Mental Well-Being, Neuroscience, and Religion

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THE PHYSICALIZED MIND AND THE GUT-BRAIN AXIS: TAKING MENTAL HEALTH OUT OF OUR HEADS

by Lindsay Bruce and Sarah Lane Ritchie

Abstract. As it becomes increasingly plausible that the mind–brain is explicable in naturalistic terms, science-and-religion scholars have the opportunity to engage creatively and proactively with facets of brain-related research that better inform our understanding of human well-being. That is, once mental health is recognized as being a whole-body phenomenon, exciting theological conversations can take place. One fascinating area of research involves the "gut–brain axis," or the interactive relationship between the microbiome in the gastrointestinal tract (i.e., gut bacteria), the central nervous system, and mental health. A growing body of literature explores the immensely significant interactions between the gut microbiome and mental health issues involving depression, anxiety, gene expression, and stress responses. One's mental health does not occur in a disembodied state, but in a complex physical environment that is strongly influenced by environmental factors, many of which we can control. This article argues that science-and-religion can welcome scientific research in this area, creatively incorporating such insights into a theology of mental health and physical well-being.

Keywords: consciousness; gut microbiome; mental health; philosophy of mind

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Although the incorporation of scientific research into theological frameworks has been a prominent feature of the science and religion field, the

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subject of mental health has been arguably underexplored. This in itself is an interesting observation: although the biological and psychological sciences as well as mainstream theology have devoted significant attention to understanding and engaging mental well-being and mental illness, science-and-religion has not featured prominently in the discussion. It is perhaps the case that the field has often sought to address "hard" questions of seemingly metaphysical importance (divine action, the limits of science, theodicy, methodological issues, naturalism, emergence, theological implications of evolution, etc.), while demonstrating a collective wariness toward the "softer" subjects of lived human experience. Additionally, it is noteworthy that the "dualism-lite" so often associated with Christian theology has perhaps lessened the felt need to address scientific research associated with mental health. In other words, to the extent that those in science-and-religion have assumed a view of consciousness that undermines its physicality (e.g., substance dualism, emergence theories, and perhaps even nonreductive physicalism as usually construed[1]), there has perhaps been little motivation to address biological and environmental factors that affect one's mental health.

In contrast to the historic reticence to take physicality seriously, this article assumes (with the vast majority of brain scientists, psychologists, and many philosophers) that it is plausible that the mind-brain is wholly explicable in naturalistic (or even physicalist[2]) terms—and that this need not be theologically threatening. On the contrary, a robust appreciation of physicality enables science-and-religion scholars to engage creatively and proactively with facets of brain-related research that better inform our understanding of the human person. More specifically, we here engage with an area of research that has direct implications for theologies of mental health and well-being: namely, research surrounding the "gut-brain axis," or the interactive relationships between the microbiome in the gastrointestinal tract (i.e., gut bacteria), the central nervous system (CNS), and mental health. As will be discussed, a growing body of literature reveals immensely significant interactions between the gut microbiome and mental health issues involving depression, anxiety, gene expression, and stress responses. In other words, one's mental health does not occur in a disembodied state, but in a complex physical environment that is strongly influenced by environmental factors—many of which are amenable to intentional manipulation. This article argues that science-and-religion can welcome scientific research on the gut-brain axis, incorporating such insights into theologies of mental health and overall well-being. To this end, we begin with a brief defense for taking seriously the physicality of the mind more generally, thereby offering a justification for treating the mind and mental well-being as a biopsychosocial question. With this philosophical/theological background in place, we present a snapshot of the current research surrounding the gut microbiome and its relationship to mental illness and mental health,

respectively. Finally, we discuss how science-and-religion might appropriately incorporate such research into its methodology and subject matter.

Theology, Philosophy, and the Mind

Mental health is increasingly being recognized as not only an important focus of biological and psychological research, but also as a theological good—an aspect of personhood that is integral to theological engagement with the biological and social sciences.[3] However, theology's historic reticence to accept naturalistic explanations for consciousness can make it difficult for such theological engagement to move beyond vague abstractions or well-meaning platitudes. So long as the human mind is thought to be inherently nonphysical, equated with an immaterial soul, or even privileged as being "more" than natural or physical, theological engagement with mental health research will be limited at best. In short: the ontology of consciousness matters, and one's understanding of consciousness itself directly affects the extent to which one can theologically engage biological research on mental health—in this case, research involving the gut microbiome. In other words, if the mind is a disembodied entity independent of our physical bodies (or even simply *more* than or distinct from our bodies in some way), that would lead one to think about mental health in a relatively limited way, perhaps by focusing solely on the psychological contents of one's mind, subjective felt experiences, nourishing one's "spiritual life," and so on. If the mind is not disembodied, however, but is instead a wholly natural and perhaps even physical aspect or function of one's brain/body/environment system, then one would think very differently about mental health. Although one would still deal with mental content and subjective experience, an emphasis on the physicality of the mind would urge an examination of mental health through a biological lens.

Debates about the ontology of consciousness have a long history and cannot be done justice here. Nevertheless, it is worth highlighting the more general ways in which scholars tend to approach the human mind, because different perspectives on consciousness affect one's engagement with specific areas of research—such as the gut-brain axis. First, it is rather striking to note how differently consciousness is handled by philosophers, theologians, and scientists, respectively. Scientists, for their part—and particularly within the various brain-related sciences—tend not to speak of "consciousness" much at all. That is, although theologians and philosophers expend countless hours debating the ontology of the human mind, cognitive scientists and other brain researchers tend simply to get on with the business of identifying the mechanisms enabling human cognition, emotion, behavior, and so on. Indeed, one can read an entire neurobiology textbook and find at *most* two or three references to "consciousness." The general assumption within the brain sciences is that the human mind is

a wholly natural phenomenon analyzable by studying the brain's various structures and functions, evolutionary pathways, cognitive tendencies, and neural patterns. Some, including cognitive scientists, anthropologists, and evolutionary psychologists, broaden their research beyond brain tissue and connectivity itself to examine the way natural selection, cultural evolution, and group dynamics shape the brain/body/environment system in a multilayered, holistic manner.[4] Still, even these approaches that utilize "higher" concepts of culture and sociology still presume the in-principle naturalness of human consciousness.

Philosophers and theologians, however, have tended to analyze consciousness from largely nonbiological perspectives. The Christian theological tradition, for its part, has a long history of entrenched wariness toward scientific explanations for the human mind.[5] Often in theological or philosophical discussions of consciousness, significant time and effort is spent on defending the mind's status as somehow nonphysical or more than physical, inherently mysterious, or even uniquely spiritual.[6] For example, in discussing the theological motivations of substance dualist Alvin Plantinga, Kelly Clark and Michael Rea write, "At least some of the sympathy [for dualism] arises out of religious considerations: God is a mind, and God is not material; and much in the Christian scriptures and tradition seems to suggest that human beings are to be viewed as fundamentally immaterial, or at least endowed with an immaterial component as well" (Clark and Rea 2012, 7). The theological fear, it seems, lies in an assumption that the spiritual core of humans is in tension with physicality and (presumably reductionist) scientific explanations of mental experience. Note, however, that such theological fears actually serve to prevent rigorous engagement with scientific research about mental and spiritual experience—such as research on the gut-brain axis.

Substance dualists like Plantinga notwithstanding, it is important to note that the contemporary theological discussion of the mind's significance will usually involve an awareness of the importance of the body and the brain for human mentality; there is a desire to at least take contemporary brain science seriously. For example, philosopher and theologian Keith Ward rejects extreme forms of dualism because of the overwhelming scientific evidence that "human consciousness is generated from and remains dependent upon a physical brain" (Ward 2008, 160). Indeed, it is fair to say that most philosophers and theologians seek to affirm the mind's involvement with the brain and body in an effort to avoid blatant Cartesian dualism—though there remains a general reticence to accept that the human mind is wholly explicable in empirical terms.[7] In fairness, for many this is an incredibly intuitive position—that however close the correlation between neurobiological activity and the rich, colorful subjective experience of being oneself, the association between mind and brain must never be one of identity.

This intuitive position notwithstanding, critics abound. Dissenters from the "standard" theological position will point out that there is a very real possibility that what we call "the human mind" just *is* a working brain in a functioning body in an unimaginably complex physical, social, and cultural environment. Daniel Dennett, Patricia Churchland, and others have argued that an inability to imagine the possibility of science explaining the mind in a satisfying way is, actually, a psychological fact about one's capacity for imagination: "Whether we can or cannot imagine a phenomenon being explained in a certain way is a psychological fact about us, not an objective fact about the nature of the phenomenon itself" (Churchland 1997, 42). Others argue that even if current science is not fully able to explain consciousness, the history of science would caution identifying particular phenomena as inherently beyond the scope of scientific inquiry. Still others within the Christian tradition argue that undermining human physicality as constitutive of personhood is incompatible with biblical conceptions of humanity; immateriality or "more than physicality" is unnecessary for the Christian.[8]

Beyond this philosophical and theological discussion—and most relevant for our discussion of the gut microbiome—there is the growing body of neurobiological literature demonstrating the sheer physicality of everything from emotions, cognition, and behavioral control to addiction, learning, and even religious belief. It is becoming increasingly clear that brain trauma, prenatal environments, Alzheimer's disease, pharmaceutical and hallucinogenic drugs, alcohol, meditation, and early childhood nutrition all play a part in one's conscious experience, personality, and cognitive development. While one might be appropriately wary of reductionist explanations for various subjective experiences, the overall emerging picture of conscious life is one that is unimaginably complex—involving not only the interconnectivity of more than eighty billion neurons in the brain, but also the brain's interactions with every other body system, the evolutionary context in which innate cognitive predispositions developed over millions of years, and one's daily encounter with an external environment in a specific sociocultural context. Scientific explanations of mental experience are not reductive attempts to "explain away" subjective experience, but are analyses of extremely complicated processes at a variety of levels (e.g. biochemical, evolutionary, neuroscientific, psychological, sociocultural). Affirming the physical nature of consciousness can plausibly be seen as a recognition of an intricate, multilayered, and complex natural world in which humans have always been embedded—rather than an agenda-driven commitment to reductive materialism.

This defense of viewing the mind as a natural phenomenon is meant to serve as the conceptual foundation for the important lines of science-and-religion inquiry that become possible once one takes the physicality of consciousness seriously. Once mental health is recognized as involving

the whole body and being inseparable from physicality, new and constructive theological conversations can take place—to be physical is not to be "unspiritual." Indeed, the biological factors contributing to mental well-being become not only scientifically interesting, but theologically *valuable* and *necessary*. To the extent that one affirms human well-being as both a theological good and as an area that is appropriately subject to rigorous biological research, engagement with physical factors affecting mental health becomes a responsible (and exciting!) line of inquiry for science-and-religion scholars. This being said, one potential weakness of science-and-religion has been its frequent retreat into abstractions that fail to engage concretely and specifically with empirical scientific research and its implications for theological work. That is, it is one thing to pay lip-service to the importance of theological engagement with the biological sciences in addressing mental health, and another thing entirely to engage with actual research in a rigorous manner. To this end, we here engage with the gut microbiome—a fascinating and burgeoning area of mental health research. It is suggested that such engagement results in new lines of theological inquiry, and is also indicative of the importance of empirical research within the science-and-religion field.

The Gut Microbiome

What, then, is the gut microbiome—and why does it matter for science-and-religion? The gut microbiome is the collection of microbes that colonize the gastrointestinal (GI) tract. It consists of primarily bacteria along with a small assortment of other microbes, including viruses, archaea, protozoans, and fungi. Estimates for the number of bacteria in the GI tract are in the trillions, with the bacteria in the GI tract outnumbering the human cells that make up the GI tract. Gut bacteria collectively weigh approximately the same as the human brain, 1–2 kg, and have a profound influence on health and well-being. Humans have co-evolved with these bacteria and we have only begun to understand them recently with advances in technology (Foster et al. 2016).

Colonization of the human gut is thought to begin *in utero* (Aagaard et al. 2014). A newborn's microbiome is largely shaped by mode of delivery, with vaginally delivered newborns having intestinal bacteria consistent with that of birth canal flora, and babies delivered by C-section having intestinal bacteria akin to typical skin microbiota (Biasucci et al. 2010). A wide variety of other factors influence newborn gut colonization, including gestational age, intrapartum antibiotic prophylaxis, and feeding method (Azad et al. 2016). The initial colonization of the newborn GI tract is thought to influence its final form, which appears to be set by approximately three years of age (Yatsunenko et al. 2012). But even the mature, adult microbiome can change. Humans have agency in self-directing the

microbiome and indirectly mental health through a variety of factors, including: diet, geographical location, medication (particularly antibiotics), pathogens, and disease (Lloyd-Price et al. 2016).

What has become increasingly clear is that there is no "typical" microbiome that would indicate a physically and mentally healthy individual; this idea has been replaced with the concept of a "core" healthy microbiome. It is generally accepted that the GI tract contains approximately 1,000–1,150 species of bacteria, with the overwhelming majority of bacteria belonging to phyla Bacteroidetes and Firmicutes (Qin et al. 2010; Human Microbiome Project 2012); and although there may not be one typical healthy microbiome, gut microbial dysbiosis has been linked to multiple conditions, from gut-related disorders such as irritable bowel syndrome (IBS) and Crohn's disease, to autoimmune disorders such as multiple sclerosis and lupus, and most pertinently for this discussion, psychiatric disorders such as anxiety and depression (Foster et al. 2013; Lloyd-Price et al. 2016).

Microbiome to Brain Communication

The widely disparate array of effects of the microbiome on the body gives rise to the question of how gut microbes can communicate with the body. These lines of communication are especially pertinent for the question at hand: the effects of the gut microbiome on mental health and well-being. The data regarding gut-brain communication methods are ever-expanding, but current evidence suggests that gut microbiota secrete a wide variety of peptides, neurotransmitters, hormones, and steroids. These molecules can communicate with the brain via the nervous, endocrine, and immune systems (Mayer 2011; Furness 2016).

Perhaps surprisingly, the gut has its *own* nervous system, the enteric nervous system (ENS), which is semi-autonomous and consists of 200–600 neurons that regulate gut functions. In fact, the gut is often referred to colloquially as the "little brain," reflecting its importance on mental states often usually thought to be confined to the brain itself (Hadhazy 2010). Moreover, gut communication is not limited to the ENS; the gut can also communicate with the CNS through two major pathways: vagal and spinal neurons. Communication between the brain and the gut via these pathways is bidirectional; the brain can send signals to the gut, and the gut can return signals to the brain (Mayer 2011).

The gut can also communicate with the brain via the endocrine system. Enteroendocrine (EE) cells are the endocrine cells of the GI tract. Once activated, EE cells can secrete neuropeptides and hormones that can activate vagal nerves terminating near EE cells in the gut (Mayer 2011). One specific type of EE cell, the enterochromaffin (EC) cell, is very important in serotonin regulation. Serotonin is a neurotransmitter that plays a major role in mood, anxiety, and depression, and appears to function in

gut-to-brain communication by activating vagal afferent neurons (Gershon and Tack 2007). Perhaps surprisingly, *over 95 percent* of serotonin is produced in EC cells. Here we begin to see real evidence that mental health is not merely a result of the brain, an immaterial mind, and so on, but involves the whole body.

The immune system is a final method by which the GI tract can communicate with the brain. The signaling methods used by the immune system have not been fully elucidated, but the data indicate that gut immune cells can release cytokines that can activate nearby vagal afferents (Mayer 2011). A second method of immune system activation is theorized to happen when tight junctions between the gut epithelial cells are loosened by stress or other factors, causing a "leaky gut" characterized by increased permeability of the intestinal wall and bacterial access of immune cells. This results in chronic inflammation and may activate the fight or flight stress response through the hypothalamus-pituitary-adrenal (HPA) axis (Gareau et al. 2008; Foster et al. 2017). This is especially relevant for this discussion, as an overactive or dysfunctional HPA axis has been regularly linked to depression, anxiety, and other mental health conditions (Pariante and Lightman 2008). Again, we see here that mental health is directly affected by the most physical of factors, and is not confined to one's subjective experience or even the brain itself.

The microbiome-gut-brain communication chain is not complete without communication between the microbiome and the gut. Bacteria can produce neurotransmitters, hormone-like molecules, and cytokines, and bacterial by-products through digestion, and these molecules allow the bacteria in the gut to talk to the gut, which in turn transfers information to the brain. One example of neurotransmitter production by gut bacteria is the production of γ-aminobutyric acid (more commonly known by its abbreviation GABA) by lactic acid bacteria (Dhakal et al. 2012). GABA has long been linked to depression and anxiety and it has been proposed more recently that its mechanism may be through its interactions with two molecules: the aforementioned serotonin, and brain-derived neurotrophic factor (BDNF), a molecule crucial to the development and function of the cortex and hippocampus (Cryan and Slattery 2010). Short chain fatty acids (SCFAs) are also considered crucial mediators of communication between gut microbes and the GI tract. Different SCFAs are created when bacteria metabolize certain carbohydrates. SCFAs such as butyrate are key regulators of intestinal permeability and acetate has been shown to cross the blood-brain barrier (BBB) and directly regulate genes in the hypothalamus (Suzuki et al. 2008). The types of molecules produced by the microbiome are crucially important; for instance, if one's gut microbiome is producing molecules that alert the gut to activate the stress response in the brain, it could lead to symptoms of anxiety or panic. Keeping our microbiome healthy ensures that it is giving the proper signals to the gut, and in turn, the brain.

The Microbiome-Gut-Brain Axis and Mental Disease

Although many of the complex interactions of the microbiome-gut-brain axis have yet to be fully elucidated, the current data have painted a preliminary picture of the microbiome communicating to the CNS via neuronal, endocrine, and immune pathways and each pathway influencing the others via a plethora of signaling molecules. What role do these communication pathways have in the health and well-being of organisms? It has long been known that bacterial infections can alter psychiatric state from observations of syphilis or Lyme disease patients (Logigian et al. 1990; Crozatti et al. 2015). More recent studies have looked at the effect of enteric bacteria on mental health. Interestingly, gastrointestinal diseases like IBS, in which gut dysbiosis has been implicated, have high comorbidity with anxiety and depression (Carroll et al. 2010). Because the emphasis of this article is mental health, we will specifically tailor our focus to studies linking perturbations of the gut microbiome to anxiety and depression.

One of the first major studies linking the gut microbiome to mental state was done in germ-free (GF) mice by Nobuyuki Sudo et al. (2004). GF mice were surgically delivered and raised in a completely sterile environment, so they had no exposure to bacteria and no gut microbiomes. These mice are contrasted with specific pathogen-free (SPF) mice, which have normal gut flora and no pathogenic colonization. The mice were restrained in small tubes. When the GF mice were restrained in this manner, they showed an increased fight-or-flight stress response (through the HPA axis) compared to controls. The authors theorized that the mechanism behind the increased stress response was neuroimmune (GF mice showed increased cytokine production), and the changes in the GF mouse brain appeared to be permanent over the lifetime of the mouse. The most fascinating part of this study was that the exaggerated fight-or-flight stress response in the GF mice could be ameliorated by colonization with the common infant gut bacteria *Bifidobacterium infantis*. It was also partially mitigated by fecal transplant from SPF mice to GF mice. Having "good" gut bacteria caused the mice to show fewer signs of stress. Interestingly, this effect was time-dependent, as older mice did not benefit from colonization with SPF mouse gut bacteria. This finding was key, as it indicated that microbial colonization of the gut directly after birth appears to be essential for the proper development of the HPA axis and the ability of the organism to appropriately respond to stress over a lifetime. These sorts of studies demonstrate the strong link between the makeup of one's gut microbiome and one's stress response.

Data have only very recently begun to be collected on the relationship between the gut microbiome and depression and anxiety in human subjects. Initial analysis indicates that microbiome changes occur in patients with major depressive disorder (MDD), but so far the studies have elicited

mixed results regarding gut microbiome diversity and species-specific changes, so further data and analysis is requisite for a more comprehensive picture.

Analysis of the human gut microbiome in depressed patients and healthy controls in Norway showed no difference in species richness. There was a decrease in the phyla Bacteroidetes in depressed patients, which has previously been associated with obesity, inflammation, and depression (Naseribafrouei et al. 2014). There was also an increase in genus *Alistepes*, potentially linked to depression through inflammatory pathways, and genus *Oscillibacter*, which produces the metabolite valeric acid, which is quite similar to GABA and has been shown to bind a GABA receptor (Loeb et al. 1990).

In a similar study in China, Jiang et al. (2015) looked at patients with either active MDD or responded MDD versus healthy controls. In contrast to the first study, this study found increased species diversity in the gut microbiome of patients with active MDD, but not responded MDD, compared to control subjects. The authors theorized that the difference in gut microbiome diversity could be due to a variety of factors; one factor in particular that could be very important is the difference in Eastern and Western diets, as diet has been shown to have a major effect on gut microbiome composition (David et al. 2014). Phyla Bacteroidetes, Proteobacteria, and Actinobacteria were increased and phylum Firmicutes was decreased in active MDD and responded MDD patients compared with healthy controls. One confounding factor is atypical antipsychotic use in the patients, which has been shown to affect the gut microbiome profile (Flowers et al. 2017). There were a few bacterial genera that were specifically increased in MDD patients compared with healthy controls; interestingly, two of them are genera *Alistepes* and *Oscillibacter*, previously identified by Naseribafrouei and colleagues.

A third study in the same vein compared depressed patients in Ireland to healthy controls (Kelly et al. 2016). This study found decreased gut microbiome richness and species diversity in depressed patients compared with the control group, increased levels of cytokines, and altered HPA axis activity. There was no evidence of increased gut permeability or SCFAs. Fecal samples from depressed patients were transferred to rats; fascinatingly, rats that received these transfers developed depression-like symptoms. Transplanting a "depressed" microbiome to normal, healthy rats resulted in depressed rats.

Because intestinal permeability (a.k.a "leaky gut") has also been linked to depression, two studies have looked at the movement of lipopolysaccharide (LPS), a component of gram negative bacterial cell walls, from the gut into the blood stream (Maes and Leunis 2008; Maes et al. 2012). LPS from gut enterobacteria was detected using antibodies in human patients with MDD compared with healthy controls. Significantly higher levels of LPS were found in the serum of depressed patients compared with controls,

and this finding held up when the study was repeated with a larger sample size.

Several conclusions can be drawn from the conflicted findings above. It is evident that a consensus on the interactions between the gut microbiome and the brain has yet to be reached as to whether MDD increases or decreases overall bacterial diversity and which specific bacterial species are modified. The mechanism behind these changes (or lack thereof) is also up for debate—increased cytokine production or increased gut permeability were both positively and negatively correlated with changes in the MDD gut microbiome. These findings emphasize the complexity of the interactions between the gut microbiome and the brain. The key result from an overall analysis of these studies is that patients with anxiety and depression have been shown to have major gut microbiome perturbations. It is anticipated that future studies in this vein will take into consideration additional variables, such as diet and medication, in order to obtain a more comprehensive, nuanced view of the microbiome-gut-brain axis.

Therapeutic Options

A variety of options for manipulating the gut microbiome exist, with the end goal being improved physical and mental well-being. Some of these methods include probiotics, psychobiotics, prebiotics, and diet. Studies involving each of these supplements/dietary changes have begun to be published in animal and human models for effective analysis of gut microbiome manipulation as a therapeutic option for treating depression and anxiety.

Probiotics are "[l]ive microorganisms that, when administered in adequate amounts, confer a health benefit on the host" (Hill et al. 2014). Probiotics typically contain *Bifidobacterium* and *Lactobacillus*, both proven to have health benefits. Psychobiotics (or psychomicrobiotics) are probiotics that contains bacterial species and strains correlated with improved mental health and well-being (Dinan et al. 2013). Many recent studies have looked at the effectiveness of probiotic use to improve depression and anxiety symptoms.

Studies in rodents have fairly consistently shown the benefits of probiotics in reducing anxiety. Probiotics containing *B. infantis*, one of the primary colonizers of the human newborn gut, have been found to alleviate the stress of maternal separation in rats (Desbonnet et al. 2010). A study involving lactic acid bacteria *L. rhamnosus* found that it had behavioral and physiological effects on healthy mice compared to controls that did not receive the probiotic. Mice receiving the probiotic had reduced anxiety and reduced corticosterone. Two specific types of GABA receptors show brain region–specific increases and decreases in the group receiving the probiotic compared to controls. As lactic acid bacteria are known to produce

GABA, it is thought that receiving the probiotic modified mouse brain activity through the GABA receptors. Interestingly, severing the vagus nerve in the mice eliminated the effects of receiving the probiotic, evincing a mechanism of communication via the vagus nerve (Bravo et al. 2011). A combination probiotic of two specific strains of *L. helveticus* and *B. longus* was given to rats; the probiotic treatment reduced the amount of burying done by the rodent, demonstrating anti-anxiety properties (Messaoudi et al. 2011).

Human studies looking at the effects of probiotics on mental health have generally shown positive correlations. A *L. casei* probiotic was shown to reduce the anxiety symptoms of patients with chronic fatigue syndrome (Rao et al. 2009). When given to randomized human volunteers, the probiotic reduced stress, depression, and hostility (Messaoudi et al. 2011). Healthy volunteers given a fermented milk drink containing a probiotic showed altered brain regions associated with sensory and emotion processing (Tillisch et al. 2013). A multispecies probiotic containing eight strains of *Bifidobacterium* and *Lactobacillus* given to health volunteers reduced negative thoughts associated with sad mood (Steenbergen et al. 2015). However, an analysis of ten clinical trials looking at the effect of probiotics on mood found only a mild overall effect on mood in moderately depressed patients and no overall effect on mood in healthy patients. It was recommended that further studies be conducted in patients with MDD (Ng et al. 2017).

Prebiotics. "[a] substrate that is selectively utilized by host microorganisms conferring a health benefit" and include certain compounds such as fructo-oligosaccharides (FOS) and galacto-oligosaccharides (GOS), promote the growth of *Lactobacillus* and *Bifidobacterium* in the gut (Gibson et al. 2017). A variety of fruits, vegetables, and grains are thought to be prebiotic in nature as well (Markowiak and Śliżewska 2017).

There are limited but promising studies looking at the effects of prebiotics-induced microbiome changes on depression and anxiety. Rats given FOS or GOS prebiotics showed increased BDNF in the brain (Savignac et al. 2013). In another study, rats were fed FOS, GOS, or a combination of FOS+GOS. Prebiotic administration causes changes in the gut microbiome, specifically increasing genera *Bacteroides* and *Akkermansia*, a bacterial species associated with improved gut barrier function. The prebiotic combination FOS+GOS diet reduced anxiety and depression. Prebiotics also lowered levels of inflammation, as seen in reduced levels of serum cytokines and corticosterone, and modified gene expression in the brain, shown in increased mRNA levels of certain GABA receptor genes and the *Bdnf* gene (Burokas et al. 2017).

The aforementioned studies demonstrate that manipulation of the bacterial species in the gut microbiome is a viable therapeutic option and can be accomplished via probiotics, prebiotics, and diet. It is likely that

a combination of these may work best for promotion of both gut and mental health. In a study in mice, the anti-anxiety effects of a *Lactobacillus* probiotic were dependent on both the diet and genotype of the mouse (Ohland et al. 2013). A study in monozygotic twins living apart from one another showed that genetics influenced the gut microbiome composition more than probiotic consumption (McNulty et al. 2011). Slyepchenko et al. (2017) found that diet and genetic factors both played a role in gut microbiome composition. Probiotics will continue to be refined as further research determines which bacterial strains are most beneficial for certain mental conditions or diseases (Dinan et al. 2013). A proper combination of probiotics, prebiotics, and diet could be theoretically selected based on each individual patient's genetic makeup and environment, thereby constructing a healthy gut environment that fosters mental health and well-being.

Discussion

It is evident that an enormous amount of research remains to be undertaken in an effort to understand the complex relationship between mental health, the brain, the gut microbiome, and one's environment (including diet, stress, and early exposure to various bacteria). However, the above exploration of the available literature suggests several relevant insights within a science-and-religion context.

A Brief Note on Methodology: Beyond Abstraction and into Empiricism

One goal of this article has been to demonstrate the *sort* of engagement with primary scientific research that the science-and-religion field should be undertaking. If one assumes that scientific research has real value for theology, then physical mechanisms—even at the detailed, minute level surveyed above—become necessary data points with which to rigorously engage. This is especially true when discussing consciousness and, more specifically, mental health. Given the historical tendency for theologians to adopt some sort of dualistic or quasi-dualistic approach to consciousness, we would argue that the sort of research outlined above offers an important corrective when thinking theologically about human well-being.

Taking Mental Health Out of Our Heads

Indeed, if research on the gut microbiome tells us anything, it is that mental health is not simply a matter of subjective experience, one's attitude or spiritual life, or even solely a product of brain activity. Rather, what we see from this research is that one's mental health is a whole-body, whole-environment phenomenon that is physically based. It is evident that some

of the most debilitating mental disorders and diseases—depression and anxiety, for example—are significantly affected by one's diet, medications, and stress level. To take mental health seriously, then, is to take seriously the quality of one's food, environment, and so on. To engage theologically with mental health and mental illness is to be willing to accept and implement such research *as a theological good*. Much more research needs to be done on specific therapeutic interventions within the gut microbiome, but such research should be embraced by those invested in mental well-being as theologically significant.

The Ontology of Consciousness Matters for a Theology of Mental Health

Debates about consciousness, theological anthropology, and the (im?)materiality of the human mind will continue. Note, however, how one's ability to accept scientific research on mental health (as with the gut microbiome) is affected by one's stance on the mind. Yes, it is quite acceptable (even expected) within science-and-religion to affirm that the mind is at least involved with the brain and body. Nevertheless, to the extent that one insists on the mind still being "more than physical," one will arguably be less likely to take such scientific research seriously. For example, one who insists on the mind's immateriality or essential non-physicality might assume that one's depression or anxiety is a purely psychological or even spiritual problem—one to be addressed with a therapist or in a church. Of course, one might rightly say that that few in science-and-religion are suggesting that physical factors do not impact one's mental experience. This may well be the case—and, of course, mental health professionals and religious communities can be immensely helpful for improving one's mental health. However, on the ground, many within Christianity still tend to treat the mind as a separate entity and retain a great deal of skepticism towards physical interventions for mental illness, leading to a potentially devastating lack of substantive therapeutic care. There are two potential solutions to this issue. The first solution is improved communication from the dualist camp regarding the importance of the physicalized nature of the mind and its interactions with the soul. The second solution—which we propose in this article—is to affirm the physicality of consciousness as a brain/body/environment phenomenon, which in turn leads to an emphasis on the importance of otherwise insignificant factors such as probiotics and fiber in one's theology of mental well-being.

Conclusion

The theological concern about physicalism, it seems, usually comes down to reductionism. There has long been a palpable theological resistance to anything that would seem to diminish the specialness or spirituality of the human person. Scientific explanations for the mind have been seen as

theologically threatening not only to one's understanding of the human organism, but to one's ability to affirm real spiritual union between God and humans. In short, physicality has often been viewed as the antithesis to spirituality. But this resistance to the physical need not be theologically necessary. Far from being reductionistic or deflationary, one could argue that this brief glimpse into the gut-brain axis paints a picture of the human person that is unimaginably complex. The brain itself is "the most complex object in the known universe," as neuroscientist Christof Koch describes it (Koch 2013), and the research described above indicates that *beyond* the brain itself there are trillions of bacteria that exist in intricate relationship with the brain, overall body, environment, and one's food. Far from being a reductionistic portrayal of mental health, this picture could just as well be seen as a picture of the nearly incredible intricacy and complexity of the human being. Moreover, this is an immensely *hopeful* picture of mental health. Research on the gut microbiome suggests that one's experience of oneself and the world is malleable and susceptible to alteration and treatment. Humans may well be able to affect their mental well-being by making concrete physical changes. Such physical manipulation of the microbiome need not be considered unspiritual, but a mechanism of real and lasting change. While the research surrounding the microbiome and mental health leaves much to be discovered, there is every possibility that such research could be appropriately, responsibly, and theologically engaged by those invested in mental well-being.

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Notes

1. Although nonreductive physicalism has appealed to many hoping to maintain a commitment to both scientific rigor and still allow for "something more," there are concerns that this position is not a tenable one. For instance, Jaegwon Kim argues that "if you have already made your commitment to a version of physicalism worthy of the name, you must accept the reducibility of the psychological to the physical, or, failing that, you must consider the psychological as falling outside your physicalistically respectable ontology" (Kim 1989, 32).

2. The terms "naturalism" and "physicalism" are notoriously slippery. I here take "naturalistic" to mean those explanations that do not reference supernatural agents or causation. When referring to consciousness, a naturalistic explanation would then indicate one that utilizes only entities and processes that are not themselves outside of the natural world—they are not "supernatural." "Physicalist," then, is a narrower term taken to indicate explanations that reference only empirical realities that are explicable in terms of scientific methodology or the laws of nature. Hence, one might be a naturalist but not a physicalist, whereas physicalists would also be naturalists. David Chalmers, for example, is a dualist but also a naturalist—he understands

consciousness as a somewhat basic feature of the natural world, but not of supernatural origin (Chalmers 1996). He would reject physicalism, but accept naturalism.

3. For example, see Cook (2013) and Swinton (2001).
4. For a helpful cognitive science approach to consciousness, see Kriegel (2006).
5. This has much to do with the usual conflation between "mind" and "soul." For more context on key issues surrounding the mind, soul, and theological anthropology, see Brown et al. (1998).
6. For example, Philip Clayton argues that it is likely that divine action can *only* occur in the emergent human mind, and acknowledges that his position "presupposes that human thought will not ultimately be explained in terms of physical or biological laws" (Clayton 2008, 226).
7. For a variety of defenses against the physicality of the mind (or soul), see Crisp et al. (2016).
8. See for example Green (1998).

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