Factoids about Bacteria and Fungi

There are about 5,000,000,000,000,000,000,000,000,000,000 bacteria on earth, and (only) about 6,500,000,000 people. Bacteria have been on earth about 3 ½ billion years and evolved nearly all the metabolic pathways and enzyme systems used by living creatures. Humans contain more bacterial cells than our "own" cells even when we are healthy! Mitochondria are a highly evolved Group A proteobacter, once free living organisms capable of "detoxifying" free oxygen, which were engulfed by other cells 2 ½ billion years ago and now manage the oxidative metabolism of all living cells. Chloroplasts, organelles responsible for the photosynthesis in all green plants, were once cyanobacteria engulfed by a plant progenitor billions of years ago. Bacteria measure .2 to 600 micrometers in length, usually 1-2 micrometers (a human hair is 50-100 micrometers in diameter). Under ideal circumstances bacteria can double their numbers every 20 minutes. Bacteria don't do sex but they do conjugate, freely exchanging genetic information even amongst different species, for example antibiotic resistance traits. Some bacteria are motile, moving short distances in their stiff water environment by rapidly beating flagella-like structures. Like fungi they create enzymes which dissolve complex polymers such as cellulose, lignin, and chitin (think enzymes cellulase, ligninase, and phenol oxidase), and then absorb the dissolved nutrients. Bacteria create protective layers of slime, usually neutral or alkaline in pH. They dominate garden soils and good garden composts. Bacteria cycle nutrients, combat (and cause) diseases, and help form good soil texture. They rarely die of old age, usually being eaten by something which then releases the excess nitrogen in a form suitable for plants. Bacteria literally run the nitrogen cycle, "fixing" atmospheric nitrogen into ammonia (Rhyzobium, Azobacter-think enzyme nitrogenase), in neutral pH convert ammonia into nitrite, (Nitrosomonas), convert nitrite into nitrate (Nitrobacter), and finally "denitrify" the nitrates back into atmospheric nitrogen. They inhabit virtually all the earth's surface environments and thrive in temperatures ranging from below zero to well over 100 C. under intense pressure beneath the sea.

If Bacteria excel in replication, fungi excel in growth. A fungal hypha 10-40 micrometers in diameter can grow as much as 40 micrometers in a minute! You try growing eight feet in a minute. The growth is not random, but rather can be demonstrated to exhibit tropism towards nutrients, light, and even other attractive hyphae. Tens of thousands of species have been described already; there are probably several times that many yet unnamed. Fungal polymer destroying enzymes are even more capable than those of most bacteria. Fungi "gone over to the dark side" can dissolve oak trees (sudden oak death), as well as elms and chestnuts. We are fortunate that, in the long evolutionary run, cooperation is usually more successful than unalloyed aggression. 80 percent of living plants are known to have symbiotic relationships with fungi, trading sugars and proteins for water and minerals. Fungi tend to create and maintain an acid environment, keeping available nitrogen in the ammonia form, predominating forest soils and good compost for trees and shrubs. Individual fungi are known to live for thousands of years and extend over many acres.

Actinomycetes are now considered bacteria but grow hypha-like structures, create very capable cellulase and ligninase enzymes, and are active over a broad range of pH.

Both bacteria and fungi can exhibit incredible "watchful waiting;" dormant forms such as endospores have proven viable after tens, hundreds, even thousands of years.

Books you might like;

<u>A Field Guide to Bacteria</u>, Cornell University Press, Betsy Dyer, 2003

<u>What is Life?</u>, by Margulis and Sagan (sorry I loaned it out so I lack some info.)

<u>Teaming with Microbes</u>, Timber Press, Jeff Lowenfels & Wayne Lewis, 2006

<u>The Ancestors' Tale</u>, Richard Dawkins (loaned this one too)

Compost Science Made Simple

Tom Bettman

This is, as they say, not rocket science.

Life is the carbon cycle. Black Elk said all the important things that nature does are done in cycles. Life is either producers, consumers, or decomposers. Composting is just using the natural decomposers efficiently at a scale appropriate for our needs.

The major decomposers in nature or in our compost piles are the microbes, bacteria and fungi. All you need to understand is how to keep a very large population of bacteria and fungi happy. Worms and such are merely the charismatic macro- fauna, useful and spectacular, but helpless without the microbes.

Plants (producers) take water and carbon dioxide and make sugars, utilizing chlorophyll and the energy of the sun. This process we are familiar with. It is PHOTOSYNTHESIS. Plants then make starch (storage), cellulose (structure) and a vast variety of other substances from those sugars. The consumers, (animals, plants, and decomposers) all feed off those sugars, starches, and cellulose.

CELLULOSE is the key. The only organisms that can readily consume cellulose are bacteria and fungi. We would be up to our whatevers in old cellulose if there were no bacteria and fungi. The bacteria and fungi easily break cellulose down into sugars and then use it for an energy source, utilizing oxygen if it is available. This process, shared with all plants and animals, is RESPIRATION.

Cellulose, the major component of stems, leaves, and twigs, is the energy source for our bacteria and fungi. It is the C, or CARBON, or brown stuff we talk about.

In order to replicate, all organisms, bacteria included, need a source of nitrogen to build themselves and their DNA. Composting relies on creating a huge population of microorganisms, so we must supply adequate NITROGEN, or N, or the green stuff we talk about.

All organic matter contains mostly carbon and some nitrogen. We can determine the C/N ratio of any organic matter. The microbes prefer an overall ratio of about 30/1 for their diet.

Microbes are small. Shred and mix all material.

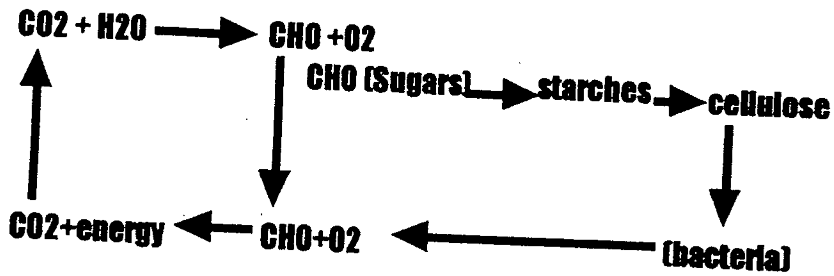
The happy microbes also need plenty of oxygen, and adequate water.

Lacking oxygen, the microbes slow down and utilize ANAEROBIC options, producing CH_4 (methane), NH_4 (ammonia), and some C-OH (alcohols) instead of CO_2. PU! Turning piles recreates structure, allowing air circulation.

Reactions, nuclear, chemical, or biologic, go faster the hotter they are. Critical mass for a thermophilic pile is one yard square.

Visuals-1) Carbon Cycle 2) Typical C/N ratios 3) Time sequence for a compost pile 4) Compost Happens (revised)

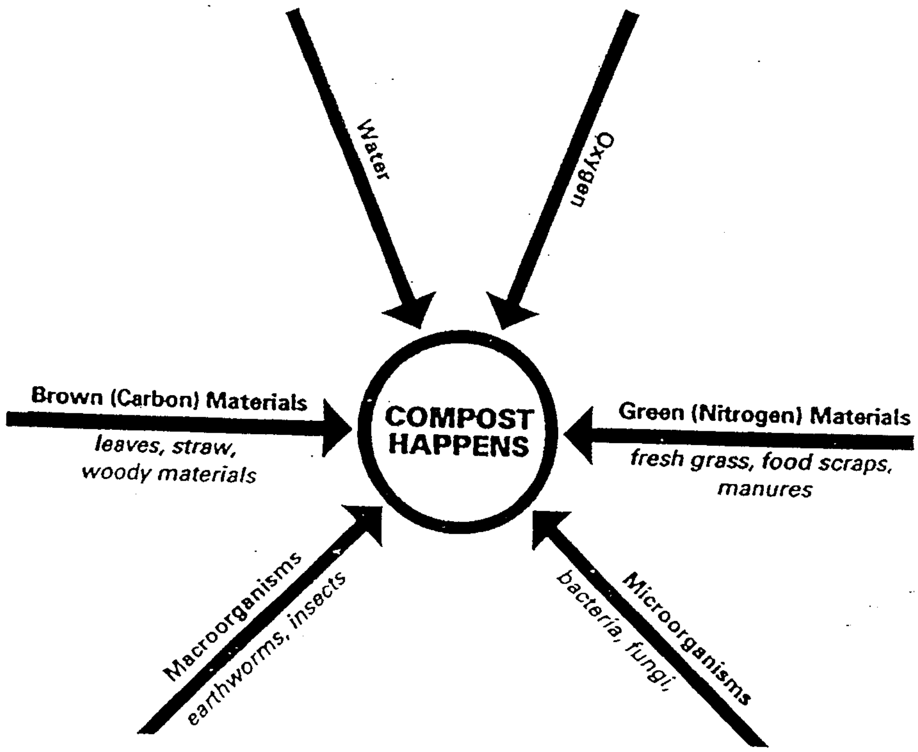
The Carbon Cycle (simplified)



Average Carbon-Nitrogen Ratios

Cotton or alfalfa seed meal	5:1	greens
Dry fish scraps	5:1	greens
Blood meal	8:1	greens
Food scraps	15:1	greens
Green clover	16:1	greens
Grass clippings, weeds	19:1	greens
Seaweed	19:1	greens
Rotted manure	25:1	greens
Corn stalks	60:1	browns
Leaves (dry)	40- 80:1	browns
Straw	80:1	browns
Paper	170:1	browns
Sawdust	500:1	browns
Wood chips	700:1	browns

Ideal Ratio **25:1 to 30:1 mixed greens/browns**


Water
Oxygen
Brown (Carbon) Materials
leaves, straw,
woody materials
COMPOST
HAPPENS
Green (Nitrogen) Materials
fresh grass, food scraps,
manures
Macroorganisms
earthworms, insects
Microorganisms
bacteria, fungi,