Writing Sample (Soil Science)

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DIRT

"As old as dirt" is one of those folksy similes that really gets a point across.

Dirt is older than the ancient Romans, who called the soils they plowed and planted in *humus*. It's older than golden-era-Rome's golden-era-Greek predecessors, who uttered the sound *khamai* to convey concepts of soil, "being on the ground," and other earthly stuff. Dirt precedes the Hindus, who provided the Latins, Greeks, and countless others with an original sound for earthy soil (*dhghem*) that turned into not just *khamai* and *humus* but also humble, home, and human[1]. And

[1] A bit off topic, but it so happens "ma," and worldwide variations of it in modern and ancient languages of both hemispheres, came from the Sanskrit word for water. It shows up as mar and mer, the words for sea in Spanish and French. As Minos, a Greek god who ruled the sea. As min and man in Native American languages where we find Minneapolis, Minnesota, Managua, Manitoba—and Manoa, which means "Noah's Water" in Brazil, Venezuela, and Peru. As a wavy line that symbolizes water in Egyptian hieroglyphics, and later became the letter M in many alphabets. As the Sanskrit "manu", where it's the name of a legendary hero who built an ark that saved eight people from the great flood, and later came to be not just the name of a primordial

according to Genesis, long before the Hindus were going around naming things, God created the dry land and called it Earth way, way back on the third day.

Dirt is clay, water, minerals, and oxygen. It's the crumbs of leaves, branches, roots, and stems that may have been alive just a few weeks ago. It's the carrion, bones, and dust of what once were animals who walked, crawled, and flew on, in, and above it.

And it's the desiccated remains of what used to be, long before anyone would even think of chiseling language into stone, lush misty swamps that teemed with life and decay for countless generations. This substance, a black preserve of plant-produced mineral-nutrients, is now the most frequent bearer of the term humus.

It has a lot of other names. People might describe a few of the tens of thousands of soil varieties with such descriptive terms as loamy peats, sandy quartzes, powdery silts, and rocky coals. When there's a plant in it, we call it soil. Get it on your clothes, it's filth. Find it in your house, it's dust. Use it in an experiment, it's humus, though there are those who say "humus" is an outdated term modern scientists have replaced with SOM, an acronym that stands for "soil organic matter." And others who say humus is only the stuff that's as decomposed as it's ever going to be, while SOM is much more: the alive, the "dead," and the still-decomposing.

Two or three hundred years ago, in the 1800s, dirt was

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hero, but also the origin of the words for "man" in many Indo-European languages. What more perfect term for "earthling" than the first half of the word "humus" followed by "man"?

on the brink of being… not understood, but better understood, for the first time ever. Eighteenth- and nineteenth-century scientists in Europe borrowed the Latin word "humus" so they could more precisely debate about what does and doesn't make plants grow—a question that's only slightly less puzzling now than it was when Aristotle first convinced aristocrats, and others, that the transformation of seed to sapling to deeply rooted beanstalk could all be attributed to behaviors of "the elements" earth, water, air, and fire. Today, textbooks still say there are four main constituents of humus, but call them minerals, water, air, and organic matter (that fourth one resulting largely from processes of carbon, oxygen, hydrogen, nitrogen, sulfur, and which, by the way, are the five most abundant elements in the human body).

German scientist Karl Franz Achard is said to have been the first to extract humic acid. (He took it from peat in 1786 by altering its pH.) In 1840, another German scientist by the name of Justus von Liebig put forth the then-controversial ideas that 1) plants can't get nutrition from humus directly, and 2) the process of decay that creates soil also produces minerals that plants not only *can* get nutrition from but also require. Turns out, he was right. In addition to such non-soil things as sunlight, air, and water, plants need dirt. But, Liebig was the first in science to say it's something very specific in dirt that they require: inorganic mineral matter. Which evokes the very reasonable question of how it gets into decomposed organic matter when it wasn't there before.

Liebig didn't know, but proof of his belief that mineral-making changes take place in soil started to show up when soil researchers saw what they saw when they

picked out the earthworms and started putting dirt under new and improved microscopes that somebody started mass-producing in 1857. So began a tradition of avid study of soil that would continue until synthetic-chemical farming seized center stage after the Second World War.

It may be no wonder science neglected the wonders of soil for so many centuries and then forgot about it again. Dirt is about as complex as it is old, and it's full of humus, or to be more specific, humic substances – whose components are really (*really*) hard to discover, define, and name.

For instance: a chemist[2] in Golden, Colorado, struggled with it like this: "Humic substances comprise an extraordinarily complex, amorphous mixture of highly heterogenous, chemically reactive yet refractory molecules, produced during early diagenesis in the decay of biomatter, and formed ubiquitously in the environment via processes involving chemical reaction of species randomly chosen from a pool of diverse molecules and through random chemical alteration of precursor molecules."

He called this The First Principle of Humic Substances, and followed it with a list of additional observations. That they're distinguished from other substances by capabilities for chemical reaction. That, like snowflakes, humic acid molecules are all unique. That their reactions to and interactions with other substances all differ. (For any scientists out there, that goes for acid dissociation,

[2] "The Principles of Humic Substances: An Introduction to the First Principle," Patrick MacCarthy, Department of Chemistry and Geochemistry, Colorado School of Mines.

metal complexation, ion exchange, sorption on minerals, and redox reactions with metal ions and organic matter.) That it might not be possible to accurately or fully describe the molecular structure of humic substances.

Wikipedia gives humus three (four, really) definitions. "1. Humus (Latin - "soil ") is the organic material in soil lending it a dark brown or black colouration. 2. In soil science, humus refers to any organic matter which has reached a point of stability, where it will break down no further and might, if conditions do not change, remain essentially as it is for centuries, if not millennia[3]. 3. In agriculture, humus is sometimes also used to describe mature compost, or natural compost extracted from a forest or other spontaneous source for use to amend soil. It is also used to describe a topsoil horizon that contains organic matter (humus type, humus form, humus profile)."

The Encyclopedia Britannica says humus is "non-living, finely divided organic matter in soil, derived from microbial decomposition of plant and animal substances"—a definition that's too narrow, according to some[4], because it neglects "the less decomposed components that many soil scientists would include as the 'light fraction'." –i.e., the decomposed plants and plant products in soil that are unstable and subject to further decomposition, while "heavy fraction" is the far

[3] Whitehead, D.C., Tinsley, J., 2006. The biochemistry of humus formation. Journal of the Science of Food and Agriculture 14:849-857.

[4] Raphaël J. Manlay, Christian Fellerc, M.J. Swift. Institute of Forestry, Agricultural and Environmental Engineering, France Institute for Research and Development, Madagascar Tropical Soil Biology and Fertility Institute of CIAT.

older, more decomposed, high-density stable organo-mineral material.

The International Humic Substances Society defines the topic for which their association exists like this: "Humic substances are complex and heterogeneous mixtures of polydispersed materials formed by biochemical and chemical reactions during the decay and transformation of plant and microbial remains…"

And none of these focused definitions acknowledge another crucial characteristic of ancient, fully decomposed former-soil, which is that it is within humus that sunlight, gases, plants, animals, insects, and microbes have become a massive store of energy.

Nor anything about what scientists of the second half of the 1800s saw when they focused their microscopes on dirt-coated slides and magnified a bit of what most of the world most of the time had mostly thought of as degraded, decayed, so-very-dead deadness.

DEATH

What scientists of the 1800s saw when they focused their microscopes on dirt-coated slides and magnified a bit of what the world had always thought of mostly as degraded, decayed, so-very-dead deadness….

…was, as you know, a metropolis not of motionless life-depleted death, but of quivering, moving life-creating life. Reproducing and multiplying. Living somethings intently engaged in all the travails of survival. A great orchestrated opus where small and microscopic beasts concert in a dance of gruesome beauty.

Now we know enough about earth's humble dirt to say, perhaps, in some unscientific and poetic way, that this is where death goes to return to life. To a place that's very much alive—not just with plants, roots, and critters that eat, excrete, and dig tunnels. Also with stuff, far too small to see, that transforms this into that, all into other—at speeds that surpass by thousands of times what

the conscious efforts of thousands of people could accomplish much less quickly.