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# The Relational Bacterium: From Pathogen to Planetary Partner

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***Abstract:*** **Bacteria have existed for approximately 3.8 billion years, predating all multicellular life and establishing the foundational biochemical relationships upon which every subsequent living system depends. They produce roughly half of Earth's atmospheric oxygen, fix the nitrogen that makes all terrestrial food webs possible, regulate mammalian immune function, synthesise neurologically active compounds, and constitute the majority of genetic material in every human body. Yet the dominant medical and cultural framework of the past century has treated bacteria primarily as pathogens to be eliminated.**

**This paper applies the Care primitive—the directional impetus for the singular to exist in harmony with the whole that allows it to exist [1]—as an analytical lens to reframe bacterial relationships across scales: from the molecular to the planetary. We argue that the dysfunction model of the Care primitive provides a unified explanatory framework for the cluster of conditions that have risen sharply in industrialised populations over the past century: allergic disease, autoimmune disorders, inflammatory bowel disease, metabolic syndrome, and certain psychiatric conditions. These are not unrelated epidemics. They are expressions of the same underlying disruption: the severing of ancient Care-oriented relationships between bacteria and their hosts.**

**The Old Friends Hypothesis [2], the Gut–Brain Axis [3], helminth therapy research [4], faecal microbiome transplantation [5], and cross-species allergy studies [6] all converge on the same conclusion the Care primitive predicts: systems calibrated by ancient cooperative relationships dysfunction when those relationships are removed. Wild animals do not get allergies. Domestic animals increasingly do. Humans living in the most thoroughly sanitised environments carry the highest burden of inflammatory disease in recorded history.**

**We conclude that the most significant medical advances of the coming century may not be new weapons in the war on bacteria. They may be carefully targeted restorations of the relationships the war destroyed.**

***Keywords:*** **Care primitive, microbiome, Old Friends Hypothesis, allergy, autoimmunity, gut–brain axis, biocentric stewardship, dysbiosis, helminth therapy, faecal microbiome transplantation, Care vs. War series.**

## 1. INTRODUCTION: THE OLDEST PRACTITIONERS

Before there were animals, before there were plants, before there was a biosphere in any meaningful sense, there were bacteria. For approximately 1.5 billion years—from roughly 3.8 to 2.3 billion years ago—bacteria were the only life on Earth. In that time they invented photosynthesis, nitrogen fixation, sulphur cycling, and the foundational biochemical pathways that all subsequent life would inherit or depend upon. They terraformed the planet, converting a reducing atmosphere to an oxidising one through the Great Oxidation Event approximately 2.4 billion years ago [7]. Every breath taken by every animal that has ever lived was made possible by bacteria.

They also invented cooperation. Biofilms—structured communities of bacteria communicating chemically, sharing resources, and collectively defending against threats—appear in the fossil record over 3.2 billion years ago [8]. Quorum sensing, the mechanism by which bacteria measure population density and coordinate collective behaviour only when the whole is ready for it, represents one of the earliest documented instances of the OUT vector of the Care primitive in biological systems. The singular waits. The whole moves together.

This paper is the third in the Care vs. War series, following *The Relational Parasite* [9] and *The Relational Virus* [10]. Each paper has applied the Care primitive as a diagnostic lens to a category of organism that the dominant biomedical framework treats primarily as enemy. Each has found the same pattern: the war metaphor blinds us to functional relationships operating at scales and time horizons that the war metaphor cannot accommodate. Each has found that dysfunction, properly understood, occurs not when the organism is present but when it is absent or when its relationship with the host system is severed.

With bacteria, the argument is at its most urgent. We are not talking about organisms that visit us occasionally. We are talking about organisms that constitute the majority of our cellular complement, that co-evolved with our immune systems over hundreds of millions of years, and that our bodies depend upon for functions we cannot perform alone. The war on bacteria is, in a measurable and clinical sense, a war on ourselves.

## 2. THE CARE PRIMITIVE AT BACTERIAL SCALE

The Care primitive, as defined within the Biocentric Stewardship Framework (BSF) [1], is the impetus for the singular to exist in harmony with the whole that allows it to exist. It is directional: the IN vector maintains the singular; the OUT vector orients toward the whole. It can dysfunction when the singular consumes too much from the whole, ultimately destabilising the system that sustains it. Systems that Care persist. Systems that dysfunction do not.

Bacteria demonstrate the Care primitive at its most ancient, most chemically explicit, and most ecologically consequential.

### 2.1 The OUT Vector: Planetary-Scale Contributions

The most fundamental expression of bacterial Care is atmospheric. Cyanobacteria, beginning approximately 2.7 billion years ago, evolved oxygenic photosynthesis and began producing molecular oxygen as a metabolic byproduct [7]. Over hundreds of millions of years this accumulated to transform Earth's atmosphere from one hostile to aerobic life to one that makes it possible. Contemporary marine cyanobacteria, particularly *Prochlorococcus* and *Synechococcus*, are responsible for approximately 20% of all photosynthesis on Earth and an estimated 50% of atmospheric oxygen production [11]. Every second breath you take was made by bacteria.

Terrestrial nitrogen cycling is equally foundational. Atmospheric nitrogen ($N_2$) is chemically inert and unavailable to plants and animals. Nitrogen-fixing bacteria—including free-living soil species such as *Azotobacter* and symbiotic species such as *Rhizobium*, which colonise legume root nodules—convert atmospheric nitrogen to bioavailable ammonia via the nitrogenase enzyme complex [12]. This process supports an estimated 50% of the protein in the human food supply [13]. The Haber-Bosch industrial process, developed in 1913, replicates this chemistry at enormous energy cost and with significant environmental side effects. Bacteria have been doing it for free, at scale, for 2.5 billion years.

The carbon cycle, the sulphur cycle, the phosphorus cycle—all depend critically on bacterial activity for the decomposition, transformation, and redistribution of nutrients that make terrestrial and aquatic ecosystems viable. Remove bacteria from any of these cycles and the system collapses within years. The planetary OUT vector is not metaphorical. It is the foundational operating condition of all higher life.

### 2.2 The OUT Vector: Host-Scale Contributions

Within multicellular hosts, bacterial Care is equally profound and equally ancient. The human microbiome contains approximately $3.8 \times 10^{13}$ bacterial cells, roughly equivalent in number to human somatic cells [14]. By genetic measure the disproportion is far greater: the human microbiome encodes approximately 150 times more genes than the human genome itself [15]. We are, in a genomic sense, mostly bacterial.

The gut microbiome performs metabolic functions the human genome does not encode: synthesis of short-chain fatty acids (SCFAs) from dietary fibre, production of vitamin K and several B vitamins, biotransformation of bile acids, and metabolism of polyphenols into bioactive forms [16]. SCFA production is the primary energy source for colonocytes and plays a regulatory role in systemic inflammation, insulin sensitivity, and appetite regulation [17].

The microbiome–immune system relationship is perhaps the most clinically consequential expression of bacterial Care in the human host. Approximately 70–80% of the immune system is located in and around the gut [18]. Commensal bacteria are not merely tolerated by this system; they are required for its development and calibration. Germ-free mice—raised in sterile conditions without any microbial colonisation—develop profoundly abnormal immune systems: reduced lymphoid

tissue, impaired regulatory T-cell development, exaggerated inflammatory responses, and susceptibility to conditions that normally colonised mice resist [19]. The immune system does not function correctly without bacteria. It was built in their presence and requires their continued presence to operate as designed.

The gut–brain axis adds a further dimension. Approximately 90% of the body's serotonin is produced in the gut, substantially through the action of specific bacterial taxa on enterochromaffin cells [20]. The vagus nerve transmits bidirectional signals between the enteric nervous system and the central nervous system, with bacterial metabolites and signals constituting a significant portion of the upward traffic [21]. Microbiome composition has been associated with anxiety, depression, autism spectrum disorder, and Parkinson's disease, with proposed mechanisms including SCFA signalling, immune modulation, and direct neurotransmitter synthesis [22].

### 2.3 Quorum Sensing: The OUT Vector in Action

Quorum sensing deserves special attention as an expression of the Care primitive at the cellular level. Bacteria continuously secrete small signalling molecules called autoinducers into their environment. Each bacterium simultaneously produces and detects these molecules. When the local population reaches a threshold density—when the whole is present and ready—autoinducer concentration crosses a threshold and triggers coordinated collective behaviour: biofilm formation, bioluminescence, virulence factor production, or sporulation, depending on species and context [23].

The singular does not act until the whole is ready. This is not a metaphor for the Care primitive. It is its biochemical instantiation, operating in organisms that evolved three billion years before the concept had a name. Systems biology has documented quorum sensing in virtually every bacterial species studied [24]. It is not a special adaptation. It is a foundational feature of bacterial existence.

## 3. THE WAR METAPHOR AND ITS COSTS

The germ theory of disease, developed by Pasteur and Koch in the latter half of the nineteenth century, was one of the most consequential advances in medical history [25]. The identification of specific bacterial species as causes of specific diseases provided a causal framework that enabled targeted interventions and saved hundreds of millions of lives. The subsequent development of antibiotics, beginning with Fleming's discovery of penicillin in 1928, extended that framework into direct chemical warfare against bacterial pathogens [26].

The framework was not wrong. It was incomplete. And the incompleteness became costly.

The war metaphor that emerged from germ theory—bacteria as enemy, the body as battlefield, medicine as armament—oriented an entire century of biomedical research and public health practice around elimination. Antibiotics were administered broadly, often for viral infections against which they are ineffective, generating selection pressure for resistance while decimating commensal microbiomes [27]. Antiseptic and antibacterial consumer products were marketed as improvements to domestic hygiene. Caesarean delivery rates rose, bypassing the vaginal bacterial transfer that seeds infant microbiomes [28]. Formula feeding replaced breast milk, which contains hundreds of bacterial species and prebiotic compounds specifically supporting microbiome establishment [29]. Ultra-processed food diets eliminated the dietary fibre that commensal bacteria require [30].

Each of these changes was, in isolation, either medically indicated or commercially driven. Collectively, they constituted a systematic dismantling of ancient Care-oriented relationships. The consequences were not immediately visible. They accumulated over decades, expressing themselves as epidemics of conditions that had been rare in pre-industrial populations.

### 3.1 The Rising Epidemic of Allergy and Autoimmunity

The prevalence of allergic and autoimmune conditions in industrialised populations has increased dramatically over the past fifty years, at a rate far exceeding any plausible genetic explanation [31]. In the United Kingdom, the prevalence of hay fever rose from approximately 10% in 1960 to over 30% by 2010 [32]. Childhood asthma prevalence in the United States approximately tripled between 1980 and 2000 [33]. Peanut allergy prevalence in Western children increased approximately fivefold between 1997 and 2008 [34]. Type 1 diabetes incidence has roughly doubled in Europe since the 1980s [35]. Multiple sclerosis, Crohn's disease, ulcerative colitis, rheumatoid arthritis, and systemic lupus erythematosus all show similar upward trajectories in industrialised populations while remaining relatively rare in low-income, rural, and less-sanitised populations [36].

These conditions share a common immunological signature: dysregulation of immune tolerance. The immune system fails to distinguish correctly between things that should trigger a response (genuine pathogens) and things that should not (harmless proteins in pollen, food, or self-tissue). The result is inflammatory response directed at the wrong targets.

The question the war metaphor cannot answer is: why now? These conditions are not new. But they have increased specifically, dramatically, and consistently in populations that have most thoroughly implemented the sanitation, antibiotic, and dietary changes of the past century. The war metaphor cannot explain its own casualties.

### 3.2 The Old Friends Hypothesis

The most compelling explanatory framework for this pattern is the Old Friends Hypothesis, proposed by Graham Rook and colleagues in 2003 as a refinement of the earlier Hygiene Hypothesis [2]. The mammalian immune system co-evolved over hundreds of millions of years in the continuous presence of specific microorganisms: commensal bacteria, soil bacteria, helminths, and certain protozoa. These organisms were not incidental to immune development; they were required for it. They provided the calibration signals that taught the immune system what to tolerate, trained regulatory T-cell populations that suppress inappropriate inflammation, and occupied ecological niches in the immune landscape that prevented other, more harmful responses from filling them.

Rook termed these organisms ‘old friends’: not pathogens that cause disease, but ancient companions whose presence had become a biological requirement. When these relationships are severed—through sanitation, antibiotics, urban living, and dietary change—the immune system develops without its reference points. Regulatory circuits are undertrained. The inflammatory capacity that evolved to respond to genuine threats is redirected at harmless targets. Allergy, autoimmunity, and inflammatory bowel disease are, on this account, not diseases of the immune system failing. They are diseases of the immune system being deprived of the ancient relationships it requires to function correctly [37].

In Care primitive terms: the OUT vector of bacterial and helminth relationships was calibrating the immune system’s IN/OUT balance. Remove the OUT vector, and the IN vector dysregulates. The singular turns against itself.

## 4. ALLERGY ACROSS SPECIES: NATURE’S CONTROL GROUP

One of the most compelling lines of evidence for the Care primitive interpretation of allergic disease is cross-species comparison. If allergy and autoimmunity are products of severed microbial relationships, we would predict that they should be rare in wild animals living in continuous contact with diverse microbial environments, and more prevalent in domestic and zoo animals living in sanitised conditions. This is precisely what the evidence shows.

### 4.1 Wild Animals

Spontaneous allergic disease in wild mammal populations is documented but rare. Wild ungulates, primates, carnivores, and rodents in natural environments show minimal prevalence of atopic conditions [38]. The immune systems of wild animals are continuously exposed to diverse bacterial, parasitic, and environmental antigens from birth. Their microbiomes are species-rich and functionally robust. Their regulatory immune circuits are fully calibrated.

Notably, wild animals carry helminth parasite loads that in humans we would classify as infections requiring treatment. Within the Old Friends framework, these parasite loads are not purely pathological. They occupy the immune ecological niche that evolution built for them, maintaining regulatory T-cell populations and suppressing the inflammatory overreach that in their absence manifests as allergy [39]. The relationship is not one of parasite exploiting host. It is one of mutual calibration across geological time.

### 4.2 Domestic and Zoo Animals

Domestic dogs and cats, living in human homes with antibiotic exposure, commercial processed diets, and reduced environmental microbial diversity, develop atopic dermatitis at significant rates. Canine atopic dermatitis affects an estimated 10–15% of dogs globally, with higher prevalence in urban populations [40]. Feline asthma affects approximately 1–5% of cats [41]. Both conditions have increased in prevalence over recent decades, tracking the increasing sanitisation of domestic animal environments.

Zoo animals on commercial diets and in clean enclosures show immune dysregulation, inflammatory conditions, and metabolic disorders that their wild counterparts do not [42]. Captive primates have been documented to develop conditions—including inflammatory bowel disease and autoimmune symptoms—that are rare in wild populations of the same species.

The gradient is consistent. As microbial exposure decreases and ancient Care-oriented relationships are severed, the immune system loses calibration and inflammatory dysregulation increases. The effect is not species-specific. It follows the disruption of the relationship regardless of the host.

### 4.3 The Farm Effect

Within human populations, perhaps the most striking evidence comes from the 'farm effect': the consistently lower prevalence of allergy and asthma in children raised on traditional farms compared to urban children in the same geographic region [43]. The ALEX study [44], the PARSIFAL study [45], and multiple subsequent investigations have found that farm children have significantly reduced rates of hay fever, asthma, and atopy, associated with higher microbial diversity in farm environments, raw milk consumption, and contact with farm animals and their associated microbiomes.

The protection is not explained by genetics, income, or healthcare access. It is explained by microbial exposure. Farm children retain more of their 'old friends.' Their immune systems develop in the presence of the calibrating relationships they evolved to require. The effect disappears within a generation of migration to urban environments [46].

## 5. THE GUT–BRAIN AXIS: CARE DYSFUNCTION AND MENTAL HEALTH

The relationship between microbiome disruption and mental health represents one of the most rapidly developing areas of contemporary biomedical research and one of the most striking expressions of the Care primitive in clinical medicine.

The enteric nervous system contains approximately 500 million neurons, more than the spinal cord [47]. It communicates bidirectionally with the central nervous system via the vagus nerve, the enteric-immune interface, and circulating metabolites. Bacterial populations in the gut contribute to this communication through multiple mechanisms: production of neurotransmitter precursors (tryptophan for serotonin; tyrosine for dopamine), production of SCFAs that cross the blood–brain barrier and influence neuroinflammation, modulation of vagal signalling, and regulation of hypothalamic–pituitary–adrenal axis activity [21].

Germ-free mice show exaggerated stress responses, abnormal HPA axis activity, and anxiety-like behaviour that normalise following colonisation with specific bacterial taxa [48]. Studies in humans have found associations between microbiome composition and depression, anxiety, autism spectrum disorder, and Parkinson's disease [22]. Faecal microbiome transplantation from depressed donors to germ-free rodents has been shown to induce depressive behaviour in recipients [49].

The pattern is consistent with the Care primitive framework. The ancient bacterial relationships that calibrate immune function also calibrate neurological function. Disrupt the relationship, and the dysfunction is not limited to the gut.

## 6. THE HELMINTH CONNECTION: WHERE THE SERIES CONVERGES

The Old Friends Hypothesis bridges the bacterial and parasite papers in the Care vs. War series. The immune ecological niches occupied by helminths and commensal bacteria are distinct but functionally related: both suppress the inflammatory overreach that in their absence manifests as allergy and autoimmunity. The eradication of both—through antiparasitic campaigns and antibiotic overuse—has left the immune system doubly deprived of its ancient calibrating partners.

Controlled clinical trials of deliberate helminth colonisation with *Trichuris suis* (pig whipworm) have shown benefit in Crohn's disease, ulcerative colitis, multiple sclerosis, and coeliac disease [4]. The mechanism is immunological: helminths induce regulatory T-cell responses and anti-inflammatory cytokine profiles that suppress the inflammatory overreach characteristic of autoimmune and allergic conditions.

The therapeutic use of organisms that the war metaphor classified as pure pathogens—to treat conditions that the war metaphor helped create—is perhaps the most striking illustration of the Care vs. War argument available across all three papers in this series. The parasite, the virus, and the bacterium: all framed as enemies. All, in their proper relational context, as partners.

## 7. RESTORATION: MEDICINE OPERATING ON THE CARE PRIMITIVE

If the disruption of ancient Care-oriented bacterial relationships underlies a cluster of modern epidemics, the logical therapeutic direction is restoration. Several clinical approaches now converging on this principle represent, in effect, medicine beginning to operate on the Care primitive rather than against it.

### 7.1 Faecal Microbiome Transplantation

Faecal microbiome transplantation (FMT)—the transfer of stool from a healthy donor to a patient with disrupted microbiome—has achieved cure rates exceeding 90% for recurrent *Clostridioides difficile* infection, a condition that kills approximately 29,000 people annually in the United States and responds poorly to repeated antibiotic treatment [5]. The mechanism is ecological: a diverse, functional bacterial community is restored and outcompetes the pathological monoculture that antibiotics created.

FMT trials are ongoing for inflammatory bowel disease, metabolic syndrome, autism spectrum disorder, and multiple sclerosis, with preliminary results suggesting benefit in several conditions [50]. The therapeutic principle is not the addition of a new weapon. It is the restoration of a disrupted relationship.

### 7.2 Helminth Therapy

Controlled reintroduction of benign parasitic helminths has shown significant benefit in autoimmune and allergic conditions, as described in Section 6 and in *The Relational Parasite* [9]. These findings represent the restoration of an immune ecological relationship that co-evolved over hundreds of millions of years. The organisms the war metaphor eradicated are, in part, being carefully reintroduced to treat the conditions their eradication created.

### 7.3 Dietary Restoration

The dramatic reduction in dietary fibre in industrialised food systems—from an estimated 100–150g per day in hunter-gatherer populations to approximately 15g per day in contemporary Western diets—has removed the primary nutritional substrate for commensal bacterial communities [51]. Dietary fibre is not, strictly speaking, food for humans. It is food for bacteria. We evolved to eat it precisely because it feeds the communities that calibrate our immune systems, produce our neurotransmitters, and maintain our metabolic health.

High-fibre, plant-diverse diets consistently associate with microbiome richness, lower inflammatory markers, and reduced prevalence of allergic and autoimmune conditions [52]. The Hadza hunter-gatherers of Tanzania maintain microbiome diversity two to three times greater than industrialised populations and show minimal prevalence of the inflammatory conditions rising in Western societies [53].

### 7.4 Early-Life Microbial Exposure

The first years of life are critical for microbiome establishment and immune calibration. Vaginal delivery transfers a founding bacterial community to the infant; caesarean delivery bypasses this, producing microbiome compositions that differ significantly for months to years [28]. Breastfeeding provides human milk oligosaccharides that specific beneficial bacteria can digest, along with hundreds of bacterial species, immune modulators, and growth factors that support microbiome development [29]. Early antibiotic exposure disrupts founding microbiome communities during the critical window of immune calibration [54].

Paediatric guidelines are beginning to incorporate this evidence, with recommendations for antibiotic stewardship in early childhood and support for vaginal delivery and breastfeeding where clinically appropriate. These are, in effect, recommendations to preserve ancient Care-oriented relationships during the developmental window when they matter most.

## 8. GEOLOGICAL TIME AND THE TAPESTRY

The Care primitive framework requires thinking in geological time. Human medicine operates on the scale of clinical trials, treatment courses, and patient lifetimes. The relationships between bacteria and their hosts were established and refined over hundreds of millions of years. The immune system's dependence on bacterial calibration signals was not designed. It evolved, incrementally, through billions of generations of selection in environments where those signals were continuously present.

When we view bacterial relationships at geological scale, the tapestry becomes extraordinary. The cyanobacteria that oxygenated Earth's atmosphere 2.4 billion years ago are the ancestors of the chloroplasts in every plant cell—captured by endosymbiosis, their ancient Care orientation preserved and repurposed within a new cellular context [55]. The mitochondria that power every eukaryotic cell are the descendants of proteobacteria engulfed by ancestral cells approximately 1.5 billion years ago and retained because their energy production served the host [56]. We are not merely accompanied by bacteria. We are, in part, assembled from them.

The nitrogen-fixing bacteria that make terrestrial food webs possible have been doing so for approximately 2.5 billion years [12]. The mycorrhizal networks through which forest trees share carbon and chemical signals are mediated in part by bacterial communities associated with fungal hyphae [57]. The deep-sea hydrothermal vent communities, entirely independent of solar energy, are built on chemosynthetic bacteria that fixed carbon and sulphur for billions of years before photosynthesis diversified life's energy sources [58].

In every case, the pattern is the same. The Care primitive operating over geological time weaves a tapestry of extraordinary richness and resilience. The war metaphor, operating over a century, has begun to unravel threads whose importance we did not understand until they were gone.

## 9. CONCLUSION

Bacteria are not our enemies. They are our oldest partners, our most essential collaborators, and in a genomic and evolutionary sense, our partial ancestors. The war on bacteria, conducted over a century with genuine medical achievements and genuine medical costs, was built on a framework that saw the singular and ignored the whole. It saw the pathogen and missed the partner. It saw the short-term and missed the geological.

The Care primitive provides what the war metaphor cannot: a framework for understanding bacterial relationships at the scale and time horizon at which they actually operate. Applied as a diagnostic lens, it predicts—and the evidence confirms—that the systematic disruption of ancient Care-oriented bacterial relationships produces immune dysregulation, allergy, autoimmunity, metabolic dysfunction, and neurological disruption. Not as separate epidemics with separate causes. As expressions of a single underlying dysfunction: the severance of relationships that evolution requires.

The restorative approaches now gaining clinical traction—FMT, helminth therapy, dietary restoration, microbiome-conscious early-life care—are not alternative medicine. They are medicine finally operating on the Care primitive rather than against it. They are medicine beginning to think in geological time.

Wild animals do not get allergies. Domestic animals increasingly do. Humans living in the most thoroughly sanitised environments carry the highest burden of inflammatory disease in recorded history. The experiment has been running for a century. The results are in.

Systems that Care persist. Systems that dysfunction do not.

*"The day science begins to study non-physical phenomena, it will make more progress in one decade than in all the previous centuries of its existence." — Nikola Tesla*

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