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The Organosubstrate of Life: A Creationist Perspective of Microbes and Viruses

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Abstract

In this paper a new concept in creation biology, the organosubstrate, is described. I propose that microbes and viruses were created as a link between macro-organisms and a chemically rich but inert physical environment, to provide a substrate upon which multicellular creatures can thrive and persist in intricately designed ecosystems. Consistent with this perspective, microbes and viruses a) are abundant in all ecosystems, b) are separated by discontinuity from macro-organisms and discontinuity separates the major groups of viruses and microbes, c) are designed for symbiotic relationships with both macro-organisms and other microbes and viruses, d) extract inorganic minerals from earth minerals, e) participate in the cycling of all elements and compounds important in macro-organismal biology, and f) effect bioremediation. The organosubstrate concept explains organelle/bacterial similarities used as evidence of evolutionary endosymbiosis theory. The organosubstrate concept also suggests that microbe and viral pathogenesis is a relatively recent and rare deviation from original created function. Evidence of this includes the rarity and lower fitness of pathological forms and the late addition to and modification of symbiotic design features in microbes and viruses. The organosubstrate concept is an imminently testable, well-supported concept in biology.

Keywords

microbiology, microbes, viruses, symbiosis, biogeochemical cycles, bioremediation, endosymbiosis, pathology

Introduction

Microbes and viruses perform essential roles in all ecosystems of the biosphere. However, creationists have published few papers in microbiology.[1–8] Perhaps this is due to the fact that microbes (which we define in this paper as bacteria, algae, protists, and unicellular fungi) and viruses are not explicitly mentioned in Scripture and they are often associated with parasitism and pathogenesis, activities that are inconsistent with God's perfect pre-Fall creation. However, our understanding of microbial function remains very incomplete; in fact, many microbiologists believe that we have only discovered a fraction of all the microbes and viruses that exist on earth. In addition, in contrast to their well-known destructive nature, microbes and viruses perform many beneficial activities in ecosystems and in symbiotic partnerships with all biological organisms. Correspondingly, evolutionary biologists believe that eukaryotic cells were derived from an ancient symbiotic relationship involving bacteria and primitive eukaryotes. This theory is referred to as the seriel endosymbiotic theory (SET)[9] and was popularized by Lynn Margulis who proposed that eukaryotic cell organelles were derived from ancient prokaryotic symbionts. Some creationists have characterized the data supporting the endosymbiotic theory as weak and mostly inferential, yet the theory cannot easily be dismissed because the microbial world is replete with examples of symbiotic relationships. Therefore, perhaps because of our fervent attention to the debate, we have missed a larger and broader story about the role of microbes and viruses in creation.

The Organosubstrate Concept

I propose that microbes were created as an organosubstrate; a link between macro-organisms and a chemically rich but inert physical environment, to provide a substrate upon which multicellular creatures can thrive and persist in intricately designed ecosystems. Viewed in this context microbes and viruses could also be thought of as a single, complex, massive, multicellular, multitaxon organism with incredible and powerful life supporting properties. Just as tissues and organs cooperatively divide the many tasks in the body of a macro-organism, so microbes and viruses cooperatively divide the many tasks macro-organisms need performed to survive in this world. This paper reviews the biological data that supports the organosubstrate concept. Other than microbes and viruses in the world as a whole, and the tissues and organs of a body, God created other distinct entities to interact in complex ways. Humans, for example, were created as individuals, but are created with abilities needed to interact and complement one another within the body of Christ (Ephesians 4:11–13). All this might be expected, though, from a (triune) God whose very nature involves interdependent relationships (Matthew 28:19; 1 John 5:7).

Separately Created

Creationists generally expect any particular created kind is separated by discontinuity from all other created kinds. Since the organosubstrate concept visualizes microbes and viruses as a multitaxon organism in a world otherwise populated by multicellular created kinds, microbes and viruses might be separated by discontinuity from all macro-organisms. Furthermore, given different microbe and viral groups often interact with different macro-organismal created kinds, different microbe and viral groups might be separated from one another by discontinuities. In fact, creationists have documented evidence supporting a separate origin for microbes,[10–12] and viruses.[13] Even the secular disciplines of cell biology and molecular biology have revealed major structural and functional discontinuities, both among the major groupings of microbes and viruses and between them and macro-organisms. For instance, the cell division mechanisms of bacteria are vastly different from those of eukaryotes—even microbial eukaryotes.[14] In fact, some evolutionary biologists have noted that the complexity required to replicate the circular chromosome of bacteria could have only occurred after the "simpler" eukaryotic replication mechanisms evolved, a concept contrary to the long-held belief that bacteria evolved prior to the appearance of eukaryotes.[15] This evidence suggests microbes and viruses are in fact divided into many separate baramins. This would make the organosubstrate analogous to another part of God's creation (the plants), where a variety of different baramins were created to cooperatively provide a nutritional function for animals (Genesis 1:11–12, 29).

Designed

If, as the organosubstrate concept suggests, microbes and viruses were created to function as the intermediary between the inorganic world and macro-organisms, then they might be expected to possess evidence of design. If, for example, they were created for this function, they would have to be common and ubiquitous. To accomplish this, they had to be designed with efficient reproductive mechanisms and with structures allowing survival in all environments. Likewise, the organosubstrate function would require them to create complex communities and sophisticated interactions with macro-organisms. To accomplish this, they had to be designed with efficient symbiosis mechanisms. And, since their ultimate function would be to provide nutrients to macro-organisms, they had to be designed with efficient mechanisms of extracting macro-organism-needed nutrients from the inorganic world.

Designed to be abundant

As expected in the organosubstrate concept, microbes and viruses are abundant. It is estimated that there are more than $4–6\times10^{30}$ bacteria and archaea on the earth.[16] The nascent atmosphere (lower 3 km) is home to something on the order of 5×10^{19} bacteria.[17] The hydrosphere literally teems with microbes. A liter of seawater typically contains billions of bacteria and other microbes. It is estimated that 50–70% of the biomass found in the ocean is made up of bacteria. Although many of the marine bacteria have not yet been isolated, their existence has been predicted from DNA analysis of seawater.[18] In calm aquatic systems, the surface water literally teems with microbes—making up a film layer called the neuston. But, of all the environments on earth, the vast majority of microbes are found in marine and terrestrial subsurfaces.[19] A single gram of topsoil, for example, can easily contain 10 billion bacteria, 100,000 fungi, and 25,000 algae.[20,21] As might be expected from their abundance, microbes and viruses reproduce very rapidly—in fact more rapidly than all other organisms. This suggests they were created with efficient reproductive mechanisms.

Designed to be ubiquitous

As expected in the organosubstrate concept, microbes and viruses are ubiquitous. As alluded to above, they are found in the atmosphere, the hydrosphere, the lithosphere, and the biosphere, and in many extreme environments within each. Marine bacteria, for example, can survive great ocean depths and immense pressures up to 1.6 gigapascals, which is equivalent to over 10,000 atms. or the pressure at the bottom of a 160 km column of water.[22] On land, microbes are found on all exposed surfaces, including those that are nutrient poor. In desert areas, for example, bacteria, algae, and fungi form soil crusts on exposed surfaces. Lichens, which are plant-like creatures made up of fungi and algae living in mutual symbiosis, are found throughout the world and form the dominant vegetation over about 9% of the earth's terrestrial surface.[23, 24] Lichens have been found growing in desert areas, the frozen tundra, mountains above the tree line, and other desolate locations.[25–27] Microbes also populate habitats hostile to most life forms but which are rich in inorganic minerals.[28, 29] For instance, some bacteria, called extremophiles, populate environments that contain toxic mineral gases, degrading acids and extreme temperatures (>100°C)—conditions deadly to multicellular organisms.[30, 31] Microbes and viruses

can also endure and survive in permanent ice flows in remote regions like the North and South Pole and atop mountains, and some can even thrive in the presence of damaging radioactivity.[32, 33]

To be so very ubiquitous, microbes and viruses are provided with an impressive variety of survival mechanisms. For example, many microbes and viruses also seem to be designed for long-distance dispersal. Although their small size is partially responsible for this ability, other designs seem essential as well—including mechanisms for cyst and spore development. So efficient are some of these mechanisms that even intercontinental travel has been documented for fungal spores.[34] These dispersal mechanisms seem designed to permit microbes and viruses to get to remote environments. Once there, microbes and viruses utilize another set of dormant state mechanisms that allow them to survive hostile environments. Many microbes also possess unique, elaborate, and resilient outer cell walls that seem to have been designed to protect them from hydrolysis and extreme environments. The small size of microbes and viruses permit them to fit into the internal interstices of macro-organisms. In the aquatic realm, the small size of bacteria seems designed to provide them with a greater surface area to volume ratio, promoting a more efficient uptake of nutrients. Furthermore, some of the microbes that populate the neuston have been provided with the ability to exist in both sub-aqueous and sub-aerial environments simultaneously. Further designs include elaborate mechanisms to survive the harsh conditions within tissues and cells of macro-organisms. For instance, in the presence of disruptive acidic fluids and solids, symbionts of the digestive system are designed to safely attach to intestinal linings.[35] Viruses possess mechanisms that foster their incorporation into the genome allowing them to escape the degrading enzymes of the cytoplasm.

Designed to form symbiotic microbial communities

The organisms of the organosubstrate also appear to be designed to thrive in interdependent relationships with one another. For instance, a variety of microbes exist in large macro-colonies called biofilms and mats. Biofilms constitute an organized conglomeration of bacteria that are attached to surfaces and can be found growing in many different aquatic habitats. Recent evidence suggests that biofilm formation is not the result of stochastic processes but instead involves specific environmental sensing capabilities, activation of specific genetic components and complex microbial community interactions.[36] For instance, some aquatic bacteria work together as a colony and can secrete a slime thread that intertwines with other threads creating a slime veil. The motile bacteria that produce the veil have been observed to move the veil within the water column to a position that can promote the separation of oxic water from anoxic. This fascinating action allows the bacteria to control the fluxes of oxygen and sulfide "so that they match the stoichiometry of their chemolithotrophic metabolism".[37] A recent review suggests that these community interactions within complex biofilms are highly organized and organism-like.[38] "Within these communities metabolic activities are integrated, and developmental sequences, not unlike those of multicellular organisms can be detected." This is most dramatically illustrated in complex aquatic communities of microbes where it can be observed that heterogeneous groups of microbes appear to select the specific electron acceptor that yields the maximum energy regardless of the availability of other acceptors and the presence of organisms that can utilize them.[39] Some researchers have suggested that under certain environmental conditions bacterial colonies appear to act like multicellular organisms. The basis for this may involve the release of "quorum sensors", factors that affect the colony as a whole and also cause alteration of gene expression at the colony level.[40] In fact several studies show that genetic factors can control colony differentiation. Investigators of these studies propose that when bacterial colonies are stressed they respond as a group and often display elaborate colony formations and patterns. One researcher proposes that:

> "… these features indicate that a stressed colony turns into a genetic network, which is the highest level of colony cooperation. To emphasize that the network is composed of agents I refer to it as a genomic web. I further assume, that in order to establish the genomic web, the bacteria produce (or activate) special cybernators enhancing the efficient and sophisticated genomic communication. Once formed the genomic web is a "supermind" relative to the individual genome."[41, 42]

Bacteria are not alone in their ability to act cooperatively among themselves. Individual cells of the cellular slime mold Dictyostelium (slime molds are classified as protists) can communicate with one another using chemical attractants and signals and join together to form a multicellular plant-like fruiting body.[43] Additionally, at first glance, protozoan pond organisms appear to survive as independent cellular organisms, however many have been found to harbor microbial symbionts and are dependent on other microbes for food.[44] To accomplish such symbiosis, one might expect much inter-organismal population control. In fact, many bacterial populations can be modulated by bacteriophages and the algae and fungal partners of the lichen symbiosis appear to directly affect the population of their partner symbiont.[45] Also several factors secreted by microbes appear to modulate population growth including quorum sensors and proteases.

Designed to form symbioses with macro-organisms

The morphologies and proteins of many of the organosubstrate organisms are designed for attachment, invasion and integration into macro-organismal cells and tissues. Because of their size, shape, and exposed proteins, viruses are able to enter a wide variety of cells and nuclei. Symbiotic bacteria and algae possess specialized mechanisms to enter and survive in eukaryotic cells and tissue spaces. The bacterial genus Wolbachia, for example, is so well adapted to insects that it is estimated to associate symbiotically with five million insect species.[46] Some symbiotic bacteria can effect profound changes in cell morphology in the presence of their symbiont. For instance, the nitrogen-fixing Rhizobium bacterium that invades plant roots is a rod shaped bacterium in its free-living form. However upon entering plant cells it swells and adopts a substantially different cell shape.[47]

Many microbes live on and within living organisms. It is estimated that the number of microbes living on the human body far exceeds the 70 trillion human cells that comprise it.[48] The discipline of microbial ecology is increasingly revealing that microbial and viral symbionts play vitally important roles within organisms and ecosystems. In fact, axenic (germ free life) probably does not exist in nature; all animal species with the exception of prenatal life are thought to live with microbial symbionts. A tremendous number of symbiotic relationships are being discovered. Many of these relationships involve complex lifestyles and anatomies that appear to be designed to foster the symbiotic lifestyle.[49] A general survey of symbiotic relationships also shows that the most common functions provided by symbionts involve nutritional support, protection and reproduction/population control.

As an example, there are a number of ant species that harvest fungi for food. The most studied are the leaf-cutter ants.[50] The symbiotic relationships observed in these ant communities are remarkable because this is the only example of microbial symbiosis discovered so far that involves a four-way symbiotic partnership. The ants literally culture fungal gardens by collecting leaves for the fungi to grow upon. The fungal species is unique to a given ant farm, however it can be invaded and destroyed by Escovopsis, a micro fungus. This micro fungus has the potential to wipe out the entire fungal farm system and in turn destroy the ant colony. However, remarkably, the ants carry a Streptomyces bacterium in specially designed areas of their exoskeleton.[51] The Streptomyces secrete an antibiotic that controls but does not eliminate the Escovopsis micro fungus population.

In the second example we briefly note the remarkable microbial symbiotic relationships within the digestive systems of mammals and humans.[52] The intricacies of these relationships would involve documentation equal to an entire text. In general, though, complex communities of microbes provide nutritional support in the form of digestive enzymes, vitamins and other nutrients.[53] Intestinal symbionts also play a protective role by controlling the population dynamics of the symbionts such that pathogens are less likely to grow and colonize this environment. Furthermore, some studies suggest that the intestinal symbionts maintain the immune system in a constant form of readiness by promoting a basal level of activity. Also, remarkably, recent evidence suggests that intestinal symbionts are necessary for intestinal development in neonates and may be responsible for promoting angiogenesis.[54]

Designed to free elements from the inorganic world

A number of elements essential to the structure and function of biological molecules (for example, Mb, Ni, Fe, Mg, P, S, Ca, K) would be available for use by macro-organisms if they could be extracted directly from minerals found in earth rocks. In the last couple decades design features have been discovered in some microbes that allow them to mine at least some of these elements from rocks. They then modify and incorporate those elements into biomolecules that are released into the environment, permitting their use by other organisms. Phosphorus and iron, for example, are required by living organisms but tend to precipitate in aerobic environments and therefore are typically unavailable to living organisms. Therefore, the dissolution of these elements by microbes is essential to maintaining life in the biosphere.[55] Some microbes have been found to possess mechanisms to capture both of these elements extracellularly. For instance, aquatic bacteria secrete iron chelators called siderophores that increase the solubility of iron in seawater. One study has shown >99% of the dissolved iron in seawater is associated with chelators.[56] Bacteria that possess siderophore receptor proteins can then internalize the siderophores-bound iron. There are micro algae that secrete reductase enzymes to dismantle the complexed iron outside the algal cell and then take up the iron.

Microbes can also extract needed elements from atmospheric gases. This is most dramatically displayed by the unique ability of microbes to harvest biologically inert di-nitrogen from the atmosphere and convert it into a useful form.[57] Nitrogen is a key component of proteins and nucleic acids, thus it is required by all living organisms. It is estimated that the adult human requires several pounds of nitrogen annually to maintain biosynthetic processes.[58] Weathering processes only convert a small amount of nitrogen to a usable form in the

biosphere. Therefore nitrogen is considered to be a limiting factor in most ecosystems that have an abundant water supply and nitrogen-fixing bacteria are the primary natural suppliers of nitrogen to all living organisms in the biosphere. Half of the total nitrogen used by crop plants comes from human-manufactured fertilizers. These fertilizer-manufacturing processes consume 1% of all the energy all humans on earth generate in a given year![59] The other half of the nitrogen used by crop plants is produced by microbial nitrogen-fixation and is performed at ambient temperatures and pressures with no burden on human energy production. The organosubstrate is so important in the cycling of so many atmospheric gases that it is most probably critical in stabilizing the atmospheric gases in the ratios required for aerobic (that is, macro-organismal) life.

Many nitrogen-assimilating bacteria live in symbiotic relationships with plant hosts that can directly benefit from the uptake of the biologically useful nitrogen. After responding to factors released by the plants the nitrogen fixing bacteria develop an elaborate connection with the roots. This allows for direct supply of nitrogen to the plant as well as protection of the nitrogenase enzyme from oxygen. In addition, some filamentous bacteria possess heterocysts, specialized organelles that allow for separation of the oxygen-producing photosynthetic process from the nitrogen fixation process in the same organism.[60]

Besides extracting nutrients from an otherwise inert environment, the internal sequestration of nutrients by organosubstrate organisms concentrates those nutrients so they can be used by macro-organisms. Also, because the organosubstrate organisms are so small, ubiquitous, and fast growing, they have the ability to rapidly adjust their metabolic capabilities as per the environment's nutrient concentration. This effectively maintains an ecosystem's nutrients at a needed concentration. The organosubstrate also functions by transferring nutrients between macro-organisms. Mycorrhizae, for example, have been implicated in transferring nutrients from nutrient-rich trees to other trees exposed to unproductive environmental conditions.[61] The organosubstrate probably transfers nutrients across ecosystem boundaries as well.

Designed to cycle elements in the biological world

Not only can they extract elements from the inorganic environment, microbes themselves can be a major source of essential elements within ecosystems. The carbon to nitrogen (C:N) ratio of microbes (~13:1), for example, makes them optimally suited for macro-organism consumption (for example, animals require a diet with a C:N ratio of less than 17:1[62]). The total amount of carbon, nitrogen and phosphorus contained in earthbound bacteria and archaea is estimated to be 500×10^{15}g, 100×10^{15}g and 10×10^{15}g respectively.[63] This pool of carbon is estimated to be equivalent to 60% of the total carbon contained in plants. Bacterially associated nitrogen and phosphorus represent the largest biological pools of these elements. These estimates are most likely underestimates since these values do not reflect the contribution of non-bacterial microbes.

Microbes can also export cellular products that act as a direct food source for macro-organisms (for example, vitamins). In many cases microbes do not even benefit from the nutrients that they produce, something understandable with the organosubstrate concept.

Microbes also play critical roles in cycling biologically important elements. Sulfur, for example, is a component of two essential amino acids and therefore is required by all living organisms. It also can act as an electron acceptor in anoxic environments. It even influences the cycling of other elements, including all major and many minor elements (for example, P, Fe) either by promoting their precipitation or (via sulfuric acid) their solution. The cycling activity of sulfur is primarily controlled by sulfate reducing bacteria.[64]

Plants are important sources of many elements for the animal world. However, increasingly we have come to be aware that even the nutritional role of plants is dependent upon the actions of microbes. For instance, all the nitrogen that plants provide to animals was captured, processed, and provided to plants by microbes. Microbes also play a major role in the carbon cycle. Table 1 shows the major reservoirs of carbon.

One of the striking features of the carbon reservoir data is that the concentration of dissolved carbon in the atmosphere and hydrosphere is small compared to the other reservoirs.[65] This is postulated to be due to microbial activity in the marine environment which promotes the fixation of carbon into living organisms

Table 1. Estimates of the carbon content of major carbon reservoirs on earth. Data is from Atlas (1998).

Major carbon reservoirs	Trillions of metric tons
Atmosphere (CO_2)	0.7
Dissolved carbon (seawater surface)	0.5
Deep sea carbon	34.5
Dead organic matter (humus, organic sediment)	3.7
Fossil fuels	10.0
Sedimentary rocks	20,000

(primary production) and the movement of carbon to less accessible deep sea reservoirs. These actions often referred to as the ocean's "biological pump" produce an important benefit; it is predicted that if the pump did not exist, released carbon would have the potential to combine with oxygen and threaten the global atmospheric oxygen concentration. [66]

Carbon, as well as oxygen and hydrogen are cycled mainly by the biological processes of photosynthesis and respiration. In the terrestrial and shallow water environments, plants dominate primary production. In the oceans, however, microbes are responsible for most of the primary production. In fact it has recently been discovered with the aid of satellite technology that ocean dwelling phytoplankton assimilate as much inorganic carbon (CO_2) into organic matter as all the land plants combined—roughly 50 billion metric tons.[67] The phytoplankton involved in this carbon fixation are primarily diatoms and other algae. Once captured by the phytoplankton much of the fixed carbon enters the food web or is deposited in shale and oil deposits. Since oceans cover nearly three fourths of the earth's surface, phytoplankton extracts enough CO_2 from the atmosphere to affect global climate.[68] Interestingly, phytoplanktonic microbes also fix nitrogen, thus the global carbon and nitrogen cycles are intimately linked through the actions of the organosubstrate.

Microbes also recycle essential elements from the products and dead bodies of the biological world. Some bacteria, for example, specialize in converting reduced nitrogen from organic molecules in decaying organisms back to di-nitrogen gas that can be released into the atmosphere. Even though microbes do not play a primary role in primary production of carbon in terrestrial environments they play a vitally important role in the terrestrial carbon cycle via "secondary production" or recovery of carbon from decaying matter. For instance, the recovery of carbon from decomposing plants represents a major contribution to the carbon cycle since herbivores typically consume only 5% (and rarely more than 50%) of the terrestrially available carbon via consumption of plants.[69] Microbes also contribute to the carbon cycle by assimilating dissolved carbon and other nutrients from extremely dilute solutions and converting these nutrients to biomass. In addition, microbes are unique in their ability to digest "indigestible" polysaccharides such as cellulose and lignin. This is significant if one considers that cellulose is the most abundant organic macromolecule found on the earth.

The organosubstrate organisms also link the various cycles. The nitrogen-fixing metabolism of nitrogen-fixing bacteria, for example, is dependent primarily on a single enzyme complex, the nitrogenase complex. At the heart of the complex is the nitrogenase enzyme, a metalloprotein requiring the metals iron and molybdenum for its action.[70] This links the nitrogen cycle with both the iron and molybdenum mineral cycles.

Designed to cycle water

Although microbes do not participate in the global water cycle to the extent that they participate in the other biogeochemical cycles, water is mobilized within the organosubstrate as a consequence of many aspects of microbial metabolism. For instance, water is a product of microbial respiration and fermentation. The organosubstrate organisms play a vital role in the provision of water to plants. Fungal symbionts associated with plant roots are called mycorrhizae. They can form massive underground networks and aid the plants in absorbing water from soil.[71, 72] Many mycorrhizal fungi are obligate symbionts, requiring nutrients from the plant for survival. It may turn out that most (if not all) trees and shrubs depend upon mycorrhyzal fungi for their water acquisition.

The organosubstrate performs other water conservation roles within the terrestrial environment. For example, microbes adhere to soil and small rocks within soil and tend to fill spaces between soil aggregates. These microbally stabilized soil aggregates improve water infiltration and enhance water retention in the soil.[73] Microbes that form crusts or mats on soil surfaces also conserve water. Amazingly, the mats can perform their functions in a severely dehydrated state in desert ecosystems.

Designed for bioremediation

Another interesting function of the organosubstrate is the detoxification of environmental toxins. In general, if organosubstrate organisms internally sequester toxic elements and compounds, the extra-cellular concentration of those substances is decreased. Sulfate reducing bacteria, for example, play important roles in the removal of toxic amounts of elements like zinc.[74] Over 250 microbe strains have been identified which degrade toxic substances and the degradation of over 150 different toxic compounds by microbes has been documented.[75]

Biochemical Similarities

To be a thoroughly effective intermediary between the biotic and abiotic, organosubstrate organisms might be expected to occupy all interstices. In macro-organisms, for example, both extra cellular and intracellular

microbial and viral symbionts would be expected. In fact there is evidence to suggest that some microbes exist as mobile symbionts, moving between both the extracellular and intracellular environments.[76] To make this happen, one would expect a large number of biochemical similarities between various symbionts and macro-organisms. Such similarities have been observed between bacteria and the cellular organelles mitochondria and chloroplasts. Shared genes and proteins and similar membranes and ribosomes have been used as evidence for evolutionary endosymbiotic theory.[77] G.A. Kerkut, for example, noted that "[*Rickettsiae* bacteria] are capable of oxidizing glutamate, pyruvate, succinate, fumarate and oxalo-acetate. These substances are also oxidized by the mitochondria of the normal cell, and the suggestion has been made that the rickettsiae are in fact free mitochondria." The organosubstrate concept explains this data (and the evidence for discontinuity) better than endosymbiotic theory.

Pathology

According to the organosubstrate concept, all microbes and viruses were created as mutual symbionts—that is, without pathology. Pathology arose after the creation, probably after man's Fall. This leads to several expectations or predictions about pathology.

Pathology is uncommon

If pathology were a modification from the original creation and relatively little time has elapsed since the Fall, then microbial and viral pathology would be expected to be relatively rare. Determining the actual number of microbes and viruses in the world is a difficult task. This is because only about one percent of microbes are culturable in any given environment. Some scientists estimate that there are more than 6×10^6 bacteria and archaea species but only about 5,000 have been formally described.[78, 79] In addition, it is estimated that there are about 100,000 species of fungi and over 200,000 species of protists. As best as can be determined, however, pathogens may make up less than one percent of all microbes and viruses.[80, 81] In fact, pathogens have not been discovered in some major taxonomic groups of microbes, for instance in the Archaea.[82] Even in the human body, the diversity of symbiotic microbes substantially outnumbers the diversity of pathogens.

Pathology as under fit

If the organosubstrate was created in a state of optimality, pathological modifications on that design are likely to have lead to under fitness. If this is true, then non-pathological organosubstrate populations might usually be expected to keep pathological populations in check. Evidence consistent with this includes the fact that "germ free" laboratory animals are more susceptible to pathogenic microbes.[83] Additionally, McCoy[84] presented evidence that the pathogenic state in an organism arises primarily when the pathogen population dominates over the normal flora bacteria.[85] This is consistent with Lumsden's[86] claim that the normal microbe flora of plants and animals protect the macro-organisms by out competing the pathogen for resources and space. Viruses of several plant species, for instance, including the American chestnut tree, protect the plant by controlling the population of bacterial or fungal plant pathogens.

If organismal health is due at least in part to the presence of well-established populations of beneficial microbes, there are several important implications for treatment of disease. We might expect, for example, that inoculation or culturing beneficial microbes may control some microbial-based diseases. Questions are also raised about generic antibiotic therapies that kill not only pathogens but normal flora as well.

Pathological DNA as a late addition

If pathology is post-Fall, then any changes due to pathogenesis should have evidence of having been added to the original symbiotic organism. Pathogenesis in *E. coli* seems to be consistent with this. *E. coli* is a well-known intestinal symbiont involved in waste formation and vitamin production. It is found in humans and mammals. The extremely virulent pathogenic strain of *E. coli* known as OH157:H7 has a larger genome than the non-pathological strain, and the extra DNA bears the signature of a bacteriophage transfer. The pathological strain also contains 131 proteins involved in pathogenesis that are not found in the non-pathogenic form.[87–89] This is consistent with *E. coli* virulence being due to the late addition of DNA by lateral gene transfer. There is substantial evidence showing that many other pathogenic bacteria have obtained genes from lateral gene transfer events. In fact, the process of lateral gene transfer of virulence genes is so common that scientists have classified the transferred gene sets as "pathogenicity islands".[90] The fact that many diverse and unrelated bacteria have been discovered to carry a common set of virulence genes is further evidence that lateral gene transfers are probably responsible for the pathogenicity.

Pathological behavior as a modification of symbiotic design

If organosubstrate design was created to facilitate symbiotic function, complex mechanisms that function pathologically are probably modified symbiotic mechanisms. Pathology might involve a modification of such things as symbiotic behavior, timing, chemistry, or morphology. Three possible examples are given here: 1) The Polydna virus is a beneficial symbiont of several wasp species.[91] The virus aids the growth of wasp eggs by promoting the secretion of a factor called EP-1 and yet the EP-1 factor is very similar if not identical to wasp venom protein. This protein is beneficial in one setting and destructive in another setting. Perhaps wasp venom arose by genetic exchange mechanisms moving an otherwise beneficial gene into new species and new locations. 2) The closely related bacteria Brucella abortus and Rhizobium meliloti both contain a BacA gene. In the symbiotic Rhizobium the BacA protein is an essential membrane transport protein; in the pathological Brucella the BacA protein is somehow responsible for its pathological activity. The Brucella BacA gene may well be a beneficial BacA gene modified and/or transferred from Rhizobium and used in the former in pathological manner. 3) The main shaft of the bacterial flagellum is generated by the secretion of proteins from the flagellum base apparatus that are then assembled outside the bacterial cell. Very similar to the flagellum base apparatus is the type III secretory apparatus that is used by bacteria to secrete toxins.[92–94] Design features suggest that the toxin secretion is derived from the flagellum design as might be expected in organosubstrate concept.[95]

Conclusion

In this report I have shown that microbes provide many benefits to living organisms and they are essential to life in the biosphere. Therefore, I propose that microbes were not created as causative agents of disease and death but as part of a life sustaining organosubstrate present throughout the biosphere. Even with post-Fall compromise of this design, it is evidenced among the microbes and viruses by their abundance, their ubiquity, their design, their symbiotic relations, their extraction and cycling of elements and nutrients, and their bioremediation. The organosubstrate concept also explains the similarities between organelles and free-living bacteria that evolutionists use to argue for endosymbiosis theory. It also suggests that microbial and viral pathogenicity is due to small post-Flood modifications of the original symbiotic design.

The organosubstrate concept can be tested in a variety of ways. The following predictions can be derived from the concept as per the discussions above:

- Profound discontinuity separates the major groups of microbes and viruses and separates those groups from macro-organisms.
- Microbes and viruses contain special design features that permit them to be ubiquitous and abundant.
- Independent, self-sufficient lifestyles of individual microbes and viruses will rarely (if ever) be observed in nature.
- Most (or all) macro-organisms possess designed mechanisms and structures to interact with organosubstrate organisms.
- For each of the biologically useful elements, microbes have been designed to free that element from minerals and release it into the biological world.
- At ecosystem boundaries there are organosubstrate organisms designed to transfer nutrients between the adjoining ecosystems (for example, microbes which enhance mineral uptake into oceanic reservoirs and subsequently promote mineral balance in the atmosphere will be located at interfaces near both the aquatic and atmospheric subdivisions of the biosphere.).
- Macro-organisms are receptive to the secreted products of organosubstrate organisms.
- For each of the biologically useful elements, microbes have been designed to cycle that element in and out of the world of macro-organisms.
- Disruption of the microbial mineral provision processes in local environments may explain the fluctuation and/or extinction of many animal and plant populations.
- The health and survivability of macro-organisms is directly related in many ways to their ability to successfully interact with the organosubstrate.
- Microbial metabolic diversity should reflect biogeochemical cycle diversity.
- Controlling the concentrations of minerals required in microbial metabolism can control biogeochemical cycles.
- Microbes possess design features and mechanisms that promote water formation and water retention in dry environments.
- Organisms that live in xeric conditions depend on the organosubstrate for survival.
- For every toxic substance organosubstrate designs exist to detoxify the environment.
- The vast majority of microbe and viral forms are non-pathological, so most of the yet undescribed microbes

are expected to display beneficial attributes.
- Pathological organisms will tend to be less fit than their non-pathological close relatives.
- Some pathogenicity is due to the genetic transfer of virulence genes.
- Genetic causes of pathogenicity will appear as a late addition to a symbiont's genome.
- Pathogenic mechanisms are modified beneficial mechanisms. Many more aspects of the organosubstrate concept remain to be elucidated. For instance there is data to suggest that microbes and viruses are adept at promoting exchange of genetic material. Since microbially based genetic exchange could potentially act on germ cells, research into this could provide insight into speciation. Microbes and viruses might participate as speciation vectors promoting rapid but limited speciation in a post-Flood environment.[96]

Further investigation into the symbiotic relationships between microbes and mammals may also lead to insight into the originally created purpose of the immune system. For instance, among microbes phagocytosis can function as a non-destructive mechanism to acquire symbionts and is common among unicellular and multicellular pond organisms. In contrast, phagocytosis in macro-organisms is an immune response that participates in destruction of pathogens. I predict that future investigation of this phenomenon will lead to a hypothesis that the immune system may have been originally created as an environmental sensing device that received data about the environment through the phagocytosis of beneficial microbes. Indeed the mammalian immune system possesses very specific and complex mechanisms that interact with microbes, often causing inflammation and tissue-destructive autoimmune responses and therefore appear to make little sense in the context of evolutionary biology.

Perhaps some of the greatest practical applications of the organosubstrate concept will be in the areas of pathology and bioremediation. Identifying the pathological and symbiotic contributions of microbes and viruses to the health of organisms, environments, and ecosystems should lead to better treatment of disease and environmental destruction. Study of the role microbes play in the carbon cycle may even suggest ways to control CO_2 levels in the atmosphere.[97]

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