. Organic energy. Many organic molecules (also known as carbon compounds) are big macromolecules that contain a lot of energy bonds. They are composed mostly of carbon, hydrogen, oxygen and nitrogen because of the ways in which these four atoms are capable of joining with each other. We will remember again what you probably already know, that the major organic macromolecules that we think of as "food" are proteins, carbohydrates, lipids and nucleic acids.

Macromolecules are big molecules composed of smaller molecules joined together by energy bonds. Proteins are made of long strings of amino acids; large carbohydrates are composed of smaller carbohydrates; lipids are composed of smaller lipids; nucleic acids (DNA and RNA) are made of nucleotides. Just to give you an idea of comparative sizes of these molecules, the smaller subunits, for example a nucleotide, might consist of 12 to 25 or 30 atoms bonded together, while the macromolecules, for example the nucleic acid, can contain hundreds or thousands of the smaller molecules. All held together with energy bonds. There is a lot more energy in big molecules than there is in little molecules.

When you remove or break the energy bonds of a large molecule, the molecule comes apart. For example, when a protein is "digested" in your gut, it is broken down to the amino acids of which it is composed, and other organic molecules also are broken into their subunits when they are digested. In organisms, both the joining together and the taking apart is regulated by other molecules in the cell. These are enzymes, that direct the chemical reactions, and we will talk more about how this is done when we discuss the flow of information through living things in Chapter Three. For now we need to know that the basic unit of life, the cell -- in fact nearly all cells -- are hotbeds of enzymes and molecules doing this kind of work and other kinds of work that keep the cell alive.

Now we re-connect with what we said about the second law of thermodynamics. Making large molecules from smaller molecules (or molecules from atoms) requires energy, because this is a thermodynamically "uphill" process. The products end up with more energy than was in the subunits, it takes work to do the job, and therefore requires an input of energy from outside the system.

Living cells are also able to break down the large molecules. This is a "downhill" process according to the second law, and so of course it could happen spontaneously with the release of energy. However, organic energy bonds are strong bonds, so it might take as long as a mountain falling down if we wait for them to fall apart by themselves, and the energy would be of no use to us by then. So the cell needs enzymes to direct its uphill and downhill metabolic reactions The cell requires energy input for uphill reactions; energy is released during downhill reactions. Energy can not be created or destroyed. However, whenever it is used to do any work, energy changes from a higher form to a lower (less organized) form. This is a fact of the universe; it is a reason that we can be alive; but it is also the source of our energy problems of today. When organic energy is used to do work it changes to a lower form of energy, usually heat energy.

Very important point! None of these processes is 100% efficient. Whenever work is done, some of the energy is lost as heat. Plants capture energy from the sun. Whenever any animal eats part of the plant and uses the organic molecules, about ten percent of the energy is lost as heat. If another animal eats that animal, another 10% is lost, and so on through the ecosystem until finally the waste materials and dead bodies fall to the ground and are used to generate rich, organic soil that is capable of nourishing more plants, and more energy is lost from the system.

The ecosystem takes energy from the sun and converts it to organic energy that it shunts around in every cell, every organism, and the whole ecosystem. But *energy does not recycle*. When it is used up it goes away as heat and it is gone from the system forever because heat is a lower form of energy than organic energy. Light energy comes in, it gets used and converted to heat energy, and it goes away.

As always, it is the balance of all these processes that is required to maintain life.

No more chemistry?

No Such Luck!

But it's just a little review. With a couple of added touches, and then we discuss what really causes global warming, and what is sustainability -- really.

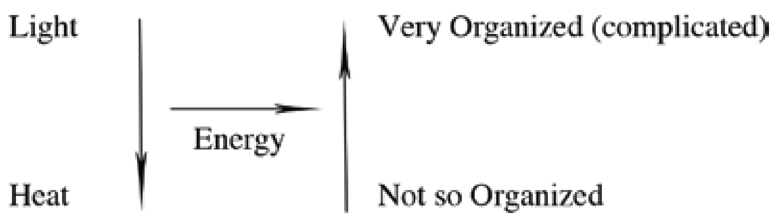
Light Energizes Life -
http://factfictionfancy.wordpress.com/2010/01/03/light-energizes-life/

Energy Flows-Or Nothing Happens

Light is one kind of energy. There are many things about light that we don't understand, but we only need three bits of very well established scientific fact to cover the most important aspects of how energy flows through the ecosystem to keep all of life alive.

1. Light is energy. We have defined energy as the ability to make actions happen, and light can make actions happen. For example, when light hits your eyes it activates molecules in a nerve cell that sends the message to your brain. That is one kind of work. Energy is the ability to do work.

2. According to the second law of thermodynamics, pushing anything from a lower level of organization to a higher level requires work. Work is necessary to push any kind of action "uphill," but "downhill" actions can happen without help. It requires energy for you to climb the stairs to the top of the Empire State Building, but it requires no energy to get to the bottom if you fall off. In a more relevant example, anything that is more complicated or more powerful is "uphill." To make a cake requires energy, but it can fall apart by itself. Cake is more complicated than flour. Life is the most complicated thing on earth. Cells require energy all the time in order to maintain their complex organization. They do this, with regard to energy, by balancing the "uphillness" of complexity with the degradation of energy. The light gives its energy to maintain the complexity of life. This is possible because energy takes different forms.



3. Some forms of energy are "uphill" from others. For example, light energy can release some of its energy to become heat, but heat energy can not spontaneously change back into light, because heat is a lower form of energy. Plants use light energy to make what I am referring to as organic energy (in food). Light energy is a higher form than organic energy, and organic energy is a higher form than heat energy.

So, the bottom line is that life maintains its "uphill" complexity, by changing light energy to organic energy and using the organic energy to feed the whole ecosystem. For some people, this is the definition of life. Life is working, working, working all the time to keep itself from falling apart, and — if it stops working — it does fall apart. It dies.

That's why people are alive and cake is not. Once you turn off the oven, the cake has no way to maintain its high level of organization and eventually it will fall apart. The miracle of life is that it can use

light energy to keep itself organized and functioning — and it does this inside of itself. Inside every cell in our bodies and every organism in the ecosystem. So far as we know, nothing else in the universe can do this and also use the energy to reproduce itself in its own image. Only life.

So the first half of our life story is about the amazing way that plants, and some bacteria, are able to capture light energy and convert it to organic energy. The process happens only in green plants and bacteria and it is called photosynthesis. Photosynthesis is the process of capturing light energy and converting it to organic energy bonds that join together groups of atoms and small molecules to make large organic molecules. The plants capture the light using a large pigment molecule that is called chlorophyll.

Capturing, or absorbing light energy is no problem. Absorption of light energy happens all around us; it is what makes the colors. Pigment is any substance that absorbs light. Light from the sun includes (contains, is made of) several different kinds (different wave lengths or different energy types) of light. We see some of these in rainbows, and we can see them because our eyes are activated differently by the different wave lengths of light energy.

We see a cat because sunlight hits the cat and bounces off the cat into our eyes and energizes some nerve cells. This cat is orange, because only the orange light bounced off her. The other wavelengths were absorbed by the pigments in her hair. (We wrote a whole book about hair pigments, available on Amazon, called The Colors of Mice, but that is blatant advertising and has nothing to do with our story here.)

The wave lengths that bounce off — that are not absorbed by the pigment — are still light energy; the wave lengths that are absorbed into the hairs change to a lower form of energy. For example, heat energy; that's one reason the cat is stretched out in the sunlight on a cool day. It makes her feel warm and cozy. The other reason is that the sun is also emitting heat energy along with the light. The pigment of a black cat absorbs most of the light that shines on it. A white cat reflects most of the different wavelengths of light. The green rug in this picture is reflecting green light back to our eyes and is absorbing the other wavelengths.

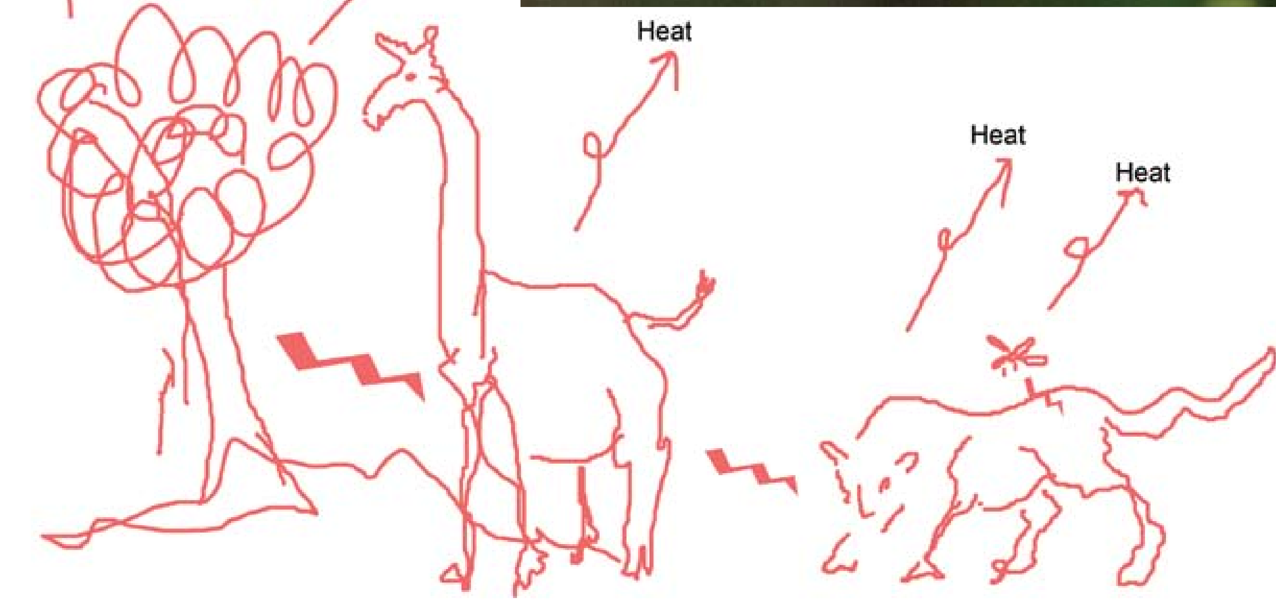
Plants, as you already realize, reflect the green light and keep the other wavelengths. Unlike cat hair pigment, however, the plant pigments (chlorophylls) do not allow the light energy to degrade into heat energy. Instead, the plant has a very complicated series of biochemical reactions (controlled by enzymes) that converts some of the light energy to make the energy bonds of large organic molecules. We will talk about the chemical reactions later.

Absorbing the light into a pigment molecule of (mostly) plants – and then using the energy to make food molecules — is the first half of the flow of energy through the ecosystem. The second half is distribution of the energy so that all the parts of the ecosystem can stay alive.

So, to recap, the energy that does all this work comes from food. And of course you know what happens when you have no food. The only food we can use to stay alive is organic molecules, and the organic molecules are made by plants. If someone tells you there is no limit to the energy available to us — because it comes from the sun — they are wrong. You and I both know we can not eat sunlight;

our food comes from plants, and we are definitely limited by the amount of plants on earth, not by the amount of sunlight. If someone tells you we can make organic molecules for ourselves to eat, that is true, but unfortunately it takes more energy to make the food than we can get back when we eat it. And anyhow food is not the only thing that keeps the ecosystem alive. The ecosystem is a network of interacting processes; it requires a lot of things, and the most important is to keep all those things in balance.

The ecosystem stays alive because the energy from the sun flows from one of its life forms to another to another to another, doing the work of keeping cells alive. Cells of plants, cells of bacteria, cells of cats and kohlrabi, cells of your body, cells of trees and tigers and nematode worms, cells of mosquitoes, grass, horses, fish. You get the idea but if you want a visual cue you can look to the elegant, if simplistic, diagram below.



Photosynthesis and Cellular Respiration
http://factfictionfancy.wordpress.com/2010/01/05/photosynthesis/

Biochemistry (for a lot more information, check out Lehninger Principles of Biochemistry by David E. Nelson,[11] or whatever similar book you have handy) is the chemistry of living things. Biochemistry focuses on organic molecules and their interactions in cells. Plants and photosynthetic one-celled organisms can do photosynthesis because the cells contain chlorophyll to absorb most of the energy from light. They can use that energy to make organic molecules in a process called carbon fixation. As we discuss each basic process -- photosynthesis, carbon fixation, cellular respiration, we will look at a diagram of the "chemical reaction." At the same time, we know that each of these major processes consists of a series of dozens or hundreds of chemical reactions and our descriptions are summaries of all those.

To make all these reactions happen at the right time in the right place, the cell uses enzymes to direct specific chemical reactions. An enzyme is a protein that functions as a catalyst. A catalyst is anything that causes a chemical reaction to happen but is not used up in the reaction. So it can continue to catalyze the same reaction many times. A specific type of enzyme is available in the cell to regulate nearly every uphill or downhill chemical reaction so that it will happen at the right time in the right place. The enzymes and all the other proteins are under the control of our genes, and this is how the cell, and the body, and the ecosystem, know how to do all the processes of life. But that's the subject of chapter three so for now we will just believe it. The genes of living things make the right actions happen at the right time and in the right place within the living thing.

A chemical reaction.is a change that happens among atoms or molecules. For example, carbon and oxygen can come together to make carbon dioxide. The equation would be:

1 carbon atom + 2 oxygen atoms ----> carbon dioxide molecule

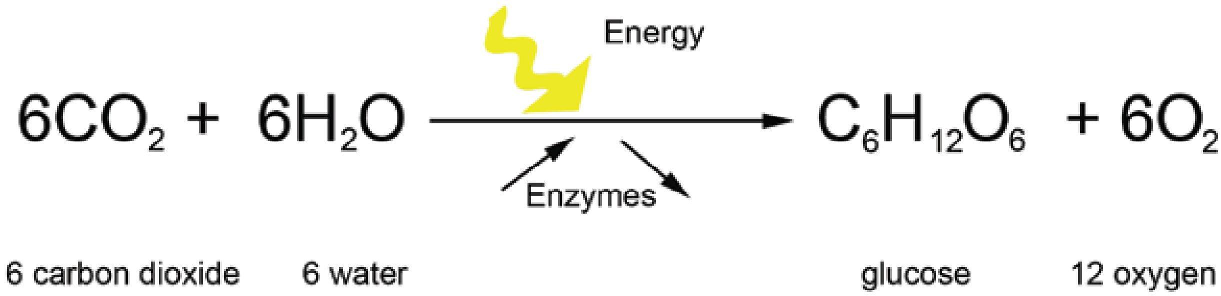
$C + 2O \rightarrow CO_2$

The symbol for carbon dioxide is CO_2. It still has one carbon atom and two oxygen atoms but the energy relationships have changed.

carbon and oxygen are the "substrates" of the reaction
carbon dioxide is the "product" of the reaction

Photosynthesis is a multistep uphill biochemical process that includes the absorption of energy, and carbon fixation. Carbon fixation is the uphill process of taking carbon dioxide from the air and using it, along with water and energy, to make the organic molecule glucose, as diagrammed on the next page. (We say O_2 because oxygen normally floats around as a molecule of two oxygen atoms.)

In terms of the second law of thermodynamics, glucose is "uphill" from carbon dioxide (CO_2) or water (H_2O). Therefore energy is required to push the reaction. How easily the molecule can fall apart (how stable it is) after it has been bonded together, depends upon how firmly the energy bonds are holding it together. Each kind of atom or molecule is unique; therefore the ways in which they can or can not fit together and remain stable depend upon their unique characteristics



Enzymes direct the reactions. Because the enzymes are not an integral part of the reactions, the enzymes are not permanently changed during the reaction. Therefore they can be used again to cause more rounds of the same kinds of reactions. Enzymes are specific to reactions. Each reaction requires its own kind of enzyme. By controlling the enzymes, the cell can control the reactions. We will discuss that fact in Chapter Three (Flow of Information through Time).

The overall process of photosynthesis and carbon fixation involves a complicated pathway consisting of many small steps during which small changes are made as energy is transferred under the direction of multiple enzymes. In eukaryotic cells (higher forms of cells, see levels of organization later in this chapter), one kind of specialized organelle, the chloroplast, is responsible for organizing the overall process of photosynthesis. A chloroplast is an organelle that functions in photosynthesis. Organelles are structures inside of eukaryotic cells that are organized to perform specialized functions. They are composed of membranes (made of lipids) that contain all the necessary enzymes (proteins), organized in the best way to cause these complicated reactions to occur. Glucose and oxygen are products of the overall reaction. The glucose is a carbohydrate with high-energy bonds. It is then made available to the entire cell, and all the cells of the body of the plant (because plants also have circulatory systems). The oxygen product is released into the atmosphere.

Glucose is a carbohydrate. An organic molecule containing organic energy. Once the ecosystem has that first organic molecule, it can change it around to make other organic molecules that it needs, or it can take it apart and recapture the organic energy that is in the organic molecules. It also can make lipids and it can add nitrogen and other kinds of atoms to make proteins and nucleic acids and other organic molecules that it needs to survive.

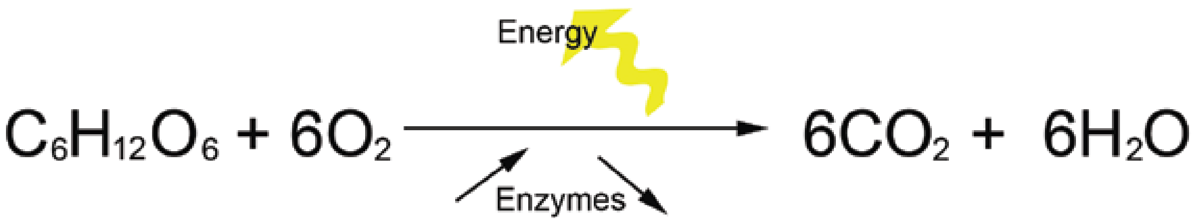
The organic molecules are then distributed throughout the ecosystem by organisms eating other organisms. And while the organic materials are circulating in the ecosystem, all the plants and animals of the entire ecosystem are keeping their bodies alive by metabolizing the organic molecules. Metabolism is the process -- actually it is thousands of processes -- of changing those organic molecules around to make all the different parts of our bodies: muscles, heart, eyes, all the structures of our bodies are made of organic molecules or they are made by organic molecules.

That is a lot of work!

The energy to do this work comes from cellular respiration. Cellular respiration is the process of breaking down the glucose molecules, under the tight control of the cells, so that the released energy is captured, still in the form of chemical bond energy. The energy is taken from the glucose to energize other important cellular functions, possibly your muscle movement, or perhaps the light receptors in your eyes, and so the glucose atoms are no longer bonded together. They are released from the cell as carbon dioxide and water. Oxygen bonds with carbon or hydrogen because it is a downhill reaction -- the energy bonds (added together) contain less energy in the carbon dioxide and water than they did when these atoms were bonded in the glucose molecule, and some of the energy is lost as heat.

Notice that it requires oxygen to burn glucose, but it would not be correct to say that we are burning the oxygen. The energy is released from the glucose - just as energy is released from the organic compounds in wood or gasoline when these are burned in the presence of oxygen. The oxygen is required to remove the waste products (carbon and hydrogen) of the reaction so the energy can be released.

The equation for breaking down glucose can be written:



But of course it is not only one reaction. It is a series of dozens of reactions that are catalyzed by enzymes. In higher forms of cells, these reactions are organized in organelles known as mitochondria. Mitochondria are organelles that are specialized to direct the process of cellular respiration.

You probably already know that plants release oxygen that the animals require to breath, and the animals release carbon dioxide that the plants require to “breath.” Almost everyone knows this, but did they tell us why we need to breath? Or did they let us believe the plants are here on earth so that people can breath oxygen and eat?

No way.

It’s all about carbon fixation and cellular respiration.

Animals and plants “breathe in” oxygen so that each cell of the body will have the oxygen it needs to do cellular respiration in order to release the organic energy it needs to stay alive.

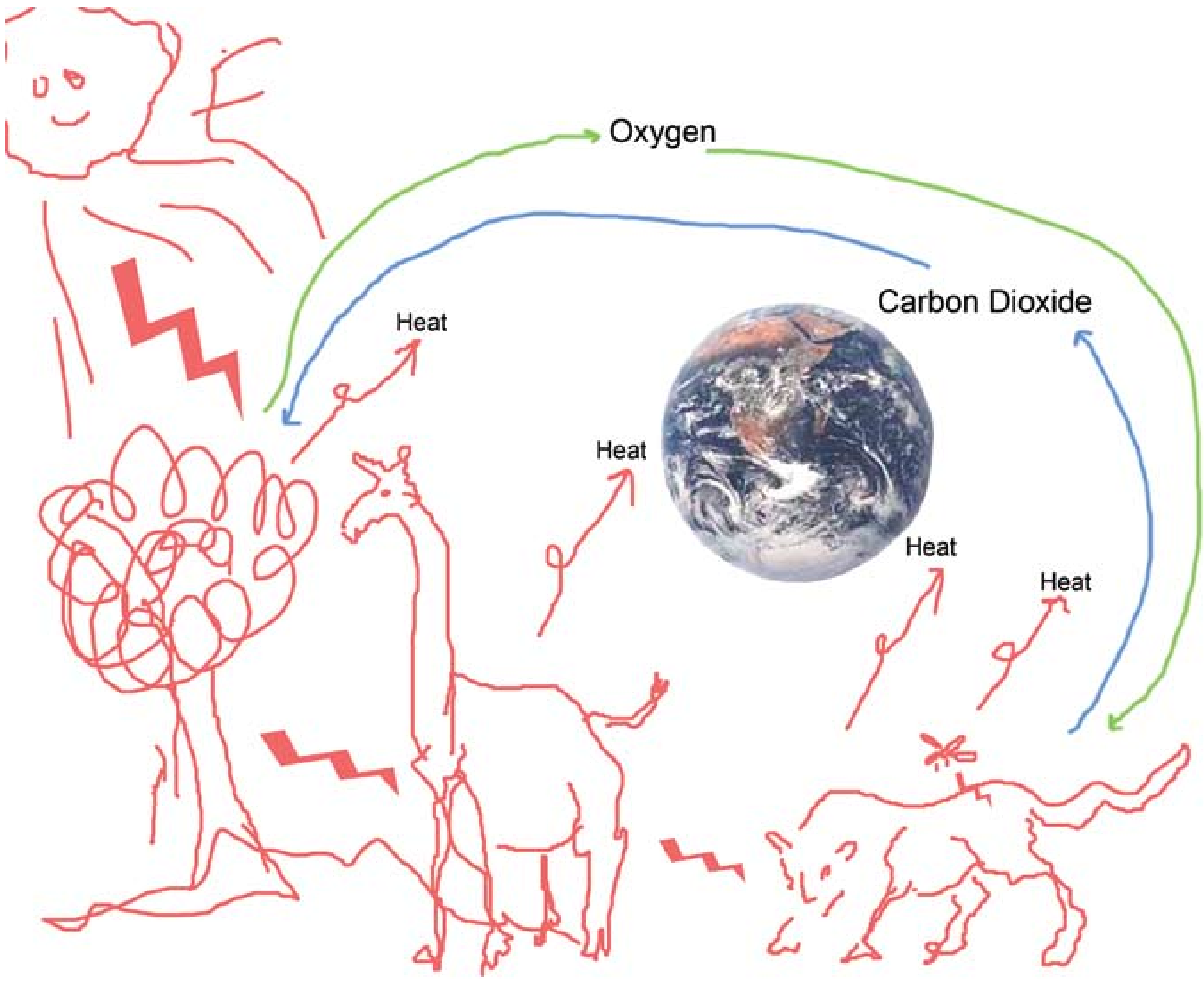
Plants "breathe out" oxygen, because it is a waste product of photosynthesis and carbon fixation. They need to get it out of the way so they can do more photosynthesis and carbon fixation.

Animals and plants "breathe out" carbon dioxide because it is a waste product of cellular respiration.

Plants "breathe in" carbon dioxide because it is a substrate in the process of carbon fixation, the process that provides food for the whole ecosystem.

It is the miracle of life that life supports life and life requires life. Nothing dominates, not even that lion in the diagram below; everything interacts so that all may survive,

but only so long as the balance is maintained.



Levels of Organization

http://factfictionfancy.wordpress.com/2009/12/07/levels-of-organization/

The Ecosystem is a Network of Levels of Organization

If you find it mind boggling to comprehend the levels of organization shown on the opposite page, all interacting among and between themselves, then join the club. You and the scientists, the politicians, the religious and everyone else. Fortunately, we do not need to understand all the little details of the system in order to have a good overall idea of how it functions — the structural and functional requirements for it to stay alive — and that is our goal.

The ecosystem consists of sets and subsets of living and nonliving entities that interact between and among themselves. We can not represent the entire system in a diagram for two reason. One is that the sets and subset (levels of organization) are flexible (resilient), a fact that is necessary for their survival (sustainability). The other is that there are just too many interactions to understand or represent.

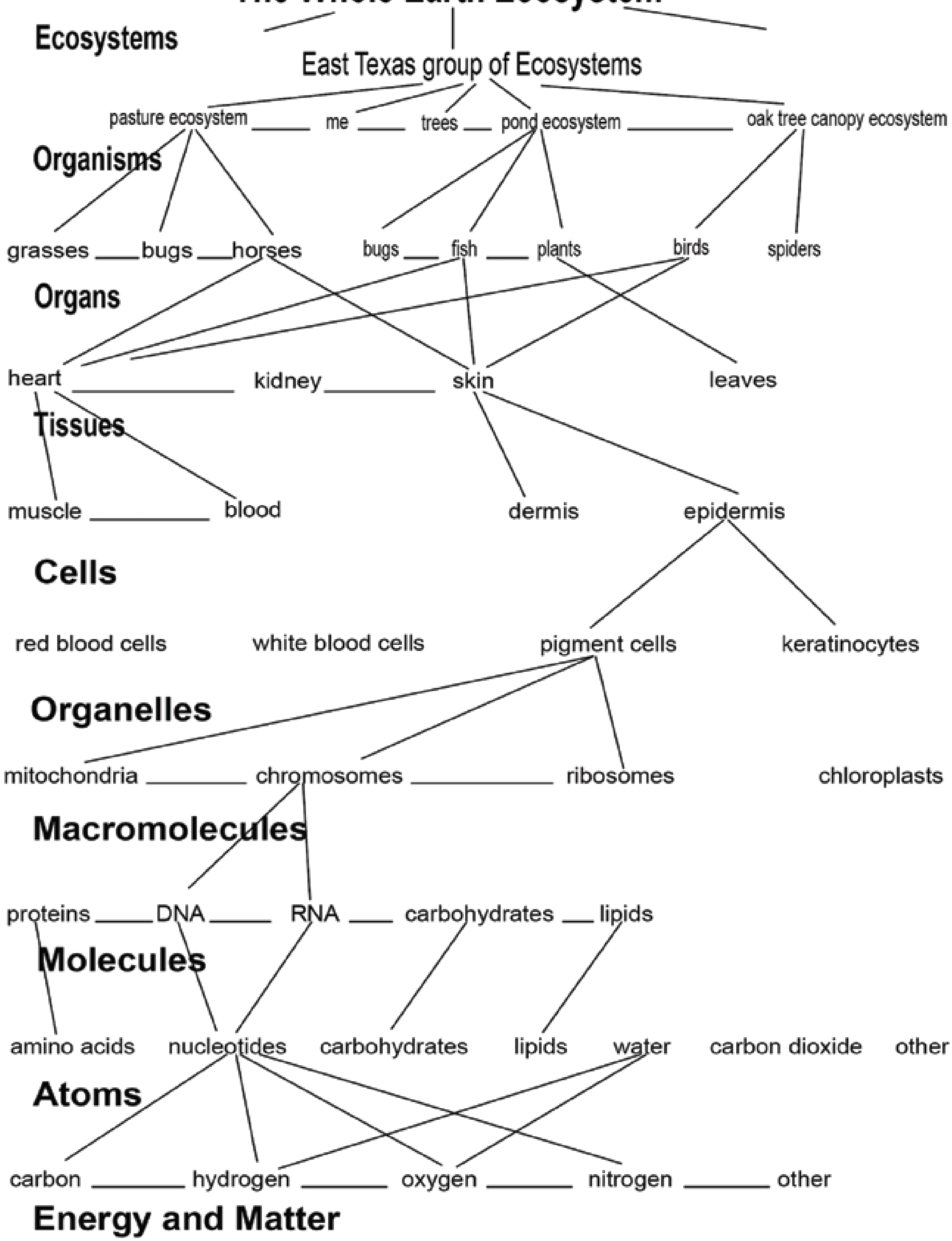
Imagine that everything interacts with everything on this diagram in some way(s) and also everything interacts with millions of other entities that make up the living system. For example, your heart interacts with every other component of your body; your resilience and therefore your survivability (sustainability) would be unlikely if any of these interacting components of your body were missing. All the organs work together to maintain your life. This is represented by the lines between the heart and kidney and skin on the diagram. The same is true of all the organs in your body. They all interact. Similarly, the leaves, bark and other organs of a tree all interact among themselves to make the tree alive, and the tree interacts with nearly everything else in the ecosystem, including us.

We are only one component of the metabolism of the ecosystem. Our lungs breathe the oxygen that is provided by plants; our food gives us the energy we require for life; the environment degrades our wastes, so that we are not suffocated in a dung-heap of the unused byproducts of our metabolism. These processes are carried out by other organisms that all are interacting within all the big and little ecosystems of life on earth. We could not survive without the other elements of the ecosystem, and we also contribute to the other elements of the network that is the ecosystem. At the same time, a special type of interaction exists that we can think of as "nested" interactions, or hierarchies, in which each of the parts is a subunit of other parts. Everything in the universe (everything we can know about) is composed of other, smaller things. These relationships are referred to as levels of organization.

A very few example relationships of this kind are shown in the diagram by the vertical lines. To summarize some of the levels of organization that exist:

1- The whole earth ecosystem is made up of smaller ecosystems and organisms. The whole earth ecosystem is the biggest (most inclusive) unit of life on earth.
2- Smaller ecosystems are made up of organisms and their environment.
3- Organisms are made up of organs and their environment

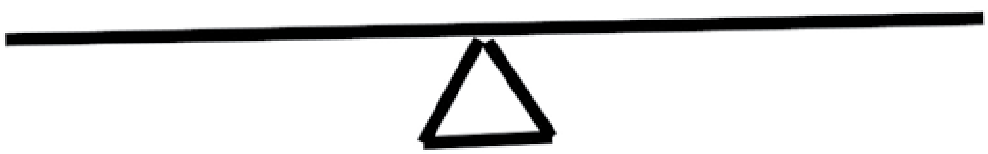
The Whole Earth Ecosystem



4- Organs are composed of specialized tissues and their environment.
5- Tissues are composed of specialized cells and their environment.
6- Cells can be organisms or they can be subunits of organisms. The cell is the basic unit of life. Below the cellular level of organization, life as we define it is not present in the interacting systems of which it is composed. However, there are many levels of organization that are non-living.
7- Cells would not be alive without the precisely organized organelles, macromolecules and molecules of which they are composed.
8- Organelles are subunits of eukaryotic cells and perform specific functions required by those cells. For example, the chloroplast and mitochondrion that we have already discussed. Eukaryotic cells are cells that have organelles. Prokaryotic cells are not so complex and are composed of macromolecules, molecules and atoms. They do not have organelles, but they have well organized macromolecules.
9- Macromolecules are large molecules composed of smaller molecules.
10-Molecules are made of atoms that are joined together in very specific ways by energy bonds. The kinds of energy bonds and the kinds of relationships between the atoms are not random. They depend upon the fact that different kinds of atoms have different characteristics.
11-Atoms can not be seen or directly measured individually. However, if we collect a few million/billion atoms of the same kind all together in one place we would call that an element.[14]
12- And smaller levels such as protons and electrons and on down for the students of physics.

All the levels and all the interactions make us what we are. And there is another complication. At every new level of organization, emergent properties arise that provide wondrous additional characteristics to the organisms that exist at that level of complexity and also to the ecosystem as a whole. These are described below (after sustainability), but here we can give one example, and that is life itself. Life is the emergent property of the cellular level of organization. The cell is the basic unit of life.

It's also important to remember that any system that has more interactions, to a point, is likely to be more resilient (suggested reading on the mathematics of network behavior, Albert-Laszlo Barabasi, Linked).[15] Resilience is largely the result of complexity and is essential to life. Increased complexity of a network (if balance is maintained among the parts) increases resilience because it makes available "fail-safe" options by providing multiple possible ways to do each process. Increased complexity can also increase the efficiency of energy usage (notice this also can be true of social organizations and is basic to our growth economy). Again, this is true only if balance is maintained among the functions. It does not mean that more complexity is always better than less complexity. Too much complexity can be as harmful to the balanced organization of a network as too little complexity. Complexity must be maintained in balance with all the other essential components of ecosystem viability (viability means ability to stay alive). We could not be alive if the nature of the chemistry and physics of our environment were different than they are, or if the interactions within the ecosystem stopped functioning. All the levels and all the interactions make us what we are. The point at which the entire intricate web might be expected to collapse would be if the interactions necessary for life could not be kept in balance with each other. We are not qualified to know this point because we do not understand all the interactions. And, as the scientists sometimes say: "We don't want to do that experiment.



Sustainability

http://factfictionfancy.wordpress.com/2009/12/03/sustainability/

Warning - personal opinions abound in this section.

When I was growing up, and when I was a productive member of the work force, my goal was to save and to share with the future (to sustain) the "American dream." Of course, that wasn't my only goal, but it was foundational, and it defined the boundaries of my personal dream. The whole point of "my" dream was that we all can have different dreams so long as my dream does not cause harm to you or your good dream. Of course, that's an ideal -- an impossible island within which to function. Therefore, the other half of my dream was a continual process of negotiating the boundaries of our individual dreams so that our community dream can be a positively functioning whole.

It was only after retirement that I realized some of the people I worked with -- and with whom I shared a commitment to the "American Dream" -- it wasn't the same dream at all. We had never explained ourselves to each other, never negotiated our ideas, and so we all were seriously trying hard to sustain different and incompatible dreams. This was a shock to us all, and we very soon were arguing/debating/fighting rather than sustaining. It became clear that we can not build an American Dream if we don't know what it is and discuss it among ourselves -- that is, discuss it before we start to fight over misunderstandings that we don't know exist. We cannot understand each other unless we define our ideas and the words we use to describe those ideas.

Sustainability is a word that we must understand if we are to build a future for ourselves, first because Americans have multiple different ideas of what should be sustained, and more importantly because the word has been co-opted and re-defined by the economic community, following the green revolution, to mean the exact opposite of what it means. The idea of sustainable growth (which is impossible within the living earth ecosystem) has overcome the actual meaning of sustainability. The implications of this reality are genocidal. I see this campaign to change the meaning of the word sustainability as a deliberate attack on the life and health of the whole earth ecosystem for the profit of a few. Worse, the attack seems to have succeeded, and the result, literally, is a Ponzi type of growth scheme that is manipulating the resources of the entire world. Like all Ponzi growth schemes, it's lots of fun while it lasts; however, it is not sustainable. The fact is that sustainable growth is physically impossible, even though the concept of sustainable growth has become embedded in our culture as a synonym for sustainability.

So the word sustainability is a problem because it seems that most or many Americans believe that it means sustainable growth, and the earth ecosystem can not grow very fast at all, and certainly not if we continue to reduce the diversity required for growth while increasing our energy use. The size of the earth ecosystem is flexible, but there is a maximum under any given set of conditions. We are challenging those conditions. Most of us are choosing to believe this is not true, but no belief can change the measured facts.[9, 12] Beliefs that are contrary to measurable and measured facts are not helpful to the welfare of human kind or of the ecosystem.

The ecosystem has become more efficient (over long periods of time) in its use of organic energy (it did this primarily by increasing diversity, as we will discuss below) but we humans can not change the size of the ecosystem, because the first and second laws of thermodynamics determine energy availability. If we continue to try to grow the ecosystem, the result will be the same as it sooner or later is with all Ponzi schemes, because sustainable growth is impossible in a living system. Growth in our whole earth ecosystem is limited by the plants, and we are destroying the plants in our efforts to grow.

If the word "sustainable" has communication problems, another approach might be to use some different words to explain the physical realities of the ecosystem and the things she needs to survive. Rob Hopkins[15] likes to describe ecosystems in terms of "resilience." He explains that resilience as a reflection of the relationship between diversity and survivability. Truly this is important.[16] Diversity is one of the basic realities of life systems; higher levels of diversity generate higher probabilities of survival because the living system is a network. As is true of the computer network, diverse possible pathways make for fewer crashes (well described in "Linked: the new science of networks" by Albert-Laszlo Barabasi).[12] A good general discussion of how this has played out in human populations is found in the historical events described in Jared Diamond's book, Collapse.[13] In our individual experience, we can use the example of cancer and the loss of diversity in our own bodies when one type of cell displaces some of the myriad other cell types we require for our survival. Ecosystems require diversity for exactly the same reasons. The high survival value of diversity in living systems is easy to demonstrate. Still, diversity/resilience is not the only essential element of ecosystem survival, is not identical in its meaning to "sustainable," and none of these terms refers to growth, which is not sustainable.

The most widely quoted definition of sustainability is the "Brundtland definition" of the 1987 Report of the World Commission on Environment and Development: "meeting the needs of the present without compromising the ability of future generations to meet their own needs." According to your computer dictionary, sustainability is: "Able to be maintained." Or, in relation to smaller ecosystems: "exploiting natural resources without destroying the ecological balance of a particular area."

The bottom line is that all the above definitions and descriptions of sustainability are accurate, with the one exception of sustainable growth, which is physically impossible, and for once the computer definition is excellent: "Able to be maintained." Life is sustainable if the requirements for life are maintained in balance. We have already stressed (ad nauseum, but it's *important!*) the minimum requirements for life of any living thing, including the ecosystem:

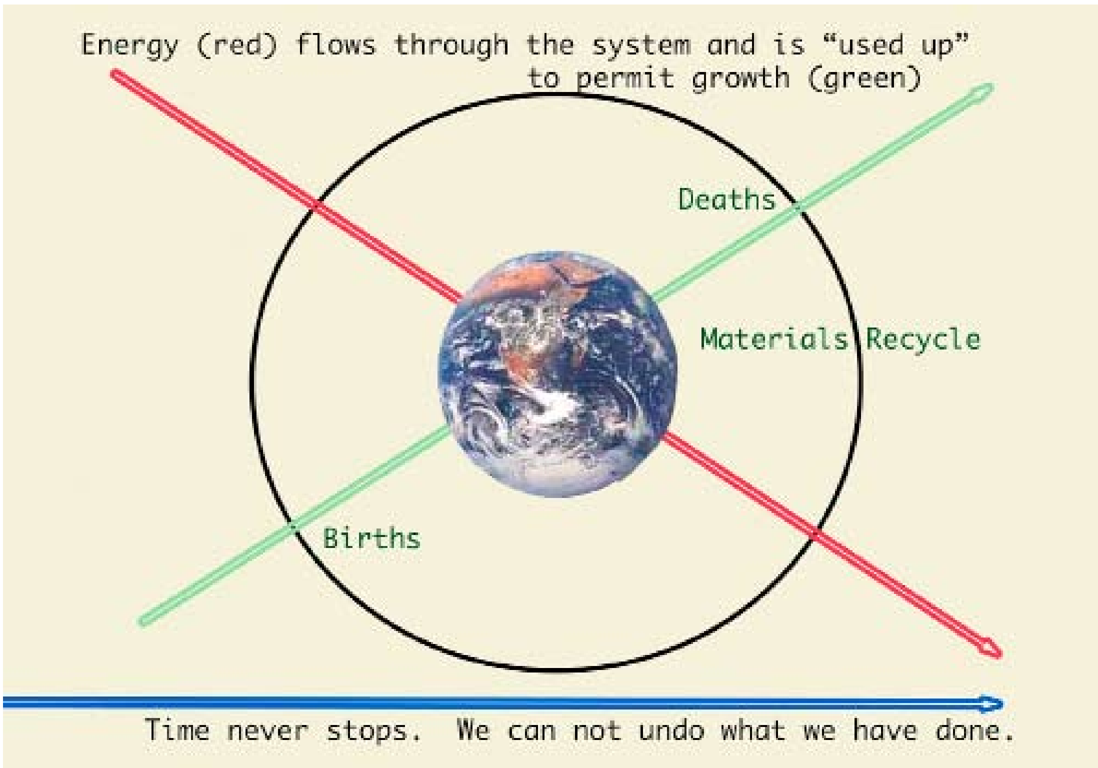
1. A forever balance between the amount of available organic energy that flows into the system and the amount of organic energy that is used up within the system (remembering that we are within the system) and the waste products and byproducts that are released;

2. The cycling of materials such as water and oxygen and carbon dioxide through the whole ecosystem. This will be discussed in our upcoming Bare Bones Ecology book that will cover all three of the major requirements and is now in production.

3. The flow through time of information that maintains the balance among all the requirements for life, and regulates their functions by providing proteins in the right places at the right times. This will also be discussed in the upcoming book.

We have said above that *life* is not the same reality as *a living thing*. The important difference is that a living thing is not sustainable. We die, and that is why most of us share the hope and dream of a sustainable ecology/economy that will nurture our grandchildren at least as well as we have been nurtured. That's also why our various versions of the "American Dream" always involve pictures in our heads of the children and the grandchildren working the land as we do, or boating on Lake Bryan as we do, or celebrating Hannukah as we do or enjoying whatever world view that we enjoy.

But dreams and pictures and words of today do not create tomorrow's realities; it takes appropriate behaviors to build a good reality for tomorrow. It is not the function of the living earth to fulfill our dreams; her job is to maintain her own life. If we really want our grandchildren to be a living, laughing presence upon this living earth we must understand what the ecosystem needs to stay alive and then we must give it to her, because otherwise our own rampant growth upon the earth, just like a cancer in our own bodies, will reduce the resilience and upset the balance to such an extent that the productivity of the earth ecosystem will be reduced and unable to provide enough organic energy to nurture human societies anything like those of today.



Emergent Properties

Can a cell imagine a brain? Probably not, because a cell's "senses" relate to the fluid that surrounds it. The brain, on the other hand, because it consists of trillions of cells, that are organized just so, has the capacity for thought. Directed thought at that. Directed thought clearly is impossible for individual cells, because what we think of as thinking requires many cells working together in an organized way to gather all the information necessary to make a thought. That is why we say that thinking is an emergent property that results when millions of the right kinds of cells come together in just the right way in just the right kind of body. It is an "emergent property" of multicellular organisms, and it's a function that can not be done by one cell alone. If you knew nothing about the brain and everything about individual cells, you could not imagine such a property as thinking.

The unpredictable nature of emergent properties results from precisely organized complexity, and that is why they use the word emergent. It's not a good word; sounds too complicated. But it's the word we have. The emergent property of a car is that you can drive around in it, where you can not drive around in an engine. The emergent property of a kidney is the ability to make urine. Not hard to appreciate when you already know what it does -- but impossible to predict. Emergent properties occur at every level of organization, from molecules to cells to multicellular organisms. They are part of the heirarchical organization of the universe.

So, the whole ecosystem surely must have emergent properties -- and they will not be human properties, any more than the brain has exactly the same functions as a cell -- but we can not know precisely what emergent properties are necessary for the ecosystem to stay alive. I mean beyond giving us oxygen, climate and the basic requirements of life -- there must be an organizing function that the ecosystem needs to stay alive, and us in it. But we can't think about it because we are just a tiny cell inside the complexity of the ecosystem "brain." If we could understand what it is, and if we could devise a technology, we still couldn't change the laws of life that permit the ecosystem to survive, any more than we can change the law of gravity. These things are bigger than we are. Cells can definitely mess up what your brain does, if they go wrong, but they can not make your brain better if they go right. The brain is already doing what it is supposed to do to keep you alive, and so is the ecosystem.

If we persist in believing that we have the ability to understand all about life; if we demand that our technologies save us from our own atrocities; if we believe they can improve the ecosystem in any way; if we become so great a challenge to the ecosystem that her own life is in danger; then she will eliminate us as she has done most other species. She will do this by the immutable processes of which she is composed -- shortage of materials; shortage of energy; the disruption of cultures, so that children cry alone and learn to fear life and grow war; the great sweeping climatological changes that we can not predict, because climate -- a self-sustaining climate on earth that supports and interacts with life -- could very well be the emergent property of the ecosystem. But we don't know if it is or is not. And all the phenomena of collapsing networks that mathematicians are only beginning to understand.

"The French philosopher Gabriel Marcel (1889-1973) distinguished between a problem 'something met which bars my passage' and 'is before me in its entirety,' and a mystery, 'something in which I find myself caught up, and whose essence is not before me in its entirety.' We have to remove a problem before we can proceed, but we are compelled to participate in a mystery…"[1]

The ecosystem is a mystery in the same way that love and infinity and God are mysteries. Science and technology can answer almost any short-term factual problem at the human level of organization, but science is not a resource -- it is not food, or energy -- and neither is technology. Neither science nor technology can change how things function in The Creation. The scientific method can not stand between us and the mystery in which we must participate as living parts of the ecosystem. The arts, religion, philosophy, history and sociology, are well suited to explore the ongoing, long-term mystery of human society, but they do not do a good job of kicking rocks out of our path. Unless our well meaning humanists choose finally to listen to what science and technology can tell us about the rocks under our feet, rather than permitting politics and technology to use our science to serve short-term human ends, they may very well star-gaze us right into history. Or infinity.

My friend says: "We don't have to worry about the ecosystem. God created the ecosystem with a set of checks and balances to protect its own life." This is true. It is also true that the ecosystem is more powerful than any technology. We can not change the way God created the ecosystem. However, our science does know a lot about what the ecosystem needs to stay alive. Her most basic need is balance. And we know that our growth ethic is challenging that balance. We know what will happen if we continue to try to cure the problems that were caused by growth -- by making more growth. As we continue trying harder and harder to do the thing that caused the problems in the first place, knowing that approach can not work and there is a way that can.

Instead of changing our behaviors, we are sitting around in our coffee shops arguing over how it will happen, or "let's wait and see." When we have only one choice remaining, as responsible, people who care about other people. That choice is to work together to give the ecosystem the balance that she needs for her survival. Our choice is to stop talking and listen. Listen to the facts of the ecosystem and give her what she needs to rebalance her life on earth. To stop our impossible quest for infinite growth and grow a sustainable, peaceful, level human presence that can be nourished by the energy resources of the life of which

we are a part.

Or not.[9]

Photo by Paul Lamoreux

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DEFINITIONS - in the order they are discussed.

The Creation = Everything, as it is.
The Ecosystem = The largest unit of life. Includes all the organisms and the environment.
Basic Science = The study of measurable facts using the scientific method.
Technology = The development of tools for humans to use. May use scientific method and facts.
Hypothesis = A scientific opinion meant to be tested using the scientific method.
Measurable facts = Realities that can be measured and do not change in human time and space.
Biology = The scientific study of facts about life and living things and how they function.
Ecology = The scientific study of facts about the living ecosystem and how it functions.
Life Form = An entity that is able to respond to its environment, and to reproduce itself in kind.
Unit of life = An individual living thing.
Life itself refers to the fact that life maintains itself by the continuing reproduction of organisms.
Cell = The most basic unit of life.
Organism = An individual living thing.
Levels of Organization = The hierarchical levels of the universe that are characterized by smaller things that are components of bigger things.
Emergent Properties = Properties of more complex levels of organization that are not present in less complex levels of organization. For example, life is the emergent property at the cell level.
The First Law of Thermodynamics = Energy can not be created or destroyed.
Energy = The ability to do work.
Work = Work is the property that causes things to happen or move or grow.
The Second Law of Thermodynamics = Things will spontaneously fall apart, become less complex. However, becoming more complex, or to join together is work, and work requires energy.
Organic = having to do with living things.
Molecule = two or more atoms joined together with energy bonds.
Macromolecule = A big molecule made of smaller molecules.
Photosynthesis = The biochemical process that uses the energy from light to make organic molecules.
Pigment = Any substance/molecule that absorbs some light waves more than others.
Enzyme = A protein that functions as a catalyst
Catalyst = Anything that causes a chemical reaction to happen but is not destroyed in the reaction.
Biochemistry = The chemistry of living things.
Chemical reaction = A change in the energy relationships among atoms or molecules.
Substrate = In chemistry the substrates are the atoms or molecules that are used up in a reaction.
Product = In chemistry, the products are the atoms or molecules that are produced by a reaction.
Carbon Fixation = The chemical process in plants that takes carbon dioxide and water from the environment and uses light energy to bond them together to make organic molecules.
Organic molecule = A molecule that contains carbon. Most organic molecules are made by organisms.
Chloroplast = An organelle that functions in photosynthesis.
Organelle = A structure inside a cell that is organized to perform a particular function.
Cellular Respiration = The chemical process in all aerobic organisms (that's organisms that breath oxygen) which takes apart organic molecules to use the energy to do the work of staying alive.
Mitochondrion = An organelle that functions in cellular respiration.
Eukaryotic = Cells that have organelles.
Prokaryotic = Cells that do not have organelles.

Everyone knows that we have an ecological (or environmental) problem. Depending upon our various worldviews, we imagine different sorts of cures for this problem, from overpowering nature at one end of the scale to empowering women at the other. From end to end of that scale of human values, we can see human heroism and concern for life, especially human life. What we do not see is an awareness of how intimately the ecosystem problem is enmeshed with our human political, economic and ethical challenges, nor do we see a recognition of how the ecosystem functions and what she needs to stay alive.

Meanwhile, the available information about life and the ecosystem are inappropriately presented by inadequate sound bites and inaccurate advertising. Many books have been published in an effort to simplify and organize the information for public consumption. To my knowledge, they all miss two important points without which we can't begin to effect solutions.

The first of these is that human technology cannot change natural law. If we decide we want to use human technology to the benefit of human welfare, we will need to first thoroughly understand the natural laws. They aren't that complicated; it's things like -- if you drop something and you are on earth, it will fall. Then we must recognize that we can't succeed if we continue to fight against Mother Nature. That is like an unborn baby trying rearrange the womb to suit himself without regard to the needs of the mother. If we want to succeed, then we must use our technologies to conform to natural law, not to fight it. If we continue trying to fight against natural law, we will continue to lose.

The second important point that has not been discussed is that human values are not universal. Rabbits do not live by human values, bacteria do not, and neither does the ecosystem. So there is no point trying to force the ecosystem to conform to human values. Instead, we must work together to find a way to nurture human values within the survival needs of the ecosystem -- not to try to change the ecosystem to conform to our vision. Because the ecosystem is bigger than we are. The ecosystem will win.

The reality of life on earth is not simple, but the bare bones facts about how the ecosystem functions are not as complicated, and not nearly as illogical, as the public media make them out to be. The basic facts about how the ecosystem uses energy to keep itself alive are presented in this little volume.

Dr. Lamoreux is a scientist and photographer/writer, whose training is in evolution, ecology and genetics. Her career has been in the basic sciences. As much as possible, she has avoided involvement with technology because technology so often believes that we have the power and the right to ignore the basic laws of nature and community. In addition to scholarly publications, Dr. Lamoreux has a weekly radio show, **Bare Bones Biology**, on KEOS, 98.1, in Bryan, Texas. Her blog is: http://www.factfictionfancy.wordpress.com.