PERSPECTIVES on Science and Christian Faith

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In This Theme Issue on Raising and Eating Our Food …

"The fear of the Lord
is the beginning of Wisdom."
Psalm 111:10

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Perspectives on Science and Christian Faith

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Thirty Revealing Seconds

James C. Peterson

Recently, I was standing in the return line at a home improvement store. In just thirty seconds, I experienced an example of how badly we need both science and Christian faith.

Six feet in front of me were two twenty-somethings. The line was not moving; so, in a cheerful voice and smiling eyes over my mask, I said, *"Well, looks like we are going to be here for a long time. Would it be OK if I did a quick survey?"*

> Puzzled and a bit suspicious, the gal shrugged and said, *"Sure."*

I then asked, *"Are you aware that people wear surgical masks like the one I am, to protect other people, not themselves? I know for myself that I don't like wearing a mask and it does not protect me. It is to protect you."*

> She looked me straight in the eye and said, *"Masks don't make any difference. You are either going to get the virus or not."*

Admittedly surprised, I said, *"So it is all fate? Nothing you can do?"*

> She nodded with resignation.

I looked at her friend and said as an honest question, *"You see it that way too?"*

> He said, *"You don't want to know what I think."*

"You sound like you may be angry," I calmly stated.

> *"I am."* Then, in a loud voice intended for everyone in line to hear, he said, *"I don't give a damn about anybody but me! If it doesn't help me, I'm not doing it, and you and nobody else is going to make me!"*

This was declared as a point of pride. No shame or embarrassment in it at all. At that second, an angelic cashier beckoned them to make their return.

So, in thirty seconds flat, I had a reminder that we have our work cut out for us at *PSCF*, and it matters. This is a journal about science and Christian faith. The first twenty-something had no place for science. Masks make no difference. Whatever scientists and medical care providers say about how the virus spreads is wrong, a waste of time. It spreads by fate. Everything is already determined. Science has no power to understand or intervene. Whatever happens, just happens. Give up.

I am so surrounded by scientists, it feels as if everyone knows its power. Not so.

My second conversation partner was incensed at the suggestion that anyone mattered besides himself. Yet we were standing in line. I guess he feared cameras and the law. Why else not just rush the desk and take what he wanted from the till? He was over six feet, young, strong, and the cashier looked frail and half his size.

One can make an argument from evolution that inner drives toward altruism and cooperation are widespread because they have been advantageous for passing on our genes. Stuff three hundred chimpanzees in a plane and they will tear the plane and each other apart. Most human beings just think about it. But we humans can also think about why we are sometimes altruistic and cooperative, and decide to reject that tendency. Our culture is at a point now where it is no longer shameful to think and even declare in public that no one else matters but me. I couldn't help but wonder what his girlfriend standing there next to him thought about his self-revelation.

We need science, a tool capable of so much good (and harm), in a world that can be pretty tough without it. And we need another great awakening. We are on borrowed time. People are acting better than their beliefs, but less so with each passing year. Science and Christian faith can be allies, each acknowledging that there is one reality beyond our own making. Each giving insights into different aspects of that one creation. When they overlap, we are better for listening to both. What we learn together in *Perspectives on Science and Christian Faith* is desperately needed. Read it. Think about it. Share it. Before it is too late.

James C. Peterson, *Editor-in-Chief*

Steven G. Hall

Raising Food for Thought

Steven G. Hall

Food is essential for life, but food also encompasses many ethically challenging aspects with both scientific and theological implications. This article invites further dialogue on these matters. With rising world population and wealth, the need for food is escalating. This article explores various concerns as to where food comes from, how food is distributed and processed, how food consumption may be healthy or unhealthy, and encourages consideration of a more sustainable, just, and sound food system.

Agriculture provides a fascinating and important intersection point to explore issues that have both theological and practical implications. We all eat; thus we depend on agriculture to survive. What do science and theology have to say about agriculture, food, and human flourishing? This article questions a broad overview of the food system, with focus on areas of interest and conflict to be addressed throughout this theme issue. It is also an invitation to address some of these problem areas in a deeper fashion, drawing on scientific and theological bases to provide vision to move forward toward a more sustainable food system.[1]

Food is a fundamental of life. We all eat and could benefit by learning more about how our food is raised: where it comes from; who grows it; how it is grown, treated, distributed, processed, and consumed; and what effects this may have on our health, society, and planet. Water is also fundamental to most food production. Only oxygen is more physically critical for our survival.

Despite amazing improvements in food production in the last century, hundreds of millions are still hungry, and world population continues to rise, with predictions of 9 billion or more people by 2050.[2] At the same time, extreme weather events such as droughts, floods, powerful storm systems, and temperature extremes are making sustainable food production more difficult, while biological challenges such as diseases of food crops and humans continue to hamper food production and health.

How can we produce sufficient, safe, healthy food and fiber while reducing inputs, and minimizing impacts on local and global ecosystems? Our agricultural and related systems must become more robust and adaptable in changing times. A sustainable food system should provide this food and fiber while also enhancing human flourishing, farming communities, and society in general; protecting and restoring God's creation; and moving food systems toward economic and environmental sustainability. This is a grand challenge, an opportunity to stand in the gap, a call to both prayer and humility, and an opportunity to consider what the Bible has to say about food and water, the culture of plants and animals, and how God sees humans, the earth, and his other creatures.

Biblical Background

A'dam, the man created from dust (the earth-ling) was placed in the garden to *sh'mar* and *a'bad* the garden (work and keep; cultivate and guard, Gen. 2:15, ESV; GNT).[3] So we were originally made of

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"the earth"—elements common in the earth's crust, oceans, and atmosphere (hydrogen, oxygen, nitrogen, carbon …). "For dust you are, and to dust you shall return" (Gen. 3:19b). In the interim, we have spirit in that physical "earthy" body. It is this intersection that helps define what it is to be human. In ways healthy or unhealthy, this also influences our approach to raising and preparing food. One could argue, in both "secular" history and in biblical history, that our first foods were "wild"—God provided fruit trees in the garden and we were gatherers. In our traditional understanding, humans were hunter-gatherers before developing agriculture, which itself allowed more "permanent" civilization to emerge.

In the Bible, the "people of God" were seen as primarily nomadic, living in tents (even the ark of God was kept in a tent or tabernacle). Cain and Abel, the first children of Adam and Eve, brought "nomadic" animal sacrifices and "settled" grain sacrifices; and we see tension both there and later in conflicts between the more-settled Canaanites and Philistines and the more-nomadic Israelites. Similar tensions continue today in some parts of the world and in food supply, for example, in tensions between wild caught fishers and settled aquaculture practitioners;[4] or between nomadic tribes, such as the Fulani in Nigeria, with nearby settled cultures. Thus, tensions in our food system have had and continue to have social or even spiritual aspects.

Jesus addresses and interacts with food in at least two ways:

1. Food is a real physical aspect of our human experience and Jesus enjoys it, eating "regular food" with his disciples and also with unexpected peoples and in unexpected (boundary pushing) ways or times (for example, on the Sabbath). He also uses food and agricultural images to share visions of God's transformative kingdom. He eats normal food such as bread, wine, and water, but makes it special. What makes such food special or celebratory? The night of the last supper, Jesus shared bread, a very simple food, and used it to remind his disciples of their personal and spiritual lives; after supper he poured wine, probably produced from local fruit, and said, "This cup is the new covenant in my blood, poured out for you" (Luke 22:20), comparing himself to traditional animal sacrifices. After his resurrection, he appeared to the disciples and broke bread and ate fish with them (John 21:9–13). Again, these simple foods remind us that he too became an "earthling." Some even conjecture that Jesus took his earthly body to heaven and that heaven will have "earthly" qualities. Addressing both the physical and spiritual aspects of food and agriculture is critically important. A Christian approach is thus critical to this conversation.
2. Food is not the ultimate point. Jesus initially resists Mary's request to turn water into wine, but then acquiesces and produces a very good wine (John 2:1–10). He was tempted by the devil to turn a stone into needed bread, but resisted. Even though "after fasting forty days and forty nights, he was hungry" (Matt 4:2), he replied, "Man does not live on bread alone, but on every word that comes from the mouth of God" (Matt. 4:4). Thus, a true theological discussion of food should not be constrained to purely physical aspects, but it should also consider social, ethical, and spiritual implications of the food system.

There are many unique images of food in the Bible. Starting early, God creates *ex nihilo*, an unfolding cosmos over periods of time, with the development of the heavens, the production of plants and animals on Earth, and eventually Adam and Eve, the earthlings. And God saw that it was good. Adam is given the responsibility of naming all the creatures. Surely, this accepting of God's handiwork and the naming implies a knowledge that humans should have of the other creatures. God creates the "beasts of the earth" and creatures of water and sky, and he places Adam in "dominion" over them. God blessed the animals and told Adam and Eve to "be fruitful and multiply" (Gen. 1:24–30, ESV). That we have done.

As of the early twenty-first century, human dominion has expanded, dominating even the large carnivores, fishing out the oceans,[5] toppling the great forests, and feeding more people than ever before. We have a moral obligation to allow humans to provide for themselves, but we are having a much harder time of caring for other creatures and keeping species alive. Is this our responsibility and how does this link with a responsible Christian view of agriculture? Human fruitfulness is tied to the fruitfulness of creation.

In our day we are blessed to live with the largest population the planet has ever hosted, but also challenged in how to care for creation and each other with limited resources. Agriculture uses the most

land and may be the largest total contributor to environmental degradation,[6] but Christians cannot in good conscience allow people to starve. In fact, we are called to care for "the least of these" (Matt. 25:40). How can we raise food and provide water and other basic necessities in a way that honors God and provides for the present population, but that also allows for a sustainable future for those who come after us? This too is a moral imperative, as it could be argued that the unsustainable way we are using resources is actually stealing food and water from our children and grandchildren. In this light, we should consider our place in history and some of the immense transitions that have taken place and will continue, as well as the need for Christian thought and action in these realms. But to consider these, we need to explore the where, who, why, when, and how of our food system.

Agricultural Challenges

Where does our food come from? Clearly, the land, water, human, and biological inputs to the agricultural system are essential to the enterprise and are critical considerations. The environment at large is of interest: agriculture is practiced around the world in varying ways, but always with the growth of plants and animals, and always with the need of soil or other media and water. Biblically, both soil and water have theological implications. Adam was taken from the dust, as were all other creatures—we are literally earthlings. Both practical stories, such as Boaz and Ruth harvesting and sharing in fruitfulness (Ruth 2–4), and parables, such as that of the sower, speak of "good soil" (Matt. 13:8). Yet many forms of agriculture encourage erosion of soil, reduce nutrient content in soil, and otherwise have negative effects on soil. Aldo Leopold suggested a "Land Ethic" in the last century,[7] and many of his ideas have been beneficial when put into practice, with conservation tillage, low-till or no-till practices, organic farming, and other techniques intended to conserve and enhance soil. What is good soil? How can we reduce negative effects on our soil? Are there types of agriculture that can conserve or even restore soil?

Similar things can be said of water. Water is essential for all forms of agriculture. "Soil-less" agriculture is totally dependent on water. Sometimes plants can flourish with natural rainfall, but many areas use various forms of irrigation. There are numerous challenges with water, and water problems will continue to contribute to both environmental and social stresses around the world. In the American southwest, laws are based on "riparian rights,"[8] which imply limits to water supplies. Ongoing tensions between urban users and agricultural needs are serious there, but water tensions are even more severe in other parts of the world. How are we to address these questions? How can we have a fruitful agriculture while also allowing both the natural environment and other humans sufficient water? These questions are not only local but also global in scope.

Food itself is now grown and shipped, frequently traveling thousands of miles, essentially shipping water and resources to other areas.[9] While global trade has many positives, what are the limits? Should agriculture be encouraged at a more local level? And what are the implications for the rich and the poor? Jesus said, "The poor you will always have with you" (Matt. 26:11), but he did not condemn the poor to remain poor. How are we to care for our local and global neighbors? How do agriculture and the food system play into this? Such questions have implications for food production and consumption.

In Genesis 2:15, NRSV, Adam is told to till and keep the garden of Eden. We are instructed not only to take an active role (the tillage interpretation), but also to "keep" or "protect," implying that we are not to destroy entire species or ecosystems. In Exodus, food was provided in the desert in the form of manna, and later, birds sacrificed themselves, but the Israelites in both cases were instructed not to "store up" too much but to trust God to provide. This contrasts with Joseph's exploits in storing up during good years (Genesis 41), and other instructions which allow for a "Sabbath for the land" (Lev. 25:2–4), but we are told that the land will still provide (there does appear to be some allowance for storage) and the "tillers" are to become something closer to hunter/gatherers during these "rest" times. Also in Leviticus, we are told *not* to harvest grain to the edge of the field but to leave some for gleaners (Lev. 23:22). This directive is not very "efficient" by modern standards, but it does have a strong social aspect, both providing for the poor and allowing the poor to work for their food. This idea of differentiation of labor and of some kind of social net, which still allows active participation, appears to be a template for a modern version of sustainable agriculture.

What should be the working conditions for agricultural laborers? Agriculture is and has been hard work. After the Fall, Adam was told that he would work "by the sweat of his brow" (Gen. 3:19). Are there ways to reduce the labor demands of agriculture? Is it good physically and spiritually to work? What are the implications for transient laborers? Are there biblical examples? Boaz greeted his workers and they greeted him back (Ruth 2:4). How could fair treatment of laborers and mutual respect be instilled in the modern context? Whom or what else should we treat well? Surely, water, air, and land must be cared for better than we are currently doing.

Many specific challenges have been noted, including unsustainable use of fresh water (rivers dammed, aquifers and waters dramatically reduced, geographic tensions over water); degradation and erosion of arable land; eutrophication of water bodies, including oceanic waters by excess nutrient runoff; excess use of fossil fuel in food production and thus air pollution and carbon dioxide changes in the atmosphere.[10] It is now recognized that atmospheric changes are leading to various other events, including more-extreme tropical storms, melting of glaciers and polar ice, rising sea levels, and changes in precipitation. Clearly, each of these could ultimately result in significant harm for agriculture and civilization itself.

What does modern science have to say about these questions? Are there fundamental limits to resource use or to biology? Have we reached or exceeded some limits? What are other ways we might provide for people's caloric needs while still allowing other species to flourish? Are there ways we can minimize degradation of the environment as we pursue agricultural goals? Are there methods by which we can help restore habitats and species while also providing sufficient food for humans?[11] How and why might we pursue these methods? What are the physical or spiritual reasons why we might not pursue them?

Land Use and Practices

How do we farm, and who does the farming? This varies dramatically around the globe. In Africa, most growing of crops is done by women. Water is often carried by women and children. In America, the image of a strong male farmer is often presented, although the actual participants in agriculture are quite diverse. What is the relationship between owners of land and workers on the land? Can land be "owned" in the biblical sense? The psalmist tells us, "The Earth is the Lord's, and everything in it" (Ps. 24:1). Some societies have practiced various forms of communal land ownership, while others have allowed individuals to claim rights to land. What are the advantages and disadvantages of each approach? The US, in practice, has a mixed approach, with substantial amounts of land owned by private individuals or families, companies, and industries such as timber, paper, and integrated farming operations; in addition, massive tracts of land are managed by state and federal government entities such as the Bureau of Land Management that leases land for timber harvest, grazing, and other activities.[12] Some moderately large areas are owned or managed by nongovernmental organizations (NGOs), including environmental and church groups. Is there a "best" or "biblical" approach? The Bible speaks of long-term ownership, with concepts such as Sabbath rest for the land once every seven years, and Jubilee every fifty years—at which time the land reverts to a more distributed ownership model.

How should we treat the land? What do we plant? A very limited number of crops, and a limited biological diversity of these crops, is now planted.[13] The implication is that high yields of "selected" crops are expected. Chickens grow bigger and faster, cows give over 100 pounds of milk per day, and yields of corn and soybeans are higher than ever. However, this is a precarious system in which a disease or other disaster can decimate large areas of crops. Should we care about "heirloom" varieties of vegetables, fruit trees, or other crops? The US government has developed several National Germplasm Repositories (for plants in New York State and for animals in Colorado) to "save," often in the form of seeds or sperm, genetic diversity.[14] Should our farming systems preserve living strains of more diverse organisms? How should this be funded or managed?

What do we add to the land? Plants tend to remove nutrients, requiring additional applications of fertilizers, either natural such as manure and compost or artificial such as phosphorus or nitrogen, often at a cost both in the process of mining or manufacturing and in loss from excess. The hypoxic zone in the Gulf of Mexico[15] and similar eutrophic areas elsewhere, such as Lake Erie (freshwater) or red tide areas

(marine/estuarine saltwater), are the result of nutrients that run off and encourage the growth of algae and bacteria; these can reduce oxygen in the water column, often killing other species. These are relatively benign chemicals, generally helpful in plant growth.

What damage is created by the more-toxic chemicals that we add to the environment? Synthetic pesticides and herbicides, antibiotics administered to animals, and other chemicals have left a mark. DDT famously killed insects but also affected the health of animals such as predatory birds, almost driving the national symbol of the US, the bald eagle, to extinction. DDT inspired Rachel Carson's *Silent Spring*[16] and ushered in laws in the 1960s and 1970s that helped protect the environment in the US. Internationally, many toxic chemicals are still used. More recently, the herbicide glyphosate has been used extensively on "roundup ready" crops, in concert with "genetically modified" (GM) crops.

Genetically modified organisms (GMOs) or GM crops are generally animals or plants whose DNAs have been modified using genetic engineering techniques. This may involve inserting or deleting genetic information to change the organism. These traits may be taken from other plants, animals, or microorganisms. There are currently ten GM crop species, including corn, cotton, and soy. In the US, more than 75% of the crop land used to cultivate these species is now GM.[17] GM crops may be more drought tolerant or resistant to disease organisms, potentially reducing inputs, including water, fertilizer, and energy. In some cases, GM crops may be resistant to herbicides, thus encouraging heavier use of those herbicides in a tension with reduced tillage and erosion, since land does not need to be cultivated as much to reduce weeds. In the US, a very high percentage of plant crops are now GM crops (94% of the corn cultivation areas since 2014 grow GM corn varieties),[18] and many other parts of the world are growing them. Some researchers note that adding these traits can reduce the need for expensive pesticides and may result in enhanced yields. Others argue that, in many cases, these create new challenges, such as excess use of certain chemicals that "match" the GM traits (for example, herbicide-resistant crops). Still others worry about the effects of current or future chemicals on both the environment and human health. Some chemicals seem relatively benign, but their degradation products may have unexpected harmful results. This could include various medical and pharmaceutical products that may end up in water systems and affect wildlife and humans.

Technological Problems

Our technological innovations can cause unintended consequences. Items from our consumptive lifestyle that we do not always think of as affecting food or ecologies can range from fuels to components to transportation to industrial systems to packaging. Microplastics are now seen as cause for concern in many ecological and agricultural systems. These may come from textiles, packaging, or consumer goods that end up in water, soil, and almost certainly, in food.

What are we to think about new technologies—biological, chemical, or otherwise? Do we "play God" too much? How much intervention in the natural system is helpful? Are there limits? It could be argued that agriculture itself is a technological innovation, and is a part of the conditions that have allowed high human densities in the first place. The plow, fossil-fueled farm equipment, artificial fertilizers, genetically modified organisms (GMOs) as food, pesticides, and antibiotics are each a technological advance that can enhance food growth, but each also has potentially damaging side effects. The dust bowl and, more recently, desertification in the Mediterranean Basin and other areas, were partially the result of excess soil tillage. Fossil fuels have increased CO_2 in the atmosphere, contributing to climate change. Too much fertilizer has led to eutrophication in both fresh and ocean waters: for example, consider the hypoxic zone in the Gulf of Mexico.[19] GMOs are a much broader description of many kinds of plants and animals whose genetic editing has been much faster than the genetic selection used since biblical times, but at a much slower rate of selection. These "new technologies" raise questions, as do other methods of agriculture that may affect the surrounding environment or genetics. Pesticides can kill selected pests but they may have unintended consequences, and while antibiotics kill microbes, they may thus select for resistant bacteria or weeds. Is selection of genetic traits by traditional or GM technologies a good thing, leading to better producers that are possibly resistant to temperature extremes or biological impacts, or is selection encouraging excess use of antibiotics or pesticides a bad thing?

Other technologies are more physical, traditionally including tractors and other implements, but more recently including electronic and geographic information systems. Automation and robotics is another area of both interest and controversy. Automation is increasing with artificial intelligence, automated tractor and processing systems, remote sensing to identify problems in fields early, and, on the horizon, even larger, more automated farming systems,[20] ultimately reducing the contact between humans and the land even further. Is this a good thing?

Moral Considerations

Can thoughtful approaches to automation enhance our understanding of the land, reducing environmental impact while improving yield? Are there moral imperatives in the Bible or Christian thought that apply here? As God sent Adam and Eve from the garden, he said that humans would work "by the sweat of your brow" (Gen. 3:19). The Puritans, Amish, and other Christian groups have seen work as something good for both the human body and soul. Can an approach such as co-robotics in which robots enable humans to be involved and make "high-level" control decisions, possibly enhance our connections with the land? Could virtual farm tours help educate the general public?

Moral treatment of animals in agriculture has some basis in the Bible. The Mosaic law places limits on working animals (Exod. 20:10). Jesus asks a hypothetical question that assumes helping an animal, in his response to a theological question about the Sabbath (Luke 14:5). He suggests that it is normal and good to treat animals well. "Animal rights," by contrast, is fairly modern terminology,[21] but the Bible does address the requirement for moral treatment of working and food animals. As animal agriculture has become more concentrated, with "feedlots" and confined animal feeding operations (CAFOs), a number of physical as well as moral issues have been raised.[22] The excess concentration of nutrients is one challenge, and the actual treatment of the animals is another. What is acceptable treatment of animals in agriculture? Should Christians seek to treat animals better than the usual "minimum acceptable" level? Are there technologies that can reduce reliance on animals or enhance animal welfare? Will we move to a primarily or totally vegetarian food system?

Thus, there are moral aspects to biotechnology, animal agriculture, food technology, and related practices. Each possible technology or practice has benefits, but also possibly dangerous side effects, both direct and indirect. Is there a moral or even a "Christian" way of vetting such technologies and practices? Could we learn from groups such as the Amish, who abstain from many technologies but do have a technique for vetting new technologies, and are more likely to adopt new technologies "partially," rather than "full scale," such as the use of electricity in barns but not in houses? Is there a logical and moral approach to these questions?

Jesus speaks in metaphorical and physical terms about food and water, animals, and even the technologies of the day, often placing himself in the story. At the beginning of his ministry, Jesus is tempted by the devil. After forty days of fasting, Jesus was hungry. The devil urges him to "tell these stones to become bread" (Matt. 4:3). Interestingly, given that Jesus not only turns water into wine but also heals and raises people from the dead, he would have been able to do this, but he declines. This is instructive for our modern world: just because we can, does not mean we should. By extension, one should be careful as to why one is "playing God": is it for good purposes or for sinful reasons, including pride, fear, and greed? Jesus, instead, replies, "Man shall not live on bread alone, but on every word that comes from the mouth of God" (Matt. 4:4, citing Deut. 8:3).

Jesus's next temptation was to take a risk: "throw yourself from the pinnacle of the temple." Again, this is something he could have done, and the devil even tempts him by citing scripture, "He will command his angels concerning you to guard you carefully; they will lift you up in their hands, so that you will not strike your foot against a stone" (Luke 4:10–11, citing Ps. 91:11–12). Jesus's response is parallel to the first, and equally useful in our current context: "Do not put the Lord your God to the test" (Luke 4:12, citing Deut. 6:16). This has a secular parallel called the "precautionary principle."[23] Interestingly, this environmental principle has health-related implications, which are often linked to environmental chemicals or risks.[24] This, of course, is among the limits of human existence: we are not God, and we do not know all. We would be wise to follow a kind of biblical "precautionary principle" and "not test

the Lord." The theology and science behind this is complex and invites further discussion and writing. It also leads us humbly back to Jesus, whom Christians acknowledge as "my Lord and my God" (John 20:28), and it guides us to observe his actions and words with regard to the environment, people, and human flourishing.

Human flourishing as well as the flourishing of God's good creation are both objectives that seem consistent with a Christian worldview. This leads to issues of food safety and food security.[25] How is food distributed and processed? What techniques for distributing food globally are feeding people in need with excess from other areas or are diversifying the diet to enhance human health? What are the food safety issues involving disease or pesticide residue? How good is food security in our current system?

Food Processing

Food processing has historically been a way of preserving food. Drying and salting were two ancient techniques. Grain was harvested, dried, and stored. Meat was often salted or smoked. In the last century, a number of additional techniques have been developed to process and preserve food, while a very large number of techniques have been used to enhance value.[26] Many of these techniques, such as refrigeration and processing to separate out valuable products, have been helpful, but many have also led to concerns in the realm of food safety.

Food processing can help provide sufficient quantities of food during times of low food availability, and keep food safe by reducing microbial spoilage. However, modern food has often been processed to the point at which many native antioxidants and other healthy components have been removed, leaving empty calories. We enjoy sugary drinks and processed salty snacks, but they make us fatter and less healthy. Many of these foods also have substantial loadings of food preservatives that allow products to sit on shelves longer, but that also degrade their healthy aspects. Should the food processing industry be involved not only in food microbial safety, but also in food quality for better nutrition? Are there techniques in processing food that can keep nutrients in, while also providing food safety? Are we too married to "convenient" food, fast food, and rich food? Are we addicted to unhealthy foods?

Food Consumption

How is food consumed? The health effects of food are significant. Food is God's way of providing for us, and sharing it is a blessing. However, there may be types of food or ways of consuming food that can be harmful. Obviously, food that is laden with unwanted chemicals, or which contains toxins such as botulism from natural processes, can be a problem. In the twenty-first century, the form and amount of food consumed may constitute the biggest harm. Specifically, more food is available in processed forms which likely exclude many needed nutrients; this leads to sufficient calories, but the food is deficient in micronutrients, antioxidants, and other food components that are present in more-raw forms of food. In other cases, salts and flavor compounds are provided at excessively high levels in processed foods, leading to other health problems such as high blood pressure due to excess sodium.

Is it the fault of the food growers that individuals may choose to eat cereals made largely of processed grains and sugars, or choose to eat excess calories, salt, or fats? While individuals make choices, it is clear that many in the US, and now many in other developed and developing countries, consume excess calories and have significant health concerns related to these excess calories—calories from nutrient-deficient food and beverages. Is there a biblical approach to food consumption that could help reduce these man-made results of bad producing? While there are still hundreds of millions hungry people,[27] more people are being fed more calories than ever before, but not with uniform enhancements to health. How can we move toward healthier approaches to food, enjoying the fruitfulness God has provided while not exceeding the limits of the land or the human body, and, indeed, treating the body as "the temple of the Holy Spirit" (1 Cor. 6:19)? Biblically, we are called to "fasting and prayer" (1 Cor. 7:5, NKJV). Is fasting also a healthy practice for the body and soul? Could limited fasting have positive effects on our views and practices in the food system?

How we treat ourselves may be linked to how we treat the land and other people and creatures. For example, both per capita and total consumption of animal products have risen in recent decades. Chicken, pork, and fish are at all-time record levels of consumption. Beef consumption has not increased in recent years, but it still accounts for a substantial

stress on the planet. Feed conversion ratios (FCRs) of these animals mean that raising animals, in most cases, is less efficient and uses more resources than eating primarily plant-based products. For example, cows require about 25 kg of feed to produce one kg of meat; pork, about 5 kg; poultry, 2–3 kg; whereas eggs, milk, and fish are generally more efficient.[28]

Interestingly, the books of Genesis and Daniel both seem to suggest that a vegetarian diet can be a godly diet. On the other hand, Jesus ate fish and Peter was told to eat what the Gentiles eat (Acts 10:13), including many kinds of animals. The early Christians who came from non-Jewish backgrounds or lived in these communities were instructed to "abstain from food sacrificed to idols, and from blood" (Acts 15:29, ESV). This teaching leaves the door open to eat with and fellowship with a wide variety of individuals, reflecting the inclusive nature of the worldwide Christian community. This is also instructive for our interactions with others.

Food as a Social and Spiritual Principle

We should be understanding of individual choices, while acknowledging Christian freedom in the realm of food, beverages, and diet. Jesus too links food with social and spiritual action, often using images of food and beverages. His first miracle recorded in John was at the urging of his mother: he turned water into wine at a wedding. This provision was not only a necessity but a celebration as well. Jesus does celebration food. In fact, on further consideration, almost all of Jesus's food-related stories and miracles have a celebration aspect, while many of them also earnestly seek to share provision at both a basic and a much deeper level. He famously shared meals both with "good" people and with "tax collectors and prostitutes." Here the focus was not on the food but on the social aspects of food, often with a sense of sharing. He did talk about himself as both food and drink: "I am the bread of life. Whoever comes to me will never go hungry, and whoever believes in me will never be thirsty" (John 6:35).

Jesus modeled and encouraged transformations. How would Jesus suggest we transform from twisted to redeemed ways of relating to food, not selfish but selfless? The Bible speaks to healthy and unhealthy ways to enjoy and share food. There are numerous examples of both in the Old and New Testaments. Excess consumption of wine led to drunkenness and other immoral behavior. Gluttony, the excess consumption of food as well as drink, is understood as a moral failure in the New Testament. However, celebration with food and drink appears not just acceptable but even central to biblical community. For example, the biblical tithe (Lev. 27:30–33) included a portion of food produced, offered to the Lord. It was to be eaten in community at the temple (Deut. 12:18). There was also a tithe intended for the foreigner, the fatherless, and the widow (Deut. 26:12) who would eat in community with the people of God in a kind of celebration. In fact, food in the Bible is frequently protrayed as having special meaning: feast days, sacrifice of special plants or animals, and many examples from Jesus's life, including his ultimate sacrifice, the substitution of himself. In 1 Corinthians 11:23–26, he speaks of his body and blood as not just physical, but also spiritual, and parallels this with food items (bread and wine).

Many types of food are mentioned in the Bible, including wine (Ezra 6:9; numerous times in the New Testament), olive oil (Deut. 8:8), bread (in both the Old and New Testaments), honey (Exod. 33:3; Judg. 14:8–9), eggs (Job 6:6, NKJV; Luke 11:12), grape juice (Num. 6:3), vinegar (Ruth 2:14; John 19:29), and vegetables (Dan. 1:12). "Plants are good" (Gen. 1:11–12, 29–30; Dan. 1:12–16; Rev. 22:2) may even be considered a biblical food principle; and, by extension, a plant-based diet, low on the trophic order, may be a wise diet. Plant-based foods appear to be good for health. Modern medicine more and more is confirming this. While a modest amount of protein is a good thing for health, many of our modern illnesses may be exacerbated by excess consumption of meat, especially processed red meat.[29] This is an area in which modern science and ancient scripture largely agree, and further detail could be added to this area to enrich our understanding of both science and theology.

Food Security While Minimizing Damage to the Ecosystem

Considering ways to minimize damage to the ecosystem while providing healthy food for humans is important in this era of fossil fuel, growing populations, and more-consumptive attitudes. We also need to wisely use wastes that are often nutrients in the wrong places, possibly to grow healthy and valu-

able plants, algae, or other green products. Moving down the trophic levels, to a more plant-based diet for people and food animals, can be both environmentally beneficial and healthier. Since plants in general are more efficient at producing food calories, this could be a wise way to increase food production harmlessly.

Demographic trends suggest that, over the next few decades, overall demand for food will rise, dramatically in some areas: The Food and Agriculture Organization of the United Nations (FAO) projections are that there will be 2–3 billion additional people in the next thirty years.[30] In addition, as people in developing countries gain wealth, they tend to eat "richer" animal-based foods, so, at this point, it appears that more food must be produced. Two fundamental approaches, or a combination of them, will likely be needed. One is to be more efficient with our land, growing more crops on less land, possibly by more inputs such as fertilizer, chemicals, and water or more-efficient use of inputs or technology. A second approach is to alter our consumption, reducing instead of increasing meat consumption, especially in the middle class and wealthy areas of the world. A more plant-based diet might be healthier in many developed areas, and it would allow us to feed more people. Paired with this might be considering ways to reduce environmental damage from distribution, packaging, and other aspects of the overall food system. The protein we do use could include more-efficient protein, such as milk, eggs, and fish.

This brings up another area of interest, namely, aquaculture: the culture of fish, shellfish, and seaweed in water. Some authors suggest that aquaculture may do damage or at least not improve wild fisheries as much as had been hoped.[31] However, with aquaculture now producing more seafood than the total of wild fisheries in our stressed oceans, we may have to go forward with more-sustainable aquaculture.[32] How do we develop an even more productive aquaculture (possibly largely in coastal or oceanic waters), while minimizing or even reversing damage to bodies of water and to the coast?

Did Jesus favor fish? Interestingly, Jesus rarely is seen eating meat. Perhaps this simply showed the food availability of the day. Bread was a basic staple; water or wine were basic beverages. He did cook fish, and there are other images of aquatic foods. Does this reflect on our overfishing of wild fish stocks? Should we abandon aquaculture because we have damaged our oceans? Or should we do more (but more-sustainable) aquaculture to take some pressure off wild fish stocks? While fish is an animal protein, it is arguably one of the most efficient animal proteins. Fish have excellent feed conversion ratios, partially because fish do not have to grow large supportive skeletons: they are supported by the water. Can alternative food sources such as aquaculture help take pressure off other land and water resources, or will we simply continue to damage the waters further?

Human Flourishing

Whether foods of the future include more plants, animals, or aquatic products, there is another question to consider: What is human flourishing? Our ultimate goal is to have healthy people living in communities on a healthy planet where focus on the spiritual life is integrated into our lives. Can a consumer culture allow for true human flourishing, or must we encourage a new kind of lifestyle that is more service oriented, caring for other humans, and providing for wild creatures? A biblical lifestyle is characterized by serving. How then do we explain the current seeming antipathy between many conservative Christians and conservation? What parts of agreeing or disagreeing with current leaders are prophetic and where are we deceiving ourselves?

Prophets such as Daniel acted out and followed tenets of the faith despite persecution as they witnessed not only to their fellow believers but also to their captors. Daniel actually put less, not more strain on the food system of his day by refusing meat and wine in favor of plant foods. Whether powerful or powerless by earthly standards, our conduct can be influential. Daniel was a healthy young man who showed "aptitude for every kind of learning, [was] well informed, quick to understand …" (Dan. 1:4), and who was selected to be trained to be a cross-cultural leader. He was provided with rich food, including meat and alcohol. He declined these, resolving "not to defile himself" and went lower on the trophic level to a plant-based diet, "nothing but vegetables to eat and water to drink" (Dan. 1:12). He "looked healthier and better nourished" (Dan. 1:15) than others. This too is a hint and a reflection back to Genesis where God gives you "every seed-bearing plant on the face of the whole earth and every tree that has fruit with seed in it. They will be yours for

food" (Gen. 1:29). These biblical precedents suggest that our agriculture and food choices can have either negative or positive influences on the world and on our health.

Proposals to Minimize Environmental Damage

What are the benefits that agriculture does or could have on the land, water, and air? How can we minimize environmental changes caused by agriculture and food? Excess nutrients pollute downstream water bodies, excess chemicals kill other creatures, and excess consumption puts our very health and lives at risk. At the same time, modern agriculture has allowed the largest human population the earth has known. More people are able to hear the good news of Jesus than ever before. Is this system sustainable? If not, what limits on chemistry and biology are appropriate? How should biblical ethical concerns be considered in the food system?

There are those who argue that eating animals that can convert feed that humans cannot consume, such as grass, trees, and saltwater algae, is a way of harvesting human food without excessively changing the environment. One could argue that some of these cultivation activities are a kind of agriculture that is actually closer to wild food harvest, a kind of cultured hunter-gatherer approach. There are, in fact, a number of agricultural activities of this sort, including various permaculture and tree or bush types of cultivation that we see in cranberries, nuts, and fruit trees, as well as some types of animal husbandry among nomads or range-type cultivation of grazing cows or goats. Other examples include some unique hybrid wild-cultivation techniques such as the biculture of rice and crayfish (~200,000 acres cultivated in Louisiana[33]), which encourages wild crayfish to harvest the standing biomass of the rice after harvest, producing a crayfish crop harvested by traps and providing a diversified income over a longer period of the year. This practice is enabling a native species to flourish, while providing a stable income. This might be considered "extensive" or low-intensity agriculture or aquaculture.

By contrast, some argue for "highly intensive" agriculture to focus the consequences of agriculture on smaller surface areas of the planet. Specifically, some argue for very intensive agriculture on lands that are extremely fertile, allowing less-fertile or optimal land to be held or restored to a wild state. The regrowth of forests on former marginal agricultural lands has been cited as having a positive effect by sequestering carbon in forests growing back on otherwise marginal lands.[34] Large swaths of undisturbed habitat may allow conservation of flora and fauna, and some charismatic megafauna may, in fact, require large and wild areas of habitat. Again, how can we care for and protect the biodiversity of God's creation while still providing for human flourishing?

There may be danger in focusing solely on extremely intensive agriculture. The Bible suggests that absolute harvest quantity is not the objective. It is said that the "land shall have rest," but also that the "beasts of the field" will be able to graze on the excess; the plants that grow during the Sabbath year, perhaps including legumes or other nitrogen-fixing plants, will be your food (Lev. 25:2–7). In Ezekiel 34:18, the prophet warns against abusing the environment: "Is it not enough … must you also muddy the rest" in reference to not caring for the land. God's response through John's vision includes this warning: God will destroy "those who destroy the earth" (Rev. 11:18). The underlying sins in both the Old and New Testaments appear to be greed and violence, still common in our day. Conflicts abound, but scientists and theologians of good will must consider these challenges to our food system, and seek a vision for a more sustainable future.

A Faith-Based Approach to Sustainability

How can we move toward a more sustainable food system? Does the Bible give advice on how to treat the land, other creatures, and each other? How can we use this to enhance our food system and lives? Are there ways to consider eternity as we thank God for our food? Are there ways in which we could manage, sustain, or even restore land, the environment, human lives, and the overall food system?

While much focus has rightfully been placed on reducing environmental damage while still producing food, a faith-based approach will seek a way that others do not see. Could we go beyond just reducing ill effects, and actively work on restoration of degraded lands, perhaps by reducing agricultural damage, but possibly by a dramatic reconsideration of agriculture itself? Could we move from management or conservation to restoration? Is this not what

Jesus does with us? He finds us in a degraded state, accepts us as we are, but then guides us toward holiness, cleanness, joy, and fruitfulness. Can we move from an exploitative approach to the land to a view of wise use and stewardship? What will this take in terms of attitude, technology, and even a philosophical or spiritual approach? Are there already examples, and could these examples be expanded or used in other contexts?

A biblical approach to food means we need to go beyond just reducing damage to our ecosystems to actually restoring them. Our food system could be part of this process. Perennial plants and trees could be harvested, while minimizing changes to the soil. Some of these plants may be native to their respective locations and could enhance the environment. In coastal waters, growth of shellfish could protect valuable coastal land while, at the same time, growing food for us. Since most shellfish are filter feeders, this process could clean coastal waters. With some creativity, what other agricultural techniques could enhance the environment, mimic natural systems, and possibly even restore local and global ecosystems?

Are there current examples of agriculture that "cultivate and guard" (Gen. 2:15, GNT)? In what ways or places are Christian values and Christian persons encouraging conservation, restoration, and care for creation? This article and this journal can help to share these stories, documenting both the biophysical and the human spiritual aspects of these efforts. Alternatively, are there non-Christian approaches that demonstrate truly excellent stewardship? Can and should Christians work together with these groups, and what limits are there to such partnerships? Perhaps even more challenging are partnerships between different strains of Christianity. Can those Christians who focus on telling about Jesus, partner with more-service-oriented groups, and are there ways to coexist and even work together to share God's word and God's love in real and tangible ways?

In summary, food and water are essential for life. Agriculture ostensibly has the largest effect on Earth's land area and some of the largest net effects on the planet. Yet it does not seem moral to allow people to starve. Are there techniques or approaches that can enhance sustainability, while still producing healthy food? How are the environment and human health linked? How much of the food system is food, and how much is distribution, packaging, processing, and other often-harmful aspects? How do we approach new technologies? And, as we look toward Christ's eventual return and see images of "the river of the water of life …" and "… leaves for the healing of the nations" (Rev. 22:1–2), how can we imitate God's agriculture, enjoy "edible landscapes," exercise restorative agriculture and aquaculture, and, in all things, demonstrate dominion over God's good creation with a grace-filled approach to agriculture, working in harmony and allowing for fruitfulness of both humans and other creatures? ◙

Notes

[1]Dorothy Boorse, "New Findings in Environmental Science and Their Implications for Christians," *Perspectives on Science and Christian Faith* 66, no. 4 (2014): 194–202. Boorse reviewed a number of environmental issues, some related to food production, including fisheries, population growth, irrigation, antibiotic resistance, "playing God," water stresses in agriculture, climate change, soil health, and heavy metals.

[2]The Food and Agriculture Organization of the United Nations (www.fao.org) tracks demographic, food production, and related information and projections. "The Future of Food and Agriculture: Trends and Challenges," published in Rome, 2017, is available at http://www.fao.org/3/a-i6583e.pdf. This publication notes "world population is expected to grow to almost 10 billion by 2050." Their "medium" prediction is 9.7 billion in 2050. They also note that "income growth in low- and middle-income countries would hasten a dietary transition towards higher consumption of meat … requiring commensurate shifts in output and adding pressure on natural resources" (p. x).

[3]All references are taken from the New International Version unless otherwise noted. ESV is the English Standard Version; GNT is the Good News Translation; NRSV is the New Revised Standard Version; and NKJV is the New King James Version.

[4]Trond Bjørndal and Jordi Guillen, "Market Competition between Farmed and Wild Fish: A Literature Survey," Food and Agriculture Organization of the United Nations, FAO Fisheries and Aquaculture Center, Rome, 2016, http://www.fao.org/3/a-i5700e.pdf.

[5]Rosamond L. Naylor et al., "Effect of Aquaculture on World Fish Supplies," *Nature* 405 (June 2000): 1017–24. This article warned against excess "appropriation of net aquatic primary production"—using small wild fish to feed to aquaculture, thus potentially damaging wild fish stocks. This article encouraged reducing the use of fish to feed aquacultured fish by using algae, plant materials, or other byproducts to encourage environmentally sound aquaculture and to allow natural fish stocks to recover. This article also noted the "increasing scarcity of freshwater resources," hinting at future expansion of marine (ocean/coastal) aquaculture.

[6]David Tilman, "Global Environmental Impacts of Agricultural Expansion: The Need for Sustainable and Efficient Practices," *PNAS* 96, no. 11 (1999): 5995–6000. This article notes not only that agriculture already has massive

consequences, but also that intensification of agriculture is expected to increase those effects unless substantial improvements in technique are made.

[7]Aldo Leopold, *A Sand County Almanac* (New York: Oxford University Press, 1949). Leopold used a series of nonfiction chapters to present the concept of a Land Ethic, a kind of contract or relationship between humans and the land. This has been influential in environmental theory and practice.

[8]Brett A. Boisjolie et al., "Legal Ecotones: A Comparative Analysis of Riparian Policy Protection in the Oregon Coast Range, USA," *Journal of Environmental Management* 197 (2017): 206–20.

[9]Christopher Weber and H. Scott Matthews, "Food-Miles and the Relative Climate Impacts of Food Choices in the United States," *Environmental Science and Technology* 42, no. 10 (2008): 3508–13. This article claims 1640 km delivery distance for food in the US, but also notes additional impacts of the food system, with a focus on greenhouse gas emissions.

[10]Boorse, "New Findings in Environmental Science," addresses a number of environmental problems that overlap with agricultural practices and production, pp. 195–200.

[11]Alex Saturday, "Restoration of Degraded Agricultural Land: A Review," *Journal of Environment and Health Science* 4, no. 2 (2018): 44–51. This review article addresses a number of problems concerning the loss of agricultural land due to unsustainable practices. These are diverse, but include salinity issues, fertility loss, and erosion. Consideration of techniques for reducing these harmful effects, while still farming, and ways to restore land that is no longer productive, are discussed. While this article does not explicitly address Christian morals, it would appear that these techniques and approaches could be considered within a biblical context.

[12]Bureau of Land Management General Land Office Records (https://glorecords.blm.gov/) includes many documents related to BLM and government land ownership, primarily in the western parts of the US.

[13]Gero Benckiser and Sylvia Schnell, eds., *Biodiversity in Agricultural Production Systems* (Boca Raton, FL: CRC Press, 2007). This book discusses soil and plant biodiversity, and a number of techniques used to address genetic problems in agriculture.

[14]The National Animal Germplasm Program (NAGP), https://nrrc.ars.usda.gov/A-GRIN/main_webpage_dev/ars?record_source=US, is run by the United States Department of Agriculture (USDA), and has objectives to "develop and expand a scientifically based germplasm and DNA/tissue collection" … "develop methods for population regeneration," and "improve cryopreservation methods." The National Plant Germplasm System (NPGS) "acquires, conserves, evaluates, documents, and distributes crop germplasm." Both the NAGP and the NPGS are funded by USDA; they acknowledge that "intensification (of agriculture) has relied heavily on producing crops with increasing genetic uniformity," https://data.nal.usda.gov/dataset/national-plant-germplasm-system.

[15]Mary Caperton Morton, "Gulf Dead Zone Looms Large in 2019," *Eos*: *Science News by AGU* (July 11, 2019), https://eos.org/articles/gulf-dead-zone-looms-large-in-2019, notes that "a new forecast predicts widespread hypoxia after a wet Midwest spring." This article defines the hypoxic zone as having oxygen levels of less than 2 parts per million, and is predicted to be over 22,000 square kilometers in 2019. The so called "dead zone" reduces survival of aquatic life and is driven significantly by fertilizer runoff of nitrogen and phosphorus.

[16]Rachel Carson, *Silent Spring* (New York: Houghton Mifflin, 1962). This classic book, written by the late Rachel Carson, focused on addressing now-confirmed disastrous results involving widespread chemical use, including the pesticide DDT that was later banned. This book was influential in both agricultural and environmental fields.

[17]USDA ARS, "Recent Trends in Genetically Engineered Crop Adoption," summarizes data from 1996–2018, showing that soy, cotton, and corn are each planted on very high acreages, and it explains more about the specific traits that are most common in genetically engineered crops, https://www.ers.usda.gov/data-products/adoption-of-genetically-engineered-crops-in-the-us/recent-trends-in-ge-adoption.aspx.

[18]Ibid.

[19]Nancy N. Rabalais et al., "Global Change and Eutrophication of Coastal Waters," *ICES Journal of Marine Science* 66, no. 7 (2009): 1528–37. This article addresses both "local" Gulf of Mexico eutrophication and the hypoxic or "dead zone," as well as implications for worldwide eutrophication driven by both agricultural and other impacts. They argue that "nutrient loadings to coastal waters need to be reduced now, so that further water quality degradation is prevented."

[20]Wouter H. Maes and Kathy Steppe, "Perspectives for Remote Sensing with Unmanned Aerial Vehicles in Precision Agriculture," *Trends in Plant Science* 24, no. 2 (2019): 152–64. This article discusses use of UAVs to assess and manage agricultural issues, including drought stress (and irrigation), pathogen detection, weed detection, and nutrient status (and fertilization).

[21]Peter Singer is well known for his sometimes controversial philosophical views, espoused in books such as *The Ethics of What We Eat: Why Our Food Choices Matter,* with Jim Mason (Emmaus, PA: Rodale Press, 2007), which addresses a number of ethical issues in the food system; and *Animal Liberation: The Definitive Classic of the Animal Movement,* rev. ed. (New York: HarperCollins, 2009), which specifically addresses morality in the production of food animals. Singer says he and his wife gave up eating meat in 1971.

[22]Dana Cole, Lori Todd, and Steve Wing, "Concentrated Swine Feeding Operations and Public Health: A Review of Occupational and Community Health Effects," *Environmental Health Perspectives* 108, no. 8 (2000): 685–99, reviews over 250 previous studies, providing a broad context for confined animal feeding operations (CAFOs) and considers animal and human health perspectives.

[23]David Kriebel et al., "The Precautionary Principle in Environmental Science," *Environmental Health Perspectives* 109, no. 9 (2001): 871–76. This article is written from a scientific perspective and acknowledges a number of ethical concerns in environmental areas, including implications for agriculture.

[24]Joel D. Kaufman and Cynthia L. Curl, "Environmental Health Sciences in a Translational Research Framework: More Than Benches and Bedsides," *Environmental Health Perspectives* 127, no. 4 (2019): 045001, https://ehp.niehs.nih.gov/doi/10.1289/EHP4067. This article acknowledges that health practice may have more complexity, including elements of human care and communication, as well as ethical and policy implications.

[25]Food security, as defined by the United Nations' Committee on World Food Security, means that all people, at all times, have physical, social, and economic access to sufficient, safe, and nutritious food that meets their food preferences and dietary needs for an active and healthy life. International Food Policy Research Institute, https://www.ifpri.org/topic/food-security.

[26]Xin-li Ran et al., "Novel Technologies Applied for Recovery and Value Addition of High Value Compounds from Plant Byproducts: A Review," *Critical Reviews in Food Science and Nutrition* 59, no. 3 (2017): 450–61. This article reviews a number of other studies on value added technologies, and acknowledges both difficulties and opportunities in food storage and quality.

[27]Food and Agriculture Organization of the United Nations, "Hunger and Food Insecurity," accessed at http://www.fao.org/hunger/en/, estimates 820 million undernourished people in 2017, estimated at 10.7% of world population. This site clarifies terms and how these estimates were made.

[28]Alon Shepon et al., "Energy and Protein Feed-to-Food Conversion Efficiencies in the US and Potential Food Security Gains from Dietary Changes," *Environmental Research Letters* 11, no. 10 (2016): 105002. This article estimates "efficiency" for a variety of animal protein sources, finding eggs and dairy the best at 17% efficiency; poultry, at 13%; pork, at 9%; and beef at 3% efficiency (implying a 97% loss of energy calories). They do imply that feed for beef is largely from pasture and "processed roughage," both largely inedible to humans.

[29]Saeed Mastour Alshahrani et al., "Red and Processed Meat and Mortality in a Low Meat Intake Population," *Nutrients* 11, no. 3 (2019): 622, http://dx.doi.org/10.3390/nu11030622; Daniel Demeyer et al., "Mechanisms Linking Colorectal Cancer to the Consumption of Processed Red Meat: A Review," *Critical Reviews in Food Science and Nutrition* 56, no. 16 (2016): 2747–66; and Adam M. Bernstein et al., "Processed and Unprocessed Red Meat and Risk of Colorectal Cancer: Analysis by Tumor Location and Modification by Time," *PLoS One* 10, no. 8 (2015): e0135959.

[30]FAO, *The Future of Food and Agriculture: Trends and Challenges* (Rome, Italy: Food and Agriculture Organization of the United Nations, 2017), http://www.fao.org/3/a-i6583e.pdf.

[31]Rosamond L. Naylor et al., "Effect of Aquaculture on World Fish Supplies," *Nature* 405 (June 2000): 1017–24. It should be noted that although this group questioned the sustainability of aquaculture at the time, they laid out a plan to enhance aquacultural sustainability, and many of the better operators now practice many or all of the suggested BMPs, leaving room for hope; and Stefano B. Longo et al., "Aquaculture and the Displacement of Fisheries Captures," *Conservation Biology* 33, no. 4 (2019): 832–41. Longo et al. modeled a hopeful case: aquaculture might displace wild fisheries enough to allow wild stocks to recover. Their findings suggest that although aquaculture now produces as much seafood as all wild fish capture in the world, it is not sufficient, and further increases in aquaculture in a sustainable manner may be needed.

[32]Bjørndal and Guillen, "Market Competition between Farmed and Wild Fish: A Literature Survey."

[33]W. Ray McClain and Robert P. Romaire, "Crawfish Culture: A Louisiana Aquaculture Success Story," *World Aquaculture* 35, no. 4 (2004): 31–35. This article gives the history of how this system developed into an ecologically friendly, robust system, in which, when either production or prices are down for one commodity, the other often makes up for it; and also allows a semi-intensive culture that can allow native species to thrive while still providing valuable food products.

[34]Thomas A. M. Pugh et al., "Role of Forest Regrowth in Global Carbon Sink Dynamics," *Proceedings of the National Academy of Sciences* 116, no. 10 (2019): 4382–87, http://dx.doi.org/10.1073/pnas.1810512116. This is one of a number of articles that acknowledge the role of forests in sequestering large amounts of carbon dioxide.

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Jay Hollman

Article

Nutrition in Science and Scripture

Jay Hollman

Diet for the prevention of disease is part of a preventive medicine program. Nutritional science has evolved and currently recommends dietary patterns such as the DASH Diet or Mediterranean Diet rather than specific nutrients. Scientific dietary recommendations are human in origin and designed to improve health, and thus differ from the Old Testament dietary laws which are divine in origin and meant to define a distinctive people. Clean and unclean distinctions do not correspond to what current nutritional science would consider healthy and unhealthy. As New Testament believers, we are no longer under the Jewish dietary laws, but we must be careful about what we eat and where we eat for the sake of our conscience and the conscience of our fellow believers. Individual believers should carefully review current nutritional recommendations and decide before God what type of diet they should follow. Diet should not be a cause for division among followers of Christ. Christians should encourage scientific nutritional science within the church, as well as community gardens and periodic fasting.

It is an awkward moment at the family Thanksgiving gathering when your daughter, returning from her first semester at college, announces that her new boyfriend, who has joined her for the family dinner, is a vegan. A scramble ensues in the kitchen to find food that has not been touched by animal products. In the minutes before sitting down to eat, grandfather, the patriarch of the family, quizzes his granddaughter's boyfriend on his reasons for not eating meat: Health? Environment? Culture? Cruelty to animals? Somewhere in this conversation scientific evidence will be cited. What should be the response of a Christian who has a high view of science and faith?

Christians have interpreted passages in 1 Corinthians, where our body is referred to as a "temple of God," as meaning that we are to promote the health of our bodies.[1] Eating a good diet does lead to improved health and prevents (or delays) some chronic diseases. The actual value of dietary changes must be placed in perspective. There are other habits such as smoking and cocaine use that are more harmful to health over time than any dietary habit.

Dan Buettner has popularized the concept of "Blue Zones," areas in the world where longevity is common with lower incidences of cancer and heart disease.[2] One element contributing to a longer life is a diet low in meat and higher in legumes. But longevity in Blue Zones, according to Buettner, is not due only to diet but also to exercising regularly, having a life purpose, experiencing low levels of stress, managing moderate calorie intake, engaging in spirituality, and maintaining strong family lives and social ties. Buettner's data are supported by other social studies. Christ followers living an obedient life should have these characteristics.

While I would endorse such a lifestyle, including a diet low in calories and

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optimal from a scientific perspective (see below), there are three caveats: First, it is important to recognize that there are human diseases that are not related to one's diet: cystic fibrosis and sickle cell anemia are devastating diseases that will shorten lives and are due to a single gene defect. Rheumatoid arthritis and lupus erythematosus are autoimmune disorders that can reduce the quality and quantity of life and are not related to diet.

Second, we should not judge individuals superficially. While some young individuals with early vascular disease have lived a lifestyle that could explain their early chronic disease, others are afflicted by single gene defects in cholesterol metabolism or possess a strong polygenic risk. We should be careful lest we become like the Pharisees in John 9 trying to link an illness to sin. In truth, we all sin and need to be treated with grace. Eating the best of diets does not guarantee a long and healthy life.

Third, from a historical perspective, dietary science and the recommended ideal diet have changed over the forty-five years of my medical practice. In 1988, the National Cholesterol Education Program published its first set of recommendations.[3] This led cardiologists to recommend a diet low in cholesterol and fat, especially saturated fat. For this reason, my mentor and President Lyndon Johnson's cardiologist, Dr. J. Willis Hurst, would not eat the eggs and bacon breakfast served on his visits to the Johnson ranch in Texas. It is now known that dietary cholesterol has little effect on blood cholesterol levels.[4] Low-fat diets are not clearly beneficial. It is now recognized that certain vegetable fats and fat from nuts and marine sources likely are beneficial. Changes in recommendations from nutritional experts as more science becomes available might confuse the public, but it should not surprise us as scientists. It is the nature of science to refine hypotheses and theories as more data become available.

The Current Concept of an Ideal Diet

With these caveats, my sense is that current dietary recommendations, if followed reasonably, will maximize the benefit of diet on health. Optimal diet is a balanced diet with vitamins and minerals being obtained from the foods in which they occur naturally. Supplemental vitamins are not needed except in the rare cases of vitamin deficiency disorders. Rather than recommending specific food components, such as how much fat or protein and minimum daily requirements of various vitamins, a dietary pattern is recommended. A full description of these dietary patterns in this article is not necessary as there are many other sources.

Two dietary patterns have been rated for years by dietitians as most healthy: the DASH diet and the Mediterranean diet.[5] Excellent links can be found to these diets at reliable sites such as the NIH and the Mayo clinic websites.[6] The USDA changed its recommendation to the public from the more abstract food pyramid to MyPlate, a simpler presentation of nutritional information.

In the scientific literature, I would suggest a review article by Dariush Mozaffarian.[7] In this article, he summarizes current nutritional recommendations (table 1). I would also suggest two authors who write for a general audience: Michael Pollan and P. K. Newby. Pollan has written several entertaining books: *Food Rules: An Eater's Manual; In Defense of Food: An Eater's Manifesto;* and *The Omnivore's Dilemma: A Natural History of Four Meals*.[8] His recommendations are generally correct: eat real foods, not too much, and mostly plants. However, I would disagree with some of his comments regarding food additives. Newby's book, *Food and Nutrition: What Everyone Needs to Know*, is more scientifically written and covers repercussions on the environment as well.[9] She includes recipes with her writings and even does cooking demonstrations on YouTube.

Table 1. Summary of Harmful and Beneficial Foods Based on Current Nutritional Research

Health Effect	Types of Food
Most beneficial	Fruits, nuts, fish, vegetables, vegetable oils, whole grains, beans, yogurt
Mildly beneficial	Cheese, eggs, poultry, milk
Mildly harmful	Butter, unprocessed red meats
Most harmful	Refined grains, starches, sugars, processed meats, high sodium foods, trans fat

The placement of each food is based on its net effect on cardiometabolic health. From data in Dariush Mozaffarian, "Dietary and Policy Priorities for Cardiovascular Disease, Diabetes, and Obesity: A Comprehensive Review," *Circulation* 133, no. 2 (2016): 187–225.

Good nutrition involves eating more beneficial foods and fewer harmful foods. But there is a danger in trying to make rigid rules. In this regard, modern nutrition recommendations contrast with the dietary laws of the Old Testament. The distinction between clean and unclean as outlined in the Hebrew Bible was complex. You could eat beef but not pork, yet current dietary science would view both as harmful, particularly if they were salted and processed. Many fish such as catfish were unclean as they do not have both fins and scales, and all shellfish were excluded, yet fish and shellfish are considered beneficial by current nutritional science.

Attempts to reconcile Jewish dietary laws with nutritional science fell into disfavor long before nutritional science reached its current level of sophistication. Clean foods are not necessarily "healthy," and unclean foods are not uniformly "unhealthy." Most current scholars believe that these dietary rules were given to make the Jewish people a distinctive people who would follow God's edicts without question. New Testament believers were freed from the distinction between clean and unclean, but they were to make some accommodation to Jewish believers. In Acts 15, the Council of Jerusalem urged Gentile believers to make three dietary concessions to believers who were from a Jewish background: (1) abstain from food polluted by idols, (2) abstain from the meat of strangled animals, and (3) abstain from drinking blood. Compromise in food selection and sensitivity to others is a major theme of the New Testament teaching on diet.

In contrast to clean and unclean, nutritional recommendations are based on science with the realization that the conclusions are tentative. Unlike clean and unclean, nutritional research does make hygienic claims. But the origins of these dietary suggestions are human and not divine. Although I personally believe that the current dietary patterns are close to the best possible diet, recommendations will change slightly as more scientific data become available. It is frustrating to me to have a medical student or social friend quote a soundbite from the news media proclaiming the discovery of some earth-shattering development in nutritional research. Definitive nutritional research requires careful weighing of evidence from animal studies, populations studies, feeding studies, and randomized studies.

Rules-based Christians sometimes have a difficult time distinguishing between the certainty of biblical commands and the conclusions of science which are often presented as relative risk. Deontological believers can err on either extreme: rigid adoption of rules without compromise, or complete rejection because dietary recommendations are not definitive enough.

Dealing with Dietary Differences

In modern culture, there are many voices calling for dietary change in the American diet that are outside the scientific consensus. Some, as in the example above, recommend the elimination of animal products from our diet. But the vegan diet is not the only form of vegetarianism, although it does have the most restrictive diet. Other types of vegetarianism include pesco vegetarians who eat fish and lacto-ovo-vegetarians who will eat dairy and/or eggs.

There are two references to the vegetarian diet in scripture: Daniel and his friends' request, "Let us be given vegetables to eat and water to drink" (Dan. 1:12b); and Paul's reference, "The weak person eats only vegetables" (Rom. 14:2b). It is clear from the context that Paul does not regard a weaker brother as a lesser member of the congregation. Anyone who has tried to eat a vegetarian diet in our culture knows that this takes considerable resolution and perseverance, hardly traits associated with weakness. The reason that these believers would not eat meat was probably not based on what was clean or unclean by Jewish dietary laws but, rather, on the desire to avoid meat from the meat market that might have been offered to idols or meat that was not prepared in a manner consistent with Jewish dietary laws. Similarly, Daniel and his friends in Babylon refused to be defiled by eating meat and drinking wine from the king's table. Their objection was more likely based on concerns regarding violations to the Jewish dietary laws, than on a desire to be a vegetarian. Paul clearly states that the eating of meat is not forbidden to the believer. But is there any value in vegetarianism?

From a scientific perspective, there is evidence that vegetarians have lower incidences of chronic disease and greater longevity. Studies of California Seventh-Day Adventists demonstrate the incidence of diabetes and hypertension to be 50% to 75% lower

in vegetarian Adventists compared to nonvegetarian Adventists.[10] But diet is not the only difference between vegetarian and nonvegetarian Adventists. Vegetarian Adventists also tend to be more health conscious. Differences in the rate of smoking and the amount of exercise might also be important differences. Since regular exercise reduces the incidence of hypertension and diabetes, difference due to exercise should be subtracted to obtain a better estimate of any difference due to diet. But subtracting differences is not always so simple. For example, vegetarians have a lower body mass index (BMI) compared to meat eaters. A lower BMI is associated with a lower incidence of diabetes and hypertension. But is the lower BMI a result of the diet? There is data to suggest that eating less meat and more fruits and vegetables will result in weight loss.[11] If it is the result of the diet, then it would not be proper to subtract the expected difference due to BMI. This short discussion serves as an illustration of how difficult it is to demonstrate the harm of meat eating to health. The short answer is, as table 1 demonstrates, that the predominance of data suggests that red meat, and especially processed red meat, is harmful to health, while poultry and fish are not.

If one is interested in a bottom-line answer regarding meat consumption, it is probably best to read the recommendations of expert panels. Dietary experts, mostly active nutritional researchers, are convened by not-for-profit groups such as the American Heart Association and governmental agencies such as the U.S. Department of Agriculture. These groups analyze the scientific literature, sometimes doing their own meta-analyses. After reviewing the data, they draft recommendations on which they vote. The consensus of these panels, while not unanimous, is that red meat and processed meat consumption should be reduced.

The *2015–2020 Dietary Guidelines for Americans* recommends limiting red meat intake, including processed meat, to one serving per week.[12] The American Institute for Cancer Research recommends limiting red meat consumption to moderate amounts and consuming very little processed meat.[13] A research agency of the World Health Organization (WHO) has indicated that the consumption of red meat is "probably carcinogenic" and processed meat is considered "carcinogenic" to humans.[14] However, the expert panels are not unanimous. Another panel of dietary experts, NutriRECS, published their analysis of the data on meat consumption in 2019 and recommended that Americans not adjust their consumption of either red or processed meats because the evidence of harm from meat eating was of a low quality.[15]

As an interested outside observer, I would agree that a low consumption of red meat is ideal and processed meat should be almost eliminated. White meat consumption from poultry is neutral or mildly beneficial. Fish, especially oily fish, is a clear positive for the diet. I would say that the science on which these recommendations are made is at least an order of magnitude less certain than the evidence that smoking is harmful to health.

Where does this leave us in our discourse with the vegan boyfriend visiting for Thanksgiving vacation? Romans 14 does not address the consumption as a health issue, but it does make it clear that eating or not eating meat should not be an issue that divides believers. Believers should be sensitive to each other's scruples. A correct application of Paul's teaching would be to accept and affirm the young man's dietary preferences. If this is followed by humble questioning and dialogue, it could be quite helpful in building a relationship.

There are reasons to abstain from meat beyond any health benefit. Stronger than the health evidence is the evidence that the production of meat, especially the production of red meat, is harmful to the environment. The semi-industrialized production of beef requires much more in land resources and supplemental feed to produce a pound of beef when compared to a pound of meat from either poultry or fish. Even though corn and soybeans are widely used by food manufacturers to produce a variety of processed foods for human consumption, most of the corn and soybeans produced in this country are fed to animals to produce our meat. The effect of heavy meat consumption on the environment is detailed by ASA member David Dornbos.[16] Industrial production of meat has also been linked to practices that compromise animal welfare for profit.[17] One might also abstain from certain meats because of religious reasons. Jews and Muslims agree on little, but they both want the animals they eat to be slaughtered in a certain manner which maximizes the drainage of blood. In short, there are many reasons why one

might choose to be a vegan; respectful discussions can be useful.

It is also important for persons on the restrictive diet not to be judgmental of those who do not share their convictions. Paul exhorts both the eater of meat and the abstainer: "Let not the one who eats despise the one who abstains, and let not the one who abstains pass judgment on the one who eats, for God has welcomed him" (Rom. 14:3). Much has changed since the first century. We now know of health consequences of one diet compared to another, and we now know of the environmental consequences of food production. Yet the principle is the same: each of us must look at the data and be fully convinced that we are making the best decisions regarding our own diet. Each of us is accountable to God for our decisions, and another's preferences for food should not be an issue that divides Christians.

Paul's teaching on eating in 1 Corinthians 8 and 10 makes it clear that we need to consider others in what we eat. Eating in an idol temple banquet hall is wrong because it would be participating in the worship of the idol and this might cause a weaker brother to believe that there is something to these idols. Chapter 10 of 1 Corinthians takes the scene to a meal in an unbeliever's house. One is free to eat the meat set before him unless it is said that the meat has been offered to an idol. One should then refuse because of the conscience of the one who made the point that the meat on the table had been offered to idols. It is not stated whether this was the conscience of the unbelieving host or the conscience of a weaker brother in Christ who might also be at the meal. In the case of the weaker brother, eating might cause him to believe that it is possible for a Christian to engage in or condone idol worship. If it is the unbelieving host who describes the meat as having been offered to idols, one should refuse for the sake of the host's conscience. By not eating, the mature Christian would be demonstrating that you cannot participate in any form of idol worship when you worship the Christian God.

The modern application of the two passages in 1 Corinthians is that mature believers should be careful to think of the consequences of their social engagements. They must think not only how it might affect themselves, but also how it might affect fellow believers, including "weaker brothers." Certain public dining venues might be off limits to us or to a weaker brother who might be joining us for a meal. As the mature Corinthian believer was to avoid eating in the banquet hall of the idol's temple, so, for some believers, it might be off limits to eat the buffet in a casino or to attend a dinner theater where unholy values are exalted in the drama being presented. This does not mean that we avoid eating with unbelievers, noting that the second example in Corinthians takes place in the home of an unbeliever. Our Lord was regarded as a friend of sinners, and he would eat with tax collectors. But it is important that our behavior at such a meal does not lead us or a weaker brother to compromise his conscience. Paul summarizes: "Therefore, if food makes my brother stumble, I will never eat meat, lest I make my brother stumble" (1 Cor. 8:13). And "So, whether you eat or drink, or whatever you do, do all to the glory of God" (1 Cor. 10:31).

In summary, the teaching on eating from scripture is that we are individually accountable for what we eat before God. In this regard, eating is like so many issues confronting modern Christians. What should we do about climate change? Install solar panels or drive an electric car? What type of school is best for our children? Public schools where we participate in the community or private Christian schools where our deepest values will not be ridiculed? Or should we home school where we will be able to exert the most control? The answer for school is complex and is dependent on the options that are available, the disposition of the child, and the availability of qualified teachers. Each of us is accountable to God for how and why we make these individual decisions. Ours is a personal faith with an infinite personal God who guides humble and obedient believers on the many issues that are not core to the faith.

What Should We Do?

Having made the point regarding our freedom in Christ as clearly as I am able, there is still more to the story. As a practicing cardiologist, it is important at times to advise my patients regarding their diet. Similarly, I should also try to do something about the dietary culture that makes it difficult for individuals to follow an ideal diet. We would expect a Christian climate scientist such as Katharine Hayhoe to not only try to reduce her individual carbon footprint but to encourage fellow believers to do so as well. In this regard, I would offer some suggestions.

Nutritional Education

Accepting that these nutritional recommendations are not new dietary laws does not mean that they have no value for the formation of godly habits. It is reasonable to promote small group classes within the church that teach scientifically verified nutritional concepts, provided that qualified teachers are available. Many people are hesitant to consider eating less meat because they do not know how to prepare tasty meals without meat as a central item. There may be value in having skilled vegetarians prepare several of their most tasty dishes for all to try.

Community Gardens

Other measures could be tied to the church's unique circumstances. If the church has access to land, a community garden could be planted. There are many such examples of church-sponsored community gardens that are not even attached to the church property. Involving the youth of the church will help them form better dietary habits as those who garden are more likely to eat vegetables. The fruits and vegetables from the garden could be shared with needy church members, neighbors of the church, and the local food bank.

It is possible to dream big. Lawndale Christian Health Center, in partnership with the Chicago Botanic Garden, has taken community gardens to a new level.[18] The Farm on Ogden is an urban garden with greenhouses and an aquaponic garden that grows fresh produce year round and sells it in their indoor market. This is an important addition to an inner-city Chicago neighborhood. Medical educators also provide nutritional classes on site. Equally important, the project provides employment for former drug users and individuals released from prison.

Improved Food Choices

The church and parachurch organizations have often been associated with mass distribution of ultra-processed foods. The premed Christian Medical group at Lousiana State University has an evening meeting every other Monday and serves pizza, partially as an enticement. My son's Christian Bible study program for special needs adults serves hot dogs and bags of chips and cookies at a typical meeting. This option is both inexpensive and convenient and well accepted by members. Having this food occasionally is probably not harmful, but it would be better if we could serve foods more in keeping with the ideal diets such as DASH or MyPlate to these individuals who often already have a significant problem with obesity. Do we really need donuts or chocolate cake at every Bible study? I believe that we can do better.

Fasting

Finally, the church and individual Christians should take a renewed interest in fasting. In the Sermon on the Mount, Jesus tells us how to fast and implies that we would fast when he says in Matt 6:16, "And when you fast …" Jesus also said that after he was gone his disciples would fast (Luke 5:35). Fasting has been more emphasized in liturgical churches, but it deserves consideration in the evangelical church as well. Bill Bright, founder of Campus Crusade for Christ, wrote extensively in his later years on the value of fasting for spiritual renewal.[19] Since the 1990s, medical science has discovered the importance of fasting for its induction of autophagy. There has been an explosion of scientific papers on the topic. The scientific journal, *Autophagy,* has been published monthly since 2005. The 2016 Nobel Prize in Physiology or Medicine was awarded to Yoshinori Ohsumi for his work in autophagy.

Periodic fasts from food are good for our physical and spiritual health. Autophagy induced by fasting stimulates cells to clear themselves of defective proteins, intracellular fat, and damaged organelles. Fasting also reduces oxidative stress; thus, fasting improves cellular metabolism, reduces inflammation, and reduces DNA damage.[20] Improved intracellular health reduces the incidence of chronic diseases such as cancer, metabolic syndrome, and neurodegenerative disease.[21]

Conclusions

We all long for human disease and the suffering it brings to have a simple cure. Unfortunately, a healthy diet can only do so much to improve health. We are subject to diseases that have little to do with diet. For Christians today, it is reasonable to study the science and choose a diet in accordance with nutritional science. Dietary choices should not become a cause for division within the church. We do need to consider the effect of our own dietary choices and personal habits on our fellow believers. Dietary education, community gardens, and fasting are positive steps that should be considered. However, diet and food should not become an obsession for a believer. "For

the kingdom of God is not a matter of eating and drinking but of righteousness and peace and joy in the Holy Spirit" (Rom. 14:17). ◙

Notes

[1]"If anyone destroys God's temple, God will destroy him. For God's temple is holy, and you are that temple" (1 Cor. 3:16); and "Or do you not know that your body is a temple of the Holy Spirit within you, whom you have from God? You are not your own" (1 Cor. 6:19). All biblical references are from the English Standard Version.

[2]Dan Buettner, *The Blue Zones, Second Edition: 9 Lessons for Living Longer from the People Who've Lived the Longest* (Washington, DC: National Geographic Society, 2012).

[3]DeWitt S. Goodman et al., "Report of the National Cholesterol Education Program Expert Panel on Detection, Evaluation, and Treatment of High Blood Cholesterol in Adults," *Archives of Internal Medicine* 148, no. 1 (1988): 36–69.

[4]Donald J. McNamara, "Dietary Cholesterol, Heart Disease Risk and Cognitive Dissonance," *Proceedings of the Nutrition Society* 73, no. 2 (2014): 161–66.

[5]U.S. News ranked 35 diets with input from a panel of health experts. To be top-rated, a diet had to be relatively easy to follow, nutritious, safe, effective for weight loss, and protective against diabetes and heart disease. "Best Diets Overall," 2020, https://health.usnews.com/best-diet/best-diets-overall.

[6]National Heart, Lung, and Blood Institute, "Dash Eating Plan," https://www.nhlbi.nih.gov/health-topics/dash-eating-plan; and Mayo Clinic Staff, "Mediterranean Diet: A Heart-Healthy Eating Plan," June 21, 2019, https://www.mayoclinic.org/healthy-lifestyle/nutrition-and-healthy-eating/in-depth/mediterranean-diet/art-20047801.

[7]Dariush Mozaffarian, "Dietary and Policy Priorities for Cardiovascular Disease, Diabetes, and Obesity: A Comprehensive Review," *Circulation* 133, no. 2 (2016): 187–225.

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[10]Gary E. Fraser, "Vegetarian Diets: What Do We Know of Their Effects on Common Chronic Diseases?," *The American Journal of Clinical Nutrition* 89, no. 5 (2009): 1607S–1612S.

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[13]World Cancer Research Fund and the American Institute for Cancer Research, "Meat, Fish and Dairy Products and the Risk of Cancer," in *Diet, Nutrition, Physical Activity and Cancer: A Global Perspective*, Continuous Update Project (The Third Expert Report, 2018), https://www.wcrf.org/dietandcancer/exposures/meat-fish-dairy.

[14]Véronique Bouvard et al., International Agency for Research on Cancer Monograph Working Group, "Carcinogenicity of Consumption of Red and Processed Meat," *Lancet Oncology* 16, no. 16 (2015): 1599–600.

[15]Bradley C. Johnston et al., "Unprocessed Red Meat and Processed Meat Consumption: Dietary Guideline Recommendations from the Nutritional Recommendations," *Annals of Internal Medicine* 171, no. 10 (2019): 756–64.

[16]David Dornbos and Jay Hollman, *Eat Meat? Evidence of Harm to People and Planet and a Sustainable Food Secure Opportunity* (Ronkonkoma, NY: Rylan Publishing, 2020), https://store.rylanbooks.com/?s=David+Dornbos.

[17]Matthew Scully, *Dominion: The Power of Man, the Suffering of Animals and the Call to Mercy* (New York: St. Martin's Press, 2002).

[18]Farm on Ogden: Food, Health, Jobs. A project of the Chicago Botanic Garden and Lawndale Christian Health Center, accessed May 17, 2020, https://www.chicagobotanic.org/urbanagriculture/farm_on_ogden.

[19]Bill Bright wrote two books on the topic: *7 Basic Steps to Successful Fasting and Prayer* (Okeene, OK: New Life Publications, 1995), and *The Transforming Power of Fasting and Prayer: Personal Accounts of Spiritual Renewal* (Okeene, OK: New Life Publications, 1997).

[20]Mark P. Mattson, "Challenging Oneself Intermittently to Improve Health," *Dose Response* 12, no. 4 (2014): 600–618.

[21]Sarbari Saha et al., "Autophagy in Health and Disease: A Comprehensive Review," *Biomedicine and Pharmacotherapy* 104 (2018): 485–95.

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"For the kingdom of God is not a matter of eating and drinking but of righteousness and peace and joy in the Holy Spirit."

— Romans 14:17

Matthew Morris

Naming as a Form of Stewardship: A Case Study on Fraudulent Fishes Sold in Calgary, Alberta, Canada

Matthew Morris

In Genesis 2, Adam was given the task of naming the animals. Naming is a relational activity that promotes stewardship—we protect what we name. The naming of food products derived from these creatures is more complex, entailing both the common and scientific names of the species as well as cultural, commercial, and legal naming practices. This complexity of naming can result in the mislabeling of foods: "what you bought" is not "what you got." Fish are particularly prone to mislabeling, not least because North Americans are typically unconcerned with fish biodiversity, and those features that permit species identification are often removed during processing.

The recent collapse of many fish stocks has given correct naming of the fishes a new urgency. A dataset generated by students taking a Principles of Genetics class at faith-based Ambrose University in Calgary, Alberta, demonstrates that mislabeling rates can be high—from 20% to 35% of fish products from a dataset of nearly three hundred were mislabeled. However, there is more to naming than mislabeling. Legally permissible names excluded culturally significant sources of cuisine, conflating the mislabeling problem and distracting from the true sources of mislabeling. Legally ambiguous labeling, in which one market name is legally applied to several species, appeared to facilitate mislabeling and hid the sale of species at risk of extinction, hinting at how both consumers and regulators could reduce the impact on endangered species. Naming is a type of knowledge; we need to develop a greater knowledge of the fish we are eating in order to better fulfill God's blessing to the fishes.

When a child encounters a new food, typically the first question they ask (complete with wrinkled nose) is, "What is this?" Many of our foods come with complex names that have little to do with the ingredients of the food—"cheese puffs" bring to mind a particular texture, shape, and taste that is more than just cheese, and there are many brands of cheese puffs with their own peculiarities. Most food ingredients are derived from living beings, which themselves have common and scientific names. These different naming conventions—for the food and the species—can come into conflict when the food name masks its true creaturely identity.[1] For the Christian this takes on significance, not least because we are called to name the living world, and this naming is itself an act of stewardship.

In Genesis 1 and 2, humans were tasked with "ruling over" the animals. Such rule was in part modeled by Adam's naming of the animals (Gen. 2:19). Naming is a foundational theme throughout the Pentateuch, being wrapped up with themes of identity and relationship. It is striking that after God speaks the world into being, Adam is invited to name (speak) the animal component of that

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creation. We are invited, like Adam, to continue the process of naming:[2] to observe living things closely, to identify superficial and significant differences between them, to determine what is worthy of receiving a name. Naming, then, is a deeply relational form of knowledge; we name what we love. In turn, we steward what we name—both legislatively, as changes to the scientific name of a species can have dire consequences for implementing laws,[3] and socially, as there is little initiative to protect that which has not been deemed worthy of naming.[4] Indeed, the act of naming helps us see the natural world differently; those who lack names for plants literally cannot see the biodiversity around them, a phenomenon known as plant blindness.[5] We cannot steward what we cannot name. The significance of naming applies not only to the living; it also applies when species are turned into our food. A significant lack of public interest—one could say, a lack of love[6]—in the food we eat has led to the improper naming of food products.[7] Such food mislabeling can and has led to economic fraud, the depletion of wild populations, public health issues,[8] and a lack of sensitivity to cultural food practices.[9] Although mislabeling has been found in many food items around the world,[10] it is particularly prevalent in one of the few remaining wild food sources—fish.

Fish constitute an important source of global protein:[11] 3.3 billion people rely on seafood for 20% of their average animal protein intake,[12] and this is disproportionately true of the poor for whom seafood has historically been an easily accessible source of protein.[13] Despite the significance of fish, wild populations are often mismanaged to the point of collapse,[14] while aquaculture carries its own ecological concerns.[15] Such issues are exacerbated by blindness to fish diversity;[16] for instance, "fish" in North America once meant Atlantic cod (*Gadus morhua*), and fish sticks were understood to be cod sticks. But as cod stocks were depleted, fish sticks were increasingly made of haddock (*Melanogrammus aeglefinus*), and eventually pollock (*Gadus chalcogrammus*)—changes from tradition that were largely unnoticed by the public, in that these species continued to be marketed under the original name.[17] Despite there being more species of fish than birds, mammals, reptiles, and amphibians combined,[18] western consumers have tended to be more concerned about the mammal or bird on their plate than the identity of their fish. We do not order mammal sandwiches or bird salads, but routinely order "fish and chips" without concern for the type of fish being consumed—was it Pacific cod (*Gadus macrocephalus*) or the vulnerable Atlantic cod (*Gadus morhua*)? Was it tuna (and if so, what species?) or the dangerous escolar (*Lepidocybium flavobrunneum*)?[19] If plant blindness is defined by the inability to see or appreciate the beauty and significance of plants,[20] then fish blindness involves the inability to distinguish between the different species of fish we routinely encounter on our plate, to appreciate the significant roles they play in the ecosystem, or to recognize the complexity of their lived experiences.

Even if consumers wished to identify the fish they were consuming, the ways in which fish are processed and presented to the consumer pose challenges for correct identification—sushi comes with few identifying features, breaded fish sticks come with no features whatsoever, and some distinguishing features such as flesh color can be manipulated through fish diet.[21] These variations can result in the opportunity for mislabeled fish products—consumers are told that they are eating one species, but, in fact, they are eating another. Monitoring the naming of fish products is therefore vital for ensuring that fish stocks are properly managed. One important tool to identify mislabeled products is DNA barcoding,[22] which permits researchers to identify to species those food samples that have otherwise lost their distinguishing characteristics. DNA barcoding is akin to using a scanner at a grocery store to read a barcode and identify the product; by sequencing a region of the *cytochrome c oxidase subunit I* (*COI*) gene, researchers can compare the sample DNA sequence to a database of known species in order to return a match.[23] DNA barcoding has provided an opportunity to test mislabeling of fish products,[24] permitting citizen scientists[25] to ask if "what they bought" is "what they got." The answer has been a resounding no.

The mislabeling of fish food—sometimes called fish fraud, although fraud in the legal sense is difficult to prove, and the perpetrators of such fraud difficult to detect[26]—is a major global issue.[27] To determine mislabeling, three types of names have to be investigated: market name, legal name, and barcode name. The market name is the name of the food product as identified on the packaging or menu; the legal name is the list of species that can be sold under that

market name; and the barcode name is the actual species identification determined through DNA barcoding (fig. 1). As long as the barcode name of the product does not match any of the legal names associated with the market name, the product is considered to be mislabeled. For instance, in Canada, "basa" is the common name given to the freshwater catfish *Pangasius bocourti*. However, there is a related marine species with the common name of iridescent shark, *Pangasianodon hypophthalmus*. If a consumer purchases a product marketed as basa, they might reasonably expect to be consuming *Pangasius bocourti*. But if DNA barcoding reveals the tissue to actually belong to *Pangasianodon hypophthalmus*, no mislabeling has occurred, because, in Canada, basa can legally refer to either species, even if, in common vernacular, it applies to only one.[28] That is, the market name (basa) can have two legal names (basa or iridescent shark); if the barcode name is one of the legal names, mislabeling has not occurred. Mislabeling, then, is a legal, not a scientific, determination.

In every country in which mislabeling has been investigated, it has been detected[29]—and often at

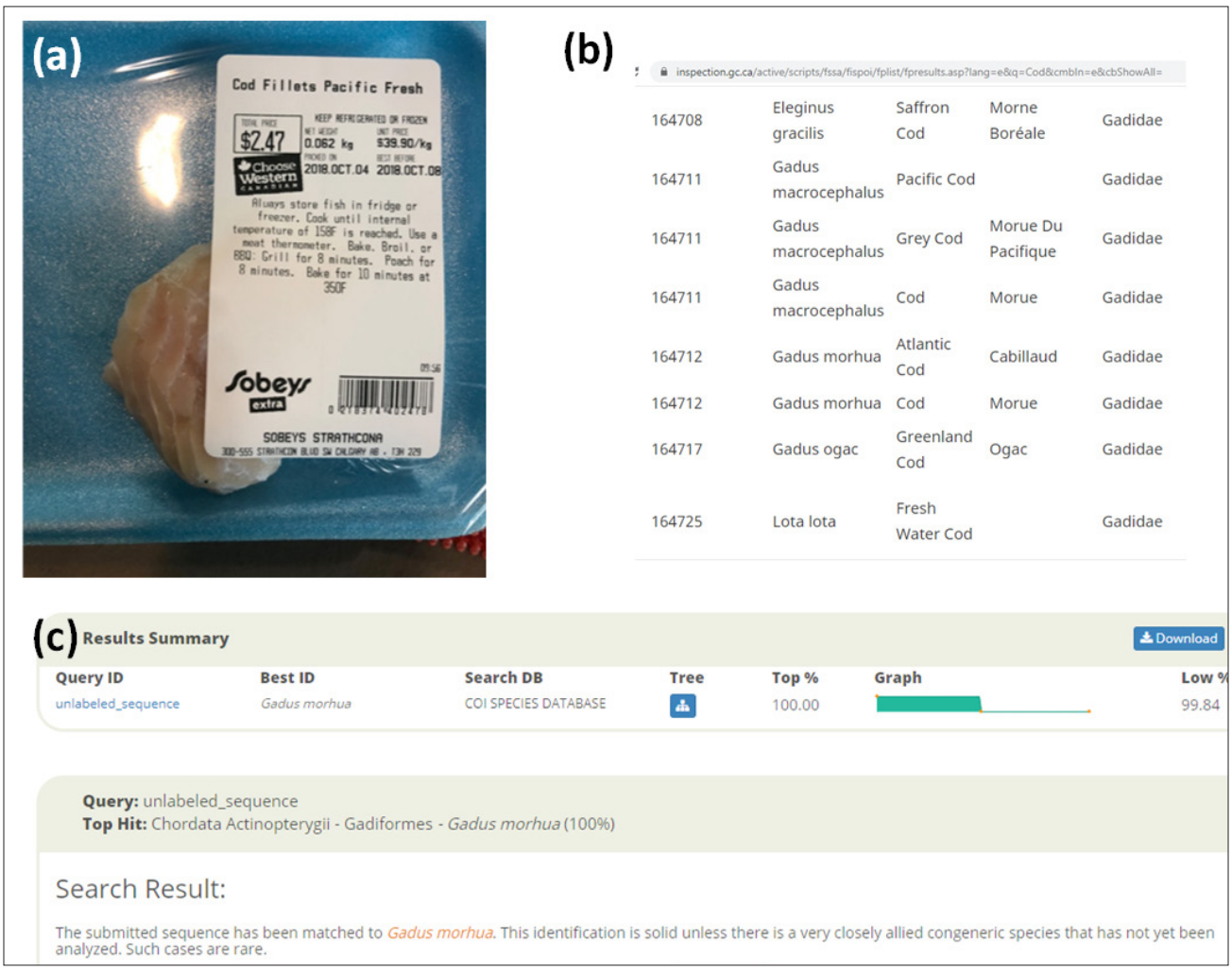

Figure 1. The determination of mislabeling involves comparing three different sources of naming. (a) The market name is the name advertised on the product, either on a label or in the menu. In this example, the name is not easy to determine—"cod fillets Pacific fresh" contains information about the species, the type of tissue, geography, and the method of preservation. The most likely interpretation of this label for the average consumer would be "Pacific cod." (b) In order to determine mislabeling, a standard for naming is required. The legal names for all legally sold species of fish in Canada are maintained by the Canadian Food Inspection Agency (CFIA) on their Fish List. A search for "cod" returns a variety of species. Note that cod is a legal name for two species of *Gadus*, while Pacific cod is a legal name only for *Gadus macrocephalus*. (c) The sample from (a) was DNA barcoded. The DNA sequence was compared to all animal species with DNA barcodes in the Barcode of Life Database (BOLD). Our sample had 100% sequence similarity to *Gadus morhua*, which from (b) goes by the legal names of cod or Atlantic cod. Therefore, this sample had a market name of Pacific cod but a barcode name of Atlantic cod; Pacific cod is not a legal name for Atlantic cod; therefore this product is mislabeled. Although this is a real example and the vendor is named in the image, this in no way means that the vendor was knowingly selling mislabeled products. Indeed, this is a rare example of mislabeling from a grocery store, and the mislabeling could have occurred anywhere on the supply chain.

high proportions. A recent Oceana meta-analysis of 55 countries reported a global mislabeling rate of 20%—that is, 1 in 5 fish products are in contravention of local labeling regulations.[30] Canada is no exception to the fish mislabeling problem. Surveys across several years and in many Canadian cities suggest anywhere from 19–47% of Canadian fish products for human consumption are mislabeled.[31]

Mislabeling is associated with reduced creaturely flourishing. Mislabeling can compromise human health, through poisoning (e.g., purchasing a product labeled as squid that actually contains a toxic pufferfish that, if cooked improperly, can be lethal),[32] to gastrointestinal distress caused by consuming fish with indigestible fatty acids,[33] to long-term health effects of consuming products that contain low doses of contaminants.[34] There are economic consequences, when mislabeling is committed in order to pass inexpensive products off as more-expensive products.[35] Mislabeling can also have serious implications for conservation. Mislabeling can permit consumers to unknowingly purchase endangered species, when they have been passed off as sustainably harvested species.[36] Less intuitive, but equally alarming, is the opposite occurrence—when a species on the brink of collapse is legally sold, but the product belongs to a sustainable or farmed species. This happens routinely with products sold as the marine "snapper" or "red snapper" that are actually farmed freshwater tilapia or other rockfish species. Flooding the market with non-snapper, but selling them under the name of red snapper, confuses the public as to the availability and conservation status of real red snapper (in Canada, red snapper legally must be either *Lutjanus campechanus* or *Sebastes ruberrimus*).[37]

Detecting fish fraud, given the relative simplicity of DNA-based species identification, lends itself to citizen science campaigns, whether among public or religious groups. Whereas published data are typically not available for analysis, citizen science puts the data in the hands of the public, permitting more robust discussions of the significance of mislabeling. Here I report multiyear sampling of fish products from Calgary, Alberta, Canada, conducted primarily by genetics students at faith-based Ambrose University. This local effort to uncover fish mislabeling has highlighted not only that mislabeling occurs, but also that there are significant social and legal dimensions to the naming of food products. Failing to take these dimensions into consideration can conflate mislabeling estimates and put fish species at risk of extinction.

Methods

To assess the extent of fish mislabeling in Calgary, Alberta, Canada, the second-year Principles of Genetics class at Ambrose University[38] has sampled Calgary fish products from grocery stores, restaurants, and sea food markets for the past several years (2014–2019). Sampling was always conducted in September. Photographs of fish products, including the market name of the product (that is, "what you bought"—whether found in a menu, a sticker, or printed on the packaging itself) and its retail value, were taken by students and uploaded to the Barcode of Life Data System (BOLD).[39] A sample, approximately the size of a kidney bean, was removed from each fish product and placed in a LifeScanner kit with DNA preservative, and shipped to Guelph, Ontario, Canada, for DNA extraction and sequencing.[40] A region of the *cytochrome c oxidase subunit I* (*COI*) gene on the mitochondrial genome was sequenced. An average of 562 nucleotides was sequenced, with a standard deviation of 163 due to variation in DNA quality. This region evolves at the sweet spot in fishes—many mutations are deleterious and quickly weeded out of the population, but enough neutral or adaptive mutations can accumulate in such a way that fish species can typically be identified one from another.[41] There are some caveats—barcoding poorly resolves hybrids, for instance, as only the maternal lineage is sequenced, and some economically important fishes, such as tilapia species (members of the genus *Oreochromis*), Atlantic and Pacific halibut (*Hippoglossus*), Pacific and Arctic cod (*Gadus macrocephalus* and *Boreogadus saida*), and many tuna species, cannot be differentiated by sequencing this region.[42] That is, a sample can convincingly be demonstrated to be halibut through its DNA sequence, but the species of halibut (Atlantic or Pacific) cannot be determined without sequencing at other regions or using morphological data.

Samples of 344 fish products were submitted, but due to varying states of DNA integrity, only 295 samples returned usable DNA sequences. For instance, of nineteen canned samples purchased, only three provided usable DNA. After 2017, students were advised to stop collecting canned products, as the per-sample

cost was too high to justify failed sequencing. All statistics will refer to the usable 295 samples. DNA sequences were uploaded to BOLD and searched for a match to DNA sequences maintained in the BOLD records.

In order to determine mislabeling, the market name and barcode name must be compared to a list of legal names. The naming of fish food products in Canada is regulated by the Food and Drugs Act and Regulations, and the Safe Food for Canadians Act and Regulations. The legal names for fish products are maintained by the Canadian Food Inspection Agency (CFIA) through their Fish List.[43] A product was determined to be correctly labeled if the legal name for the fish product, as determined by searching the CFIA Fish List for the market name, was a match to the barcode name. If BOLD identified multiple possible species that matched the DNA sample, and one of those was a legal match for the market name, the item was not considered to be mislabeled, although mislabeling could still be possible for that sample. All other possibilities, from the barcode name not matching the market name, to the market name having *no* legal names, were considered examples of mislabeling.

All market names were scored as "precise," meaning that the market name could apply to one and only one species on the CFIA Fish List; "ambiguous," meaning that the market name could apply to more than one species; or "not legal," meaning that the market name could not be found on the CFIA Fish List. The International Union for Conservation of Nature status of the barcode name or names was determined using the Red List of Threatened Species.[44] Associations between mislabeling, legally permissible ambiguous labeling, and conservation status were determined using Fisher's exact tests.[45]

Results and Discussion

An Overview of Mislabeling in Calgary

Of 295 fish samples, 102 samples (35%) were mislabeled (fig. 2). Across years this varied from 21% in 2019 (6/28) to 42% in 2017 (53/127).[46] These data encompassed 71 different market names, but the majority (55%) of samples came from products labeled as salmon, tuna, Atlantic salmon, sockeye salmon, red snapper, hamachi, yellowtail, basa, cod, and mackerel (table 1). Therefore, overall mislabeling rates are biased toward these labels, which probably reflect the fish products encountered by typical budget-wise Calgarians.

Sometimes a single species was represented by a variety of market names. Eel (*Anguilla rostrata*), for instance, was sold as unagi, freshwater/fresh water eel, dancing eel, and saltwater eel, encompassing a total of eleven products.

Mislabeling rates varied among species (table 1). The most egregious example of mislabeling involved 100% mislabeling of red snapper—these marine fish (legally either *Sebastes ruberrimus* or *Lutjanus campechanus*) were without exception freshwater tilapia from the genus *Oreochromis*. Tilapia also showed up in products labeled snapper, yellowtail, and albacore tuna. Salmon products were routinely identified as rainbow trout. Some important health risks were noted: for instance, butterfish (*Peprilus* spp.) and one sample of tuna were actually escolar (*Lepidocybium flavobrunneum*), which has been linked with gastrointestinal distress. Many species, such as sockeye salmon, basa, mackerel, and halibut were legally labeled.

Vendors could be subdivided into four main categories: grocery stores, including large chains and small convenience stores (n=127); Japanese-styled restaurants (n=141); western-styled restaurants (n=19); and seafood markets (n=8). Of these, no seafood market samples were mislabeled, 21% and 23% of western-styled restaurant and grocery store samples were mislabeled, and 49% of Japanese-styled restaurant samples were mislabeled.

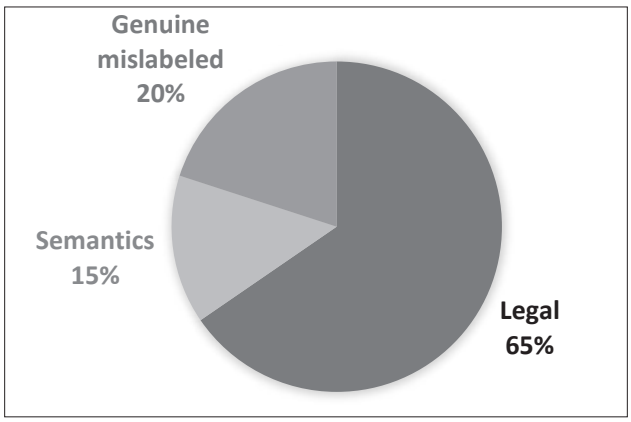

Figure 2. Proportion of fish sampled in Calgary that were legally labeled (dark grey), mislabeled due to semantics (sushi names or added geographic or habitat identifiers to an otherwise legal name) (light grey), and genuinely mislabeled (medium grey).

The above results could be summarized as follows: Calgary has a fish mislabeling problem that is in line with the rest of Canada.[47] Approximately one in three fish products were illegally labeled—what consumers "bought" is not "what they got." This is particularly true for sushi products coming from Japanese-style restaurants. The most commonly encountered sushi fish (tuna, salmon, hamachi, snapper, and eel) were also the most commonly mislabeled, while other species typically purchased as fillets (basa, sockeye salmon, halibut) seemed to fare better. However, although the above makes

Table 1. Occurrence of Mislabeling in Calgary Fish Products, 2014–2019. Percent mislabeled includes all sources of mislabeling, whereas percent genuine mislabeled refers to mislabeling not due exclusively to the use of common sushi names, or to the seemingly well-intentioned use of a descriptor in front of the species name. See text for details. BOLD-identified species are provided only for instances of genuine mislabeling.

Market name	No.	Percent mislabeled	Percent genuine mislabeled	BOLD-identified species
Red snapper	13	100%	100%	Tilapia
Snapper	7	100%	100%	Tilapia or incorrect species of *Sebastes*
Alaskan salmon	2	100%	100%	Sockeye salmon or *Sebastes*
Atlantic cod	1	100%	100%	Pacific cod
Butterfish	1	100%	100%	Escolar
Corvina	1	100%	100%	Whitemouth croaker
Golden threadfin bream	1	100%	100%	Japanese threadfin bream
Marlin	1	100%	100%	Black marlin
Sea bass	1	100%	100%	Chum salmon
Sea eel	1	100%	100%	Punctuated snake-eel
Freshwater eel / Unagi / Eel / Dacing eel / Saltwater eel	10	100%	20%	European eel
Hamachi / Yellowtail	13	100%	8%	Tilapia
Red tuna / Ahi tuna / Ahi red tuna / Red bluefin tuna / White tuna	16	100%		
Pacific rockfish	2	100%		
Albacore tuna	2	50%	50%	Tilapia
Pollock	2	50%	50%	Yellowfin sole
Salmon	36	39%	39%	Pink or Chum salmon, Chinook salmon, Rainbow trout, Tuna
Pacific cod	9	33%	33%	Atlantic cod
Pacific snapper	5	20%	20%	Incorrect species of *Sebastes*
Cod	12	17%	17%	Southern blue whiting, *Salvelinus* trout
Tuna	30	7%	7%	Escolar, Rainbow trout
Atlantic salmon	23	0%	0%	
Sockeye salmon	15	0%	0%	
Basa	12	0%	0%	
Mackerel	10	0%	0%	
Halibut	9	0%	0%	
Alaska pollock	7	0%	0%	
Tilapia	7	0%	0%	
Steelhead salmon / Steelhead trout / Trout	7	0%	0%	
Sole	5	0%	0%	
Bluefin tuna	2	0%	0%	
Other	31	29%	10%	Incorrect species of *Sebastes*, *Salvelinus* trout instead of whitefish
Total	295	35%	20%	

a nice sound bite, there are some important concerns that should be raised about this interpretation. Mislabeling rates on their own do not tell the whole story, as not all mislabeling is equal.

Canada's Labeling Laws Reject Traditional Japanese Names for Fish Cuisine

The CFIA does not accept commonly used sushi names for fish products—and this unnecessarily inflates mislabeling estimates. Unagi, hamachi, and ahi are well-known terms to sushi connoisseurs, and such consumers know that these labels refer to Japanese (*Anguilla japonica*) or American eel (*Anguilla rostrata*), Japanese amberjack (*Seriola quinqueradiata*), and yellowfin tuna (*Thunnus albacares*) respectively. Yet according to the CFIA Fish List, none of these terms are acceptable market names for fish, and therefore violate Canadian legislation. Oceana Canada most recently included hamachi in their mislabeling statistics, providing an overall mislabeling rate for Ottawa of nearly 50%.[48] To call such foods mislabeled seems to be stretching the definition of mislabeling to its breaking point. It is true that such terms violate the CFIA Fish List, but no informed consumer would believe that they had been intentionally misled when their unagi turns out to in fact be American eel. *Of course,* I am eating *Anguilla rostrata* when I order unagi. Not a single case of unagi was *not* a member of the genus *Anguilla*. And yet eel was one of the most mislabeled products in Calgary, simply due to semantics. The same was true for hamachi—it was always Japanese amberjack. Ahi was trickier to disentangle, as the many tuna species are genetically similar; but the DNA identification of ahi tuna, with one exception, contained yellowfin tuna as one possible match.

Vendors try to get around regulations against sushi names by including an English translation of the sushi item on the menu. Unfortunately, they do not typically follow CFIA conventions for these English names. For example, unagi often has the translation of freshwater or fresh water eel—neither of which is legal. But again, this hardly seems to be true mislabeling. Similarly, most sushi vendors translate hamachi as yellowtail. Yellowtail is a regionally acceptable name for Japanese amberjack,[49] but the CFIA restricts the name yellowtail to a species of flounder (*Limanda ferruginea*). Consumers familiar with sushi would be surprised if their hamachi turned out to be a type of flatfish, yet a 2018 report of Canadian fish mislabeling included yellowtail as one of the worst mislabeled products in Canada, when 100% of yellowtail were actually Japanese amberjack.[50] Given that other non-English names are included in the Fish List, such as ayu for sweetfish (*Plecoglossus altivelis*), one has to wonder why an entire category of popular cuisine is excluded from such consideration. If Canadians wish to enjoy Japanese culture, this involves engaging with cultural practices of naming. To suggest that one can enjoy Japanese cuisine without the cuisine names is to misunderstand the significant relationship between culture and food naming practices. As it stands, Japanese-themed restaurants sell more mislabeled fish products than any other type of vendor, in part for abiding by their cultural practices.

A Portion of Mislabeling Does Not Appear to Be Due to Ill Intent

Many species that vendors receive with identifying features can be difficult for non-experts to identify. The various species of rockfish on the Pacific coast of North America, for example, are a taxonomic nightmare; if even the experts are confused, how much more so are the vendors. Although the CFIA Fish List contains ambiguity when it comes to difficult fish such as the rockfish and snappers, vendors still routinely mislabel these fish. For instance, rockfish is a perfectly acceptable name for a variety of species, yet vendors would, perhaps in an effort to be helpful, add the unapproved designator Pacific, changing the name from rockfish to Pacific rockfish. This simple change matters, and is technically not legal; yet there is almost certainly no harm intended from such mislabeling. It comes from a lack of education on the topic, rather than intentional malfeasance. This is another example of semantics being confused with genuine mislabeling.

Mislabeling Rates Drop Dramatically When Restricted to the Types of Mislabeling of Interest to Consumers

Two major sources of mislabeling included the unnecessary addition of descriptors to a product name, converting a legal label into an illegal label (e.g., selling rockfish as Pacific rockfish), and the illegal use of sushi names. Yet, in both cases, the consumer typically "got" what they "bought." That is, they were not being hoodwinked; the problem lay in Canadian labeling laws, not with the product itself (e.g., Pacific rockfish was still a rockfish; freshwater eel was still *Anguilla rostrata*). In other words,

not all mislabeling is equal. Reports typically do not differentiate between these different sources of mislabeling. As already mentioned, Oceana Canada recently included all instances of hamachi in their mislabeling statistics, because Japanese amberjack can contain ciguatera toxin, while *Limanda ferruginea* does not.[51] Presumably, using the term "hamachi" was putting consumers at risk. This remains a problem, however, only as long as the CFIA does not recognize sushi names, including yellowtail, as valid. If we retain only genuine mislabeling—that is, mislabeling in which the customer did not "get" what they could reasonably have expected to have purchased based on the label—then mislabeling drops from 35% to 20%, or from just over 1 in 3, to 1 in 5. Although still substantial, this shows that a large portion of Canada's mislabeling problem is an issue of semantics rather than of fraud (fig. 2). Hamachi mislabeling drops from 100% to 8%; tuna mislabeling drops from 38% to 6% (table 1). Rockfish/snapper mislabeling, however, remains relatively high despite its prevalence in sushi.

Genuine Mislabeling Does Occur and Comes in Different Forms

Consumers, twenty per cent of the time (59/295), did not get what they reasonably should have expected to get based on the label. These sources of mislabeling can be subdivided as follows.

Legally ambiguous label, but wrong species—

The CFIA Fish List harbors a great deal of ambiguity in its naming of species (table 2). Vendors are legally allowed to apply the same label to a number of species—sometimes even if they belong to different genera or families. This should provide vendors with some legal leeway in the naming of species. For example, to be in accordance with regulations, they do not need to know the *exact* species of tuna they have as long as they label it as tuna, and it is one of the fourteen legal species of tuna. Yet, despite this, 29 of the 59 genuine instances of mislabeling fall into this category. This includes the constant mislabeling of tilapia as snapper, when snapper could have legally referred to any of twelve genera of fishes comprising 96 possible species.

Table 2. Legal ambiguity in naming results in one legal name being used for a variety of species. Some common representatives from the Canadian Food Inspection Agency (CFIA) Fish List are shown below.

Legal name	Number of listed species	Number of listed genera	Total number of species
Rockfish	**20**	**1**	**109**
Snapper	**1**	**12**	**96**
Croaker	28	1	38
Flounder	24	0	24
Sole	22	0	22
Tuna	14	0	14
Pacific snapper	**13**	**0**	**13**
Rosefish	**11**	**0**	**11**
Shark	7	0	7
Mackerel	2	1	6
Ocean perch	**5**	**0**	**5**
Tilapia	5	0	5
Redfish	**4**	**0**	**4**
Eel	3	0	3
Cod	2	0	2
Halibut	2	0	2
Red snapper	**2**	**0**	**2**
Salmon	1	0	1

Number of listed species = the number of species designated with Linnaean binomial nomenclature on the Fish List. Number of listed genera = the number of instances in which a genus name was followed by spp. (e.g., *Scomber* spp.)—indicating that all unnamed members of the genus can be marketed under that legal name. Total number of species includes all of the species that occur in a particular genus. Items in **bold** include rockfish and snapper species. This information was accurate as of August 2019.

The salmon problem—

Despite the common use of ambiguous labels to represent multiple species, there is one instance in which the CFIA uses an ambiguous label that can legally refer to only one species—salmon cannot legally refer to any Pacific species of salmon (genus *Oncorhynchus*), nor to brown trout (*Salmo trutta*), but exclusively to the Atlantic salmon (*Salmo salar*). Fourteen of 59 instances of mislabeling are oddly attributed to salmon being used as a label for a variety of species (table 1).

Unnecessarily precise, but wrong—

Given the leeway that legally ambiguous labeling provides, it is surprising that vendors sometimes go for the legal alternative, which is to be precise in their labeling. For example, cod can legally refer to Atlantic cod or Pacific cod—and some retailers want customers to know which species they are purchasing. Unfortunately, they are sometimes wrong, but this makes up a small portion of all mislabeling cases. One instance of Atlantic cod (*Gadus morhua*) was actually Pacific cod (*Gadus macrocephalus*—or a related but genetically similar species); three instances of Pacific cod were actually Atlantic cod; one instance of Albacore tuna (*Thunnus alalunga*) was actually tilapia; and one instance of golden threadfin bream (*Nemipterus virgatus*) was actually Japanese threadfin bream (*Nemipterus japonicus*—or a related species). Although there are serious conservation concerns in these few cases, they collectively made up only six of 59 mislabeling incidents, and only 2% of all samples.

Necessarily precise, but wrong—

Sometimes a species has only one possible common name on the Fish List, and this name is unique to that species. Yet, the DNA barcode revealed it to be a different species. Such mislabeling occurred only four times in our dataset, comprising <2% of all samples.

Not on the CFIA Fish List—

The remaining instances of mislabeling were also relatively rare (6 instances, <2% of all samples), but are interesting in their own right. These involved either labels on the package that could not be found in the CFIA Fish List, such that a consumer could not reasonably expect to know what they were purchasing; or DNA barcode results that pointed to a fish species that cannot legally be sold in Canada. Of the former, two products listed as Alaskan salmon, which is not in the CFIA Fish List, were returned as sockeye salmon and some member of genus *Sebastes,* respectively. Of the latter, the most interesting case was a product labeled "sea eel," which turned out to be a South American mesopelagic species of punctuated snake-eel, *Ophichthus remiger*, which is not approved for sale in Canada. It is always interesting when a food item not approved in Canada is found in Canadian markets, and the relative ease with which undergraduate students were able to unintentionally find these samples is striking.

There Are Consequences of Ambiguous Labeling

The CFIA Fish List is a living document of legal names that can be updated in light of better scientific naming practices, or to introduce new marketable species. As of this writing (August 2019), the CFIA Fish List provides information on 742 species of fish[52] that collectively have 1371 legal English names; 910 legal names are unique, due to certain legal names being used for multiple species (table 2). Any fish product, other than products containing mixtures of fish species, is required to have at least one of the legally permissible English, French, or Latin names displayed on the package—and these names must be a match to the contents of the package. The legal names are intended to do three things: (1) protect customers against "false, misleading, or deceptive" names; (2) showcase scientific knowledge; and (3) "foster fair market practices." For example, two fish of different market values should not share the same legal name. These are the ideals of the Fish List, against which incorrect or fraudulent labeling of fish foods is judged.[53]

The irony of the CFIA Fish List is that it contains built-in ambiguity that work against their own goals. Of the 910 unique market names found on the list, 138 (15%) can be applied to more than one species (table 2). Croaker, for instance, can apply to 28 different species plus all members of the genus *Nibea*, which in turn contains ten species. These ambiguous labels blur fair market practices and scientific knowledge. Yellowfin tuna (*Thunnus albacares*) and Atlantic bluefin tuna (*Thunnus thynnus*) can both be sold as tuna, but yellowfin tuna is typically a less expensive product. The label "tuna" can also be applied to species with very different International Union for Conservation of Nature (IUCN) Red List conservation statuses. A consumer could buy some-

thing labeled "tuna" and be eating either skipjack tuna (*Katsuwonus pelamis*) (status of least concern), or the near-threatened yellowfin tuna, or the vulnerable Pacific bluefin tuna (*Thunnus orientalis*), or the endangered Atlantic bluefin tuna, or the legally sold critically endangered southern bluefin tuna (*Thunnus maccoyii*) (table 3). The CFIA Fish List also intends to showcase scientific knowledge, but certain legal names have scientific connotations that are not implied by the label. For example, steelhead is a specific term referencing anadromous forms of rainbow trout (*Oncorhynchus mykiss*), but, on the Fish List, it is a term that can be applied to any rainbow trout, regardless of its life history characteristics. Although it would be difficult in practice to enforce (DNA barcoding would be unable to tell the difference between sea-run and lake forms of rainbow trout), labels like this simply do not showcase scientific knowledge, and seem to work against the mandate of preventing "false, misleading, or deceptive names" to those who have taken the time to learn their fellow fish. Despite these problems, this list is the benchmark for determining mislabeling; different countries with distinct regulations could take the same market names and the same DNA-based results and come to very different conclusions about the extent of mislabeling in their country.

Ambiguity, as already described, is built into the CFIA Fish List such that a consumer can legally not know the exact species of fish they are eating. Over two hundred products (n = 212, 72% of all samples) that were sampled had market names that were legally ambiguous, such that the consumer could not be reasonably certain of the identity of the species they *believed* they had purchased, let alone the species they had *actually* purchased. These vague labels appeared on 120 of all 193 legally labeled products. This ambiguity has two major consequences that to our knowledge have not been described before (table 4). Presumably this is not an issue isolated to Calgary.

First, *legally ambiguous labeling facilitates mislabeling*. Labels that fail to identify the species being consumed are the norm rather than the exception. This should decrease mislabeling, but oddly appears to facilitate it. Using only the genuine forms of mislabeling as previously defined, 12% of precisely labeled products were mislabeled and 29% of ambiguously labeled products were mislabeled (Fisher's exact test, $p < 0.01$). This disparity between legally precise and legally ambiguous labeling suggests that, on average, vendors apply precise labels when they are confident in the species ID, and ambiguous labels when they are not—and this lack of confidence translates into mislabeling. This is perhaps made most clear in a single species: products labeled "Atlantic salmon" are far less likely to be mislabeled than products labeled "salmon" (table 1). Both refer to *Salmo salar* alone. Of

Table 3. International Union for Conservation of Nature (IUCN) Red List global status of fish species legally sold in Canada that were potentially consumed by Calgary undergraduate students between 2014–2019.

Species name	Legal market names	IUCN Global Conservation Status
Anguilla rostrata	American eel, Eel	Endangered
Gadus morhua	Atlantic cod, Cod	Vulnerable
Hippoglossus hippoglossus	Atlantic halibut, Halibut	Endangered
Melanogrammus aeglefinus	Haddock	Vulnerable
Oreochromis mossambicus	Mozambique tilapia, Tilapia	Vulnerable
Pangasianodon hypophthalmus	Basa, Sutchi catfish, Swai, Pangasius	Endangered
Thunnus alalunga	Albacore tuna, Albacore, Tuna	Near threatened
Thunnus albacares	Yellowfin tuna, Yellowfin, Tuna	Near threatened
Thunnus maccoyii	Southern bluefin tuna, Tuna	Critically endangered
Thunnus obesus	Bigeye tuna, Tuna	Vulnerable
Thunnus orientalis	Pacific bluefin tuna, Bluefin tuna, Oriental tuna, Tuna	Vulnerable
Thunnus thynnus	Atlantic bluefin tuna, Northern bluefin tuna, Bluefin tuna, Tuna	Endangered
Trachurus japonicus	Jack mackerel	Near threatened

36 products labeled "salmon," 39% were mislabeled, while not a single Atlantic salmon product was mislabeled (Fisher's exact test, $p < 0.0004$).

Second, *legally ambiguous labeling facilitates the consumption of species of conservation concern*. There was a significant relationship between the conservation status of a DNA-identified product and the legal ambiguity of the label.[54] Ambiguously labeled products, whether mislabeled or otherwise, were more likely to include species that were designated as anywhere from near threatened to critically endangered, while precise market names were typically for species of least concern (Fisher exact test, $p < 0.00001$). Mislabeling, which was related to legally ambiguous labeling, also facilitated sales of species of conservation concern (Fisher exact test, $p = 0.0003$) (table 4).

Naming as a Call to Action

Given rampant mislabeling of fish products, both in Calgary and globally, what is a consumer to do? Some good first steps to prevent mislabeling involve changing your naming and eating practices.

(1) Avoid products with ambiguous names. Our study found that foods with precise labels, wherein one and only one fish species could legally have that market name, were less likely to be mislabeled than products with ambiguous names. Furthermore, ambiguous labels were more likely to be applied to species of conservation concern. By purchasing cod you could unwittingly be eating Atlantic cod. By purchasing Pacific cod the chances of your actually eating Atlantic cod appear to be reduced. Consumers have a great deal of power by voting with their wallet—but first you need to learn what constitutes a precise as opposed to an ambiguous species name. That is, you need to learn your fish.

(2) Purchase whole, head-on fish whenever possible. The color of fish flesh is easy to artificially manipulate; the best way to avoid mislabeling is to avoid eating, whenever possible, fragments of fish without first seeing the whole fish from which it came. If this is not possible, see points 7 and 10 below.

(3) Learn to name your fish. It is not enough to see a whole, head-on fish. You need to be able to identify its salient features in order to avoid mislabeled products. Learn to understand the difference between a sockeye (*Oncorhynchus nerka*) and an Atlantic salmon (*Salmo salar*). Be able to identify an Atlantic mackerel (*Scomber scombrus*). You will immediately be confronted with different types and shapes of scales, fins, lateral lines, mouths, etc. Foster the curiosity that results—*why* does the Atlantic mackerel have those vivid blue stripes down its body, and what are the significance of the pinnules (those little bumpy fins) that extend down its peduncle (tail region)? Why does the Atlantic cod have that strange little barbel on its chin? Just what is this creature that I am about to eat? On your plate is a creature that you are unlikely to see or encounter in your everyday experience; take the time to appreciate it for the good work of God that it is. Naming extends to educating children. Children often develop relationships with farm animals early in their childhood without ever seeing one, through books, toys, and television. I suspect we do not order mammal sandwiches or bird salads because of this early relationship.[55] There are many books about fish names geared for children that can better prepare them for ethical fish eating.[56]

(4) Eat sacrificially. According to Norman Wirzba, this entails thinking of sacrifice in terms of self-offering to God.[57] We need to recognize that God shows his love for us through food, but that this love is costly, "because for any creature to eat, other creatures must die."[58] Properly naming the things we eat—recognizing first that they are *worthy* of names beyond simply "fish"—is the first step in appreciating the sacrifice made by the creatures we eat. It is to recognize the cost of consumption, a cost that should pose serious questions about gluttony and food waste and that should raise interesting questions about the theology of fasting.

Table 4. Number of samples of least concern vs. those of conservation concern (near threatened, vulnerable, endangered, critically endangered) as identified from DNA barcoding

	Least Concern	Conservation Concern
Precisely labeled	55	8
Ambiguously labeled	48	82
Legally labeled	96	66
Mislabeled	9	26

(5) Eating sacrificially also means taking the time to respect the food by maximizing the flavor it has to offer—in other words, learn to respect the sacrifice by cooking it well. There are several books available on cooking sustainably harvested fishes that could guide you in this.[59]

(6) Eat locally. Although no study has been done on whether this reduces mislabeling, it greatly reduces the number of species you need to learn to identify. In Canada, there are more resources on how to identify various types of salmon or cod than there are about identifying punctuated snake-eels or orange roughy.

(7) Follow the labels. Marine Stewardship Council (MSC) labels are placed on fish products that meet certain sustainability criteria. Organizations such as SeaChoice and Ocean Wise Seafood also provide labels and information on sustainably harvested seafood choices.[60] These are excellent places to start educating yourself about which species are at risk and which are not, which populations are sustainably harvested and which are not, and which capture methods are better than others, in order to avoid eating at-risk species. There still needs to be trust that the market name is indeed an accurate representation of the purchased product; but by purchasing whole fish, mislabeling is less likely. Furthermore, there is good reason to believe that mislabeling is reduced for certified-sustainable products (see below).

(8) Put on political pressure for more precise market names for fish. This is done through your wallet (see point one), and also by writing to the CFIA with your concerns about legal ambiguity in its Fish List.

(9) Put on political pressure for the acceptance and enforcement of sushi names. Genuine mislabeling is still high in Japanese-styled restaurants, but gets lost in the high number of reported sushi semantics. Permitting culturally significant naming of foods not only respects those cultures and enhances our ways of thinking about different food sources, but it also protects the fish by putting the focus on genuine sources of mislabeling.

(10) Support traceability. When a fish is caught, it can move through multiple countries, processing plants, and middle men before arriving on your plate. These fish are typically not traced, and so there is no way to know who should be held accountable for mislabeling. This makes enforcement difficult. Support traceability by purchasing fish products that have been tagged from the moment they were caught and then followed through all steps of processing and transport. For instance, MSC-labeled products have enhanced traceability and therefore accountability. A recent study examined mislabeling of products with MSC labels and reported that mislabeling was less than 1% for MSC-certified products, compared to 20% or higher in other Canadian studies that did not focus on certified products.[61] Traceability clearly works.

Conclusion

The first blessing God gives in Genesis is not to humans, but to the fish and birds—a blessing to "be fruitful and multiply" (Gen. 1:22, NASB). Humans are then told to "rule over" the fish—and this command is linked to both human and fish flourishing. In other words, the responsibility to exercise God's divine blessing was given to humans. Historically, the tremendous abundance and reproductive capacity of fish gave the appearance that God's blessing on the fish could not be overcome by human effort. Indeed, as late as 1866, Thomas Henry Huxley and the UK Royal Commission on the Sea Fisheries were reporting that global fisheries were inexhaustible.[62] As long as fish were abundant, there was not much practical need to know fish names. However, today, fish blindness, resulting in an apathy toward the state of the ocean, is actively subverting God's blessing. Many fish species have gone extinct in human history, including several in Canada.[63] Fish mislabeling has diminished coflourishing by putting species at risk as well as putting human health and financial security in jeopardy, while at the same time preventing consumers from knowing the conservation status of the species they are about to eat. Problems with labeling regulations, particularly regarding ambiguity in legal names, has facilitated mislabeling and the sale of at-risk species. But this problem extends beyond the fish—an entire culture of eating has arisen that has forgotten the theological significance of food. Although this article has focused on naming and mislabeling fish, similar arguments could be made for any creature—plant, animal, fungus, alga—that we consume.

God asked Adam to name the animals; this means learning, at an individual level, to name the creatures that have been placed within our sphere of influence.

This is not an enterprise solely for the taxonomist—humankind was given this responsibility. "If you do not know the names of things, the knowledge of them is lost too,"[64] wrote the father of the science of naming, Carl Linnaeus, in 1751. Learning the names of the tremendous diversity of creatures we consume, and ensuring that "what we bought" is "what we got," is the fundamental first step in receiving God's love "made nutritious and delicious."[65] ◙

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Notes

[1]Misleading names for food products has a lengthy history. Sometimes this is done to enhance an otherwise less desirable product—e.g., artificial crab (read: pollock) being sold as "krab." Sometimes misleading names are culturally entwined, such as the Japanese art of "surimi" in which fish paste is shaped to mimic other types of food. Mislabeling in this article is based on the Canadian Food Inspection Agency Fish List and does not consider these other forms of purposeful misidentification. Thanks to an anonymous reviewer for these important points. See also Mark Kurlansky, *Cod: A Biography of the Fish That Changed the World* (New York: Penguin Books, 1997), for a discussion on cultural uses and names for cod, and the sale of fish such as haddock under traditional cod names.

[2]The topic of naming and its theological significance deserves a paper in its own right. To prevent confusion, permit me a few words here about what I mean by naming. First, I view naming as a calling for all humans, not just Adam. From anthropological studies on how cultures name living things, there is good reason to believe that Adam's naming of the animals is built into the human condition; it is part of what makes us human. To that end, I do not view naming as an inherently scientific process that is conducted only through taxonomy. Nor do I view naming as being fulfilled when a scientist writes a formal paper naming a type specimen of a new species—although that is an important part of the naming process. Rather, I view naming as something we are all called to—to observe, engage with, name, and love the flora and fauna that are within our sphere of influence. When a child begins to discern the difference between a house sparrow and an American robin, even if they do not know the precise scientific names of these creatures—they are engaging with the Adamic task of naming. Naming is also a societal task, as we determine which things are worthy of formal naming and which are not—these decisions determine the things that are protected through conservation-related legislation. For more information on naming as an aspect of the human condition, see Carol Kaesuk Yoon, *Naming Nature: The Clash between Instinct and Science* (New York: W. W. Norton, 2009).

[3]For this reason, the International Commission on Zoological Nomenclature protects the names of endangered species, and has acted to suppress changes to scientific names when it could inhibit conservation. See https://www.iczn.org/about-the-iczn/why-is-the-iczn-important/conservation/ for case studies.

[4]In Canada, for instance, there is disagreement about whether we should name benthic and limnetic stickleback (*Gasterosteus aculeatus*) as separate species or as part of a species complex. These fish exist as recently evolved, reproductively isolated species pairs within several British Columbian lakes. Each population evolved independently. Should they be considered separate species? Under the biological species concept, all benthic stickleback would constitute one species and all limnetics another, as mate choice in this system is based on visual cues such as size. Two names for these fish would provide protection for each ecotype. Under the phylogenetic species concept, each benthic and each limnetic stickleback population is independently evolved and thus warrants its own species names, resulting in independent protection for each population in each distinct lake—there would be twice as many species as there are lakes containing them. Most recently the federal government recognized benthic and limnetic stickleback as simply belonging to the "species complex" *Gasterosteus aculeatus*. This has resulted in the Canadian government reducing their estimate of the number of fish species that have collectively gone extinct in Canadian history—because the benthic and limnetic stickleback that have gone extinct in particular lakes are no longer deemed worthy of naming, and have therefore been removed from such counts. Compare for instance the 2000 and 2015 reports on Canadian biodiversity: Canadian Endangered Species Conservation Council, *Wild Species 2000: The General Status of Species in Canada* (Ottawa, ON: Minister of Public Works and Government Services Canada, 2001), https://www.sararegistry.gc.ca/document/doc079/ind_e.cfm#tphp; and Canadian Endangered Species Conservation Council, "Wild Species 2015: The General Status of Species in Canada," https://www.wildspecies.ca/reports.

[5]James H. Wandersee and Elizabeth E. Schussler, "Preventing Plant Blindness," *The American Biology Teacher* 61, no. 2 (1999): 82–86.

[6]Yoon, in *Naming Nature,* writes, "Even in that undeniable connection to the living world that every one of us makes every single day—eating—we seem less and less able to see that what we are eating is in fact the living world" (p. 21).

[7]A word about food names. Taxonomists use binomial nomenclature to name species. This is a naming convention, popularized by Carl Linnaeus in *Systema Naturae* (10th ed. of 1758 used as the exemplar) in which organisms are given a genus and species name, e.g., *Gadus morhua* identifies a particular type of fish that is related to other species within the genus *Gadus*. This type of scientific naming is different from common names, which are used by different people groups in their common tongue to refer to creatures. For instance, *Gadus morhua* can be known as cod, codling, codfish, northern cod, Atlantic

cod, etc.—and that is just in English. The Linnaean system of naming was intended to reduce the complexity of names given by scientists, while also giving scientists a single name by which to refer to an organism that would be timeless and cross-cultural. Common names, in turn, are distinct from the cultural names given to food derived from the animal. Think, for instance, of bacon coming from a pig; similarly, historically, one could buy "fish sticks," "scrod," "saltfish," "salt cod," "cod-sounds," etc., depending on the part of the fish or its mode of preparation, but all were made of Atlantic cod. Beyond cultural names for food, there are also market names, which are the names under which a food product is advertised. Market names can include scientific names, common names, cultural food names, but they can also include commercial names designed to make food products more palatable to the consumer (e.g., "krab" for pollock designed to mimic crab meat). Legal names are those market names that are legislatively enforced, and can include scientific, common, commercial, and cultural names. DNA barcoding has resulted in yet another type of "name"—the Barcode Index Number (BIN) that comprises a cluster of DNA sequences from different organisms that have little sequence variation between them. Each unique number presumably corresponds to a species, and can thereby detect cryptic species—species that are morphologically similar but genetically distinct.

[8]See John Spink and Douglas C. Moyer, "Defining the Public Health Threat of Food Fraud," *Journal of Food Science* 76, no. 9 (2011): R157–R163; Karen Everstine, John Spink, and Shaun Kennedy, "Economically Motivated Adulteration (EMA) of Food: Common Characteristics of EMA Incidents," *Journal of Food Protection* 76, no. 4 (2013): 723–35; Marilisa Bottaro et al., "Detection of Mislabeling in Packaged Chicken Sausages by PCR," *Albanian Journal of Agricultural Sciences,* Special edition (2014): 455–60; Tara A. Okuma and Rosalee S. Hellberg, "Identification of Meat Species in Pet Foods Using a Real-Time Polymerase Chain Reaction (PCR) Assay," *Food Control* 50 (2015): 9–17; Angela Di Pinto et al., "Occurrence of Mislabeling in Meat Products Using DNA-Based Assay," *Journal of Food Science and Technology* 52, no. 4 (2015): 2479–84; Charles A. Quinto, Rebecca Tinoco, and Rosalee S. Hellberg, "DNA Barcoding Reveals Mislabeling of Game Meat Species on the U.S. Commercial Market," *Food Control* 59 (2016): 386–92.

[9]For example, naming is an important component in the marketing and consumption of edible insects. The western bias against eating insects is evident at many cultural and linguistic levels. See Heather Looy and John R. Wood, "Imagination, Hospitality, and Affection: The Unique Legacy of Food Insects?," *Animal Frontiers* 5, no. 2 (2015): 8–13; and Heather Looy, Florence V. Dunkel, and John R. Wood, "How Then Shall We Eat? Insect-Eating Attitudes and Sustainable Foodways," *Agriculture and Human Values* 31 (2014): 131–41.

[10]For example, chicken, pork and beef: Di Pinto et al., "Occurrence of Mislabeling in Meat Products Using DNA-Based Assay"; olive oil: Shashi Kumar, Talwinder Kahlon, and Shweta Chaudhary, "A Rapid Screening for Adulterants in Olive Oil Using DNA Barcodes," *Food Chemistry* 127, no. 3 (2011): 1335–41; invertebrates: Morgan L. Korzik et al., "Marketplace Shrimp Mislabeling in North Carolina," *PLoS One* 15, no. 3 (2020): e0229512.

[11]Food and Agriculture Organization of the United Nations, *The State of World Fisheries and Aquaculture 2018: Meeting the Sustainable Development Goals* (Rome, Italy: Food and Agricultural Organization, 2018), accessed June 12, 2020, http://www.fao.org/3/i9540en/i9540en.pdf.

[12]Food and Agricultural Organization of the United Nations, *FAO Yearbook: Fisheries and Aquaculture Statistics 2017* (Rome, Italy: Food and Agricultural Organization, 2019).

[13]Malcolm C. M. Beveridge et al., "Meeting the Food and Nutrition Needs of the Poor: The Role of Fish and the Opportunities and Challenges Emerging from the Rise of Aquaculture," *Journal of Fish Biology* 83, no. 4 (2013): 1067–84.

[14]Boris Worm et al., "Impacts of Biodiversity Loss on Ocean Ecosystem Services," *Science* 314, 5800 (2006): 787–90.

[15]Matthew Morris et al., "Prevalence and Recurrence of Escaped Farmed Atlantic Salmon (Salmo salar) in Eastern North American Rivers," *Canadian Journal of Fisheries and Aquatic Sciences* 65, no. 12 (2008): 2807–26; and Marcel Martinez-Porchas and Luis R. Martinez-Cordova, "World Aquaculture: Environmental Impacts and Troubleshooting Alternatives," *The Scientific World Journal* 2012 (2012): 389623.

[16]Even in the Old and New Testaments, in which food regulations play a significant role, mammals and birds are differentiated by species (e.g., ox and sheep, eagle and osprey—Deuteronomy 14), and yet all fish food is described using a single generic label (e.g., creatures with fins and scales—Deut. 14:9). Despite the significance of fishing in the New Testament, the diversity of fish species in the Sea of Galilee, and the role fish play in Jesus's miracles, not one fish is mentioned by name in the Gospels. This is not to say that fish are not worthy of being named; rather, it shows that fish blindness is nothing new. Of course, fish blindness varies culturally; traditional Japanese cuisine, for example, has multiple names for different types of food derived from the same fish—my thanks to an anonymous reviewer for this reminder.

[17]Kurlansky, *Cod: A Biography of the Fish That Changed the World*. Kurlansky writes, "'Fish,' it seems, is whatever is left" (p. 138).

[18]As of the January 2020 release of *Eschmeyer's Catalog of Fishes Online*, there are 35,401 valid fish species globally; 17,827 species are freshwater. Ronald Fricke, William N. Eschmeyer, and Richard Van der Laan, eds., *Eschmeyer's Catalog of Fishes: Genera, Species, References*, 2020, accessed January 29, 2020, http://researcharchive.calacademy.org/research/ichthyology/catalog/fishcatmain.asp.

[19]Keflemariam Yohannes et al., "An Outbreak of Gastrointestinal Illness Associated with the Consumption of Escolar Fish," *Communicable Diseases Intelligence Quarterly Report* 26, no. 3 (2002): 441–45.

[20]Wandersee and Schussler, "Preventing Plant Blindness."

[21]Charlene Elliott, "Taste™: Interrogating Food, Law, and Color," *The Senses and Society* 7, no. 3 (2012): 276–88.

[22]P. D. Hebert et al., "Biological Identifications through DNA Barcodes," *Proceedings of the Royal Society of London B* 270, no. 1512 (2003): 313–21.

[23]International Barcode of Life, "DNA Barcoding: A Tool for Specimen Identification and Species Discovery," accessed January 29, 2020, https://ibol.org/about/dna-barcoding/.

[24]Dirk Steinke and Robert Hanner, "The FISH-BOL Collaborators' Protocol," *Mitochondrial DNA* 22, Suppl. 1 (2011): 10–14; and Robert D. Ward, "FISH-BOL, A Case Study for DNA Barcodes," in *DNA Barcodes: Methods in*

Molecular Biology, vol. 858 (Totowa, NJ: Humana Press, 2012), 423–39.

[25]Rachel Hodgson et al., "DNA Barcoding in the Classroom: Investigating Fish Labeling," *The Barcode Bulletin* 6 (2015): 6–7; and Kimberly A. Warner et al., "Seafood Sleuthing: How Citizen Science Contributed to the Largest Market Study of Seafood Mislabeling in the U.S. and Informed Policy," *Marine Policy* 99 (2019): 304–11.

[26]Mislabeling occurs at any point along the supply chain, from the moment of fish capture to purchase in a grocery store or restaurant. For this reason, the vendors cannot always be held culpable—they may be the victim as much as the consumer. Hanan R. Shehata et al., "Survey of Mislabelling across Finfish Supply Chain Reveals Mislabelling Both outside and within Canada," *Food Research International* 121 (2018): 723–29.

[27]Kimberly Warner et al., "Deceptive Dishes: Seafood Swaps Found Worldwide," Oceana: Protecting the World's Oceans (2016), accessed January 29, 2020, https://usa.oceana.org/publications/reports/deceptive-dishes-seafood-swaps-found-worldwide.

[28]In reality, the CFIA Fish List permits *Pangasius bocourti* and *Pangasius hypophthalmus* to be sold as "basa." A DNA-based identification of iridescent shark, however, will return the identity of *Pangasianodon hypophthalmus* because it was recently placed in a separate genus—a new scientific status that has yet to be updated on the CFIA Fish List. Interestingly, "iridescent shark," the typical common name of *Pangasianodon hypophthalmus*, is not a legally recognized market name for this species. The biology or lack thereof underpinning these regulations is fascinating in its own right.

[29]For example, Egypt: Asmaa Galal-Khallaf et al., "DNA Barcoding Reveals a High Level of Mislabeling in Egyptian Fish Fillets," *Food Control* 46 (2014): 441–45; United States: Ramin Khaskar et al., "Unmasking Seafood Mislabeling in U.S. Markets: DNA Barcoding as a Unique Technology for Food Authentication and Quality Control," *Food Control* 56 (2015): 71–76; Italy: Andrea Armani et al., "DNA Barcoding Reveals Commercial and Health Issues in Ethnic Seafood Sold on the Italian Market," *Food Control* 55 (2015): 206–14; Brazil: Daniel C. Carvalho et al., "Food Metagenomics: Next Generation Sequencing Identifies Species Mixtures and Mislabeling within Highly Processed Cod Products," *Food Control* 80 (2017): 183–86; China: Xiong Xiong et al., "Multiple Fish Species Identified from China's Roasted *Xue Yu* Fillet Products Using DNA and Mini-DNA Barcoding: Implications on Human Health and Marine Sustainability," *Food Control* 88 (2018): 123–30; and Mexico: Uriel B. Aké et al., "High Diversity of Dried Charales in Food Markets: A Mexican Barcode of Life Network Example in the Formation of Bachelor Students," *Genome* 62 (2019): 350.

[30]Warner et al., "Deceptive Dishes: Seafood Swaps Found Worldwide."

[31]Amanda M. Naaum and Robert Hanner, "Community Engagement in Seafood Identification Using DNA Barcoding Reveals Market Substitution in Canadian Seafood," *DNA Barcodes* 3 (2015): 74–79; Julia Levin, "Mystery Fish: Seafood Fraud in Canada and How to Stop It," Oceana Canada (2017), accessed July 6, 2020, https://www.oceana.ca/en/publications/reports/mystery-fish-seafood-fraud-canada-and-how-stop-it; Julia Levin, "Seafood Fraud and Mislabeling across Canada," Oceana Canada (2018), accessed July 6, 2020, https://oceana.ca/en/publications/reports/seafood-fraud-and-mislabelling-across-canada; and Sayara Thurston and Lesley Wilmot, "Mislabelled: Montreal Investigation Results and How to Fix Canada's Seafood Fraud Problem," Oceana Canada (2019), accessed July 6, 2020, https://oceana.ca/en/publications/reports/mislabelled-montreal-investigation-results-and-how-fix-canadas-seafood-fraud.

[32]Armani et al., "DNA Barcoding Reveals Commercial and Health Issues in Ethnic Seafood Sold on the Italian Market."

[33]Yohannes et al., "An Outbreak of Gastrointestinal Illness Associated with the Consumption of Escolar Fish."

[34]Spink and Moyer, "Defining the Public Health Threat of Food Fraud."

[35]Margot L. Stiles et al., "Seafood Sticker Shock: Why You May Be Paying Too Much for Your Fish," Oceana (2013), accessed January 29, 2020, https://oceana.org/reports/seafood-sticker-shock-why-you-may-be-paying-too-much-your-fish.

[36]Naaum and Hanner, "Community Engagement in Seafood Identification Using DNA Barcoding Reveals Market Substitution in Canadian Seafood."

[37]Donna-Mareè Cawthorn, Charles Baillie, and Stefano Mariani, "Generic Names and Mislabeling Conceal High Species Diversity in Global Fisheries Markets," *Conservation Letters* 11, no. 5 (2018): e12573.

[38]With assistance from molecular ecology classes at Mount Royal University and the University of Calgary. Mount Royal contributed 10 samples, and the University of Calgary contributed 46 samples, of the total of 295 samples.

[39]Barcode of Life Data System (BOLD) advances biodiversity science through DNA-based species identification, http://boldsystems.org/.

[40]LifeScanner underwent a change of ownership throughout this time. At first, samples were processed through the University of Guelph's Biodiversity Institute of Ontario, and then through Biolytica Inc.

[41]Ward, "FISH-BOL, A Case Study for DNA Barcodes."

[42]For some possible reasons for this, see Sujeevan Ratnasingham and Paul D. N. Hebert, "A DNA-Based Registry for All Animal Species: The Barcode Index Number (BIN) System," *PLoS One* 8 (2013): e66213.

[43]Canadian Food Inspection Agency, *Fish List*, last updated December 17, 2019, accessed July 6, 2020, http://www.inspection.gc.ca/active/scripts/fssa/fispoi/fplist/fplist.asp?lang=e.

[44]Established in 1964, the International Union for Conservation of Nature's (IUCN) Red List of Threatened Species is a critical indicator of the health of the world's biodiversity. Far more than a list of species and their status, it is a powerful tool to inform and catalyze action for biodiversity conservation and policy change, critical to protecting the natural resources we need to survive. It provides information about range, population size, habitat and ecology, use and/or trade, threats, and conservation actions that will help inform necessary conservation decisions, https://www.iucnredlist.org/.

[45]For more information on this statistical test, see John H. McDonald, "Fisher's Exact Test of Independence," in *Handbook of Biological Statistics,* 3rd ed. (Baltimore, MD: Sparky House Publishing, 2014), accessed June 24, 2020, http://www.biostathandbook.com/fishers.html.

[46]The difference in mislabeling between 2017 and 2019 could be due to differences in student-led sampling or to chance; but it could also reflect real on-the-ground

changes caused by the Safe Food for Canadians Regulations that were implemented in January of 2019. It will be interesting to see how present mislabeling rates compare to future years as these new regulations get enforced.

[47]Thurston and Wilmot, "Mislabelled: Montreal Investigation Results and How to Fix Canada's Seafood Fraud Problem."

[48]Levin, "Mystery Fish: Seafood Fraud in Canada and How to Stop It."

[49]Anonymous, "Japanese amberjack," *Wikipedia*, last updated April 5, 2020, accessed July 6, 2020, https://en.wikipedia.org/wiki/Japanese_amberjack. For those who prefer, a search of FishBase returns yellowtail as an American market name for *Seriola quinqueradiata* (http://www.fishbase.org), while yellowtail is listed as an alternate name for Japanese amberjack in Wendy Sweetser, *The Connoisseur's Guide to Fish & Seafood* (New York: Sterling, 2009).

[50]Levin, "Seafood Fraud and Mislabeling Across Canada."

[51]Levin, "Mystery Fish: Seafood Fraud in Canada and How to Stop It."

[52]Not including shellfish—a variety of crustacean, mollusc, and echinoderm species are also included on this list.

[53]Canadian Food Inspection Agency, "Guidance on Determining the Common Names for Fish Sold or Processed in Canada," Government of Canada, last updated January 15, 2019, accessed January 29, 2020, https://www.inspection.gc.ca/food-label-requirements/labelling/industry/fish-and-fish-products/common-names/eng/1352987508427/1352993955238. As one reviewer noted, the Fish List does not have as a goal the protection of at-risk species. Presumably, such species, if from Canada, would be protected under the Species at Risk Act (SARA) and would therefore not be available for purchase—but species that are known to be at risk often do not get listed for protection under SARA. See Jamie M. McDevitt-Irwin et al., "Missing the Safety Net: Evidence for Inconsistent and Insufficient Management of At-Risk Marine Fishes in Canada," *Canadian Journal of Fisheries and Aquatic Sciences* 72, no. 10 (2015): 1596–608. Aquatic species listed under SARA can be found at https://www.canada.ca/en/environment-climate-change/services/species-risk-act-accord-funding/listing-process/aquatic-species-protected-fisheries-act.html. As of June 2020, 75 fish species or ecotypes are listed under SARA. Species missing from SARA include the Atlantic bluefin tuna (*Thunnus thynnus*) and the American eel (*Anguilla rostrata*) which have been declared endangered or threatened respectively by the Committee on the Status of Endangered Wildlife in Canada (COSEWIC). Similarly, only one Atlantic salmon (*Salmo salar*) stock is listed under SARA, despite recommendations by COSEWIC for further protection of other stocks. This reflection does not include consideration of at-risk species imported into Canada from other countries.

[54]To calculate this, all species not found in the IUCN database or which had a rank of "data deficient" were excluded. Only genuine examples of mislabeling were included. For DNA-based identifications in which multiple species were detected, the worst-case scenario was used: thus, if the sample was either a least concern or near threatened species of tuna, the near threatened category was used.

[55]As one reviewer noted, this only extends so far—we still order only chicken, not Rhode Island reds.

[56]A personal family favorite is April Pulley Sayre, *Trout, Trout, Trout! A Fish Chant* (Lanham, MD: Cooper Square Publishing, 2007).

[57]Norman Wirzba, "Food for Theologians," *Interpretation: A Journal of Bible and Theology* 67, no. 4 (2013): 374–82.

[58]Norman Wirzba, "Eating Our Way into the Care of Our Common Home," in *Theology and Ecology across the Disciplines: On Care for Our Common Home* (2018), ed. Celia Deane-Drummond and Rebecca Artinian-Kaiser (London, UK: T&T Clark, 2018).

[59]Thanks to an anonymous reviewer for these suggestions: Jill Lambert, *A Good Catch: Sustainable Seafood Recipes from Canada's Top Chefs* (Vancouver, BC: Greystone Books, 2009); and Jane Mundy, ed., *The Ocean Wise Cookbook 2: More Seafood Recipes That Are Good for the Planet* (Vancouver, BC: Whitecap Books, 2015).

[60]Check out SeaChoice (www.seachoice.org) and Ocean Wise Seafood (https://seafood.ocean.org/).

[61]Jaco Barendse et al., "DNA Barcoding Validates Species Labelling of Certified Seafood," *Current Biology* 29, no. 6 (2019): PR198–R199.

[62]David W. Sims and Alan J. Southward, "Dwindling Fish Numbers Already of Concern in 1883," *Nature* 439, no. 7077 (2006): 660.

[63]Don E. McAllister, Brad J. Parker, and Paul M. McKee, "Rare, Endangered and Extinct Fishes in Canada," *Syllogeus* 54 (Ottawa, ON: National Museums of Canada, 1985).

[64]C. Linnaeus, *Philosophia Botanica* (1751) as quoted in Karen Magnuson Beil, *What Linnaeus Saw: A Scientist's Quest to Name Every Living Thing* (New York: W. W. Norton, 2019).

[65]Wirzba, "Eating Our Way into the Care of Our Common Home."

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Plastics in the Food Chain

Brittany Ederer and Robert D. Sluka

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Plastic pollution affects God's creation at multiple scales, from microscopic to landscape and ocean-wide effects, including the agricultural, aquacultural, and fisheries systems we rely on for livelihoods and our daily "bread." The scope of plastics pollution, especially microplastics, in mediums pertinent to agriculture and the human food chain, is staggering. Food safety, security, and human health are at risk. Though research into food web impacts is limited, especially in terrestrial and freshwater ecosystems, this article is organized to show why food web problems exist, the potential modes of interference with food webs, and the implications of plastic contamination of the food supply for human and nonhuman organisms alike. We must contend with plastic when thinking of the future of food systems, and especially when it comes to developing a robust theological framework. We suggest that there are a number of theological challenges, which are pertinent in guiding how the Christian faith might interact with the issues outlined in this article. We discuss creation care, ethical and justice issues, and biblical wisdom literature as examples of how scripture might guide us to ask the right questions as to how we should engage with threats to food systems and plastic pollution.

Food production is tightly linked to air, water, and soil quality, and vice versa. Pure, clean waters yield the healthiest seafood and fresh fish. People flourish in the land where the soil is rich and water is plentiful. Healthy ecosystems support agriculture, in addition to all of God's creation. Where the soil, water, and air is contaminated, people and creation suffer, including agricultural systems. Creation is suffering a crisis of plastic pollution: millions of tons of waste swirl in ocean gyres and fill in the crevasses of the deep; microplastics fly through the air as dust; fish, which are later eaten by birds, eat floating fragments; environmental toxins are attracted to and adsorbed onto the surface of plastics in the oceans; microfibers from the washing of synthetic clothes are applied to agricultural fields along with sewage sludge.

The goal of this article is to highlight the concerns and implications of plastics in the human food chain and in creation more broadly. We do not seek to prescribe particular solutions for reducing plastic pollution, as this is beyond the scope of this article; there are numerous resources online to suggest action. We consider the scale of the problem of plastic pollution and the scope of plastics in the food chain, followed by the damaging consequences already known, and areas of uncertainty. Much of the literature cited in this article presents evidence from the marine environment, where most scientific research has been focused. We then look to the future of food systems in light of the ubiquity of plastic pollution, and, finally, we reflect theologically on the questions raised in order to propel thoughtful conversation on the parts of communities, organizations, and individuals seeking to live in shalom with God's creation.

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The Scale of Plastic Pollution

Plastics have changed our world since their manufacture began in earnest in the 1950s, often for the better. They are a marvel of engineering: inexpensive, lightweight, moldable, and allegedly chemically inert.[1] From sports to medicine to textiles to transport to food safety, plastics play a leading role in defining the new normal, with some researchers proposing that the Anthropocene epoch be defined according to our use of plastics.[2] Unfortunately, the properties that make plastics a marvel also make them a window into the crooked heart of sinful human society, revealing the power of ignorance, idolatry of convenience, cheapness both of price and thrill, and self-centeredness. The consequences of plastic addiction, especially single-use convenience plastics, reach into and beyond the very systems that permit agriculture: they damage terrestrial, freshwater, and marine ecosystems, destroying soil, water, and air.

The scale of global plastic production and the nature of permanent synthetic waste all but ensures that plastic pollution is ubiquitous in the environment.[3] Worldwide, an estimated 8,300 million metric tons (Mt) of virgin plastics have been produced from 1950 to 2017.[4] As of 2015, 9% of total plastic waste was recycled, 12% was incinerated, and 79% ended up in landfills or in the environment.[5] An estimated minimum 5.25 trillion items of plastic float in the oceans, weighing 268,940 tons, which does not count the plastic that sinks to the ocean floor.[6] An estimated 4.8 to 12.7 Mt of plastic waste entered the ocean in 2010.[7] Clearly, the scale of plastic pollution since the 1950s, roughly the equivalent of one billion elephants in mass,[8] will affect God's creation, including the agricultural, aquacultural, and fisheries systems we rely on for livelihoods and our daily "bread."

The large-scale harm of plastic pollution is predicated in part on the size and chemical composition of individual pieces of plastic. Microplastics are typically considered to be 5 mm in size or smaller, and macroplastics generally are larger than 5 mm.[9] Types of microplastics include foam, fibers, fragments, pellets, beads, and films, though no formal categorization exists at this time. In the scientific literature, "microplastics" is often used as a catch-all term for a variety of pieces, particles, or items. In this article, we will use "microplastics" to refer to all types, and will use "items" for specific numbers, following the example of Lisbeth Van Cauwenberghe and Colin Janssen.[10] Plastics in the micro- and nanometer size range are under current research scrutiny due to their recent discovery in marine environments,[11] and their ability to affect aquatic food chains,[12] though we will not specifically focus on them in this article.

Many plastic products are created to be small, such as the microbeads in face wash and toothpaste, and are called primary microplastics. Plastic resin pellets, called nurdles, are also a primary microplastic. Though plastic does not biodegrade, it will succumb to photo degradation due to sunlight and UV exposure and mechanical fragmentation due to wind, water, wave action, and salinity, creating secondary microplastics such as fragments, fibers, and films. Microplastics, in turn, degrade to nanoplastics.[13] Plastics by design are chemically complex and diverse from one type to another,[14] making them difficult to recycle and reuse. Differences in additive chemicals, strengths, thicknesses, and sizes mean that there are thousands of different kinds and configurations.

Research into plastic pollution, its effect on various species, and the potential for harm has skyrocketed,[15] along with global awareness and social action, such as country-wide plastic bag bans and the Microbead-Free Waters Act of 2015 passed by the US Congress.[16] A few authors have raised the question of potential consequenses on food safety and security,[17] as well as on human health.[18] There is a dearth of apparent theological resources to address plastic pollution: A Rocha has created a Microplastics Toolbox for Christians, which includes educational, theological, scientific, and lifestyle resources;[19] the Evangelical Environmental Network has introduced "The Last Straw" campaign to encourage awareness of plastic pollution and action on plastic straws in particular;[20] and Tearfund, a UK-based Christian aid organization, focuses on plastic pollution reduction in poorer countries as one of their main projects.[21]

The Scope of Plastics Pollution

The scope of plastics pollution, especially microplastics, in mediums pertinent to agriculture and the human food chain, is staggering. The vast majority of plastics are generated and used on land, while a smaller percent are used and lost at sea.[22] Global waste trade inefficiencies constitute a major source of plastic pollution in oceans. For decades, higher-income nations such as the United States, Canada,

members of the EU, and Japan have been exporting most of their plastic waste to lower-income countries in East Asia and the Pacific for waste management.[23] The top four countries in the world ranked by mismanaged plastic waste are East Asian and Pacific nations, with China at the top of the list, contributing more than 1.32 Mt of plastic marine debris per year.[24] About 10% of China's mismanaged waste came from imported plastics;[25] it is thus logical that a portion of plastic waste generated on land in the United States and shipped to China was mismanaged and contributed to marine plastic pollution. In 2017 China banned nonindustrial plastic waste imports, displacing an estimated 111 Mt of future plastic waste by 2030 that will need to go somewhere else.[26]

Land-based microplastics end up in freshwater and marine environments by passing through wastewater treatment plants; this plastic waste comes from stormwater runoff, and from industry effluent.[27] A major source of microfiber pollution comes from the washing of plastic-based textiles such as fleece, which sheds 1,900 fibers per garment per wash[28] or more.[29] Billions of microplastics, both microbeads and microfibers, are released every day from US municipal wastewater into the environment.[30] Plastic pollution is a concern in inland lakes such as the Great Lakes, due to industrial activity, wastewater effluent, and littering on beaches.[31] Wastewater treatment plants in the US are releasing, on average, over four million microplastic items per facility per day into rivers, lakes, and the ocean.[32] Cristina Munari and colleagues revealed microplastics in seabed sediment in the Ross Sea, Antarctica, possibly from Antarctic research facilities.[33] Even remote Arctic Sea ice contains concentrations of microplastics much higher than those of the "garbage patch" gyres; as global warming melts the Arctic ice, these microplastics are re-released into the marine environment.[34]

Sea-based plastic pollution sources include commercial and recreational fishing, research, tourism, and shipping. Abandoned, lost, or discarded fishing gear is widely known to "ghost fish," catching and killing not just fish, but marine mammals and reptiles.[35] Derelict nets, ropes, lines, and cages, mostly consisting of plastics, were found to harm or kill coral in a study in the Gulf of Thailand.[36] In the UK, the fishing industry is the main source of marine debris, including plastics such as packaging crates, plastic floats, nets, and rope.[37] Research vessels may also release plastics.[38]

Soil microplastic contamination is not well studied, though it is known to occur through sewage sludge application, often as agricultural fertilizer. Applying sludge to land is common and more economical than incinerating, dumping at sea, or landfilling.[39] Waste water treatment may remove 98% of microplastics by retaining them in the biosolids.[40] These biosolids in the form of sewage sludge from wastewater treatment plants and septic tanks are sometimes applied to agricultural fields or deposited in landfills. Synthetic fibers were found to be a reliable way of detecting past waste sludge application to soil because they do not degrade and are not filtered out completely during treatment.[41] Agricultural materials such as plastic mulches, fertilizer bags, and silage covers can also fragment and contribute to both terrestrial and eventually freshwater and marine plastic contamination.[42]

Microplastics even disperse into the air. A study of indoor and outdoor air in Paris showed a median of 5.4 microplastic fibers/m^3 indoors.[43] The outdoor median value was 0.9 fibers/m^3, significantly lower than indoors; however, researchers note much higher microfiber levels outdoors during rain events, demonstrating atmospheric fallout.[44]

Known Deleterious Consequenses of Plastic Pollution

Animals are known to consume plastic objects either inadvertently or intentionally; internet photos of the stomach contents of albatross, whales, sea turtles, and other marine animals that have ingested plastics are widespread. A wide range of fish and shark species attack floating plastic, potentially viewing it as prey;[45] some of this plastic may be ingested. Cattle and other livestock eat plastics, especially when feeding in urban areas where trash is prevalent and animals are allowed to graze freely, resulting in malnutrition and occasionally death.[46] Plastic object consumption thus poses a challenge to agricultural livelihoods in the Global South.[47] In freshwater, environmentally relevant concentrations of microplastic items negatively affected the survival, growth, and emergence of *Chironomus tepperi*, a sediment-dwelling midge, and this response was strongly particle-size dependent (10–27 μm).[48] In humans, a person may breathe in 26–130 airborne microplastic items per day from indoor sources, exposing vulnerable people to risks of inflammatory diseases, lesions, and plastic chemical additives.[49]

Plastics also release chemicals and adsorb environmental toxins. Microbeads from personal care products attract pollutants such as flame retardants—for example, polybrominated diphenyl ethers (PBDEs). These pollutants have been shown to bioaccumulate in fish when consumed.[50] Plastic pellets (nurdles) adsorb and highly concentrate pollutants such as polychlorinated biphenyls (PCBs), DDE, and nonylphenols (NPs) from seawater, making them a toxic raft of chemicals in the marine environment.[51] Chemicals added to plastics during the molding process, such as PCBs, polycyclic aromatic hydrocarbons (PAHs), NPs, PBDEs, and brominated diphenyl ether congener (BDs) have all been found on marine plastics.[52] Transfers of hazardous chemicals from ingested plastic to fish have been demonstrated.[53] Very few studies have attempted to understand complex, real-world scenarios of microplastic and contaminant trophic level transfer through the food web in the natural environment.[54] One of these few confirmed trophic transfer of microplastics and sorbed chemical benzo(a)pyrene from brine shrimp to zebrafish;[55] another showed nanoplastic trophic transfer from zooplankton to *Daphnia magna* to a predator fish, with a deleterious effect on the top consumer.[56]

Future of Food Systems: We Must Contend with Plastic

The pervasive, demonstrable, damaging consequences of microplastic pollution explored above do not completely address the problem of potential global systems-level disruption to food security and food safety. Scientists are concerned by the possibility of ecosystem or biome contamination through outdoor airborne fallout of microfibers onto soil, water, and crops,[57] and the microplastic-facilitated spread of exotic species and harmful bacteria dubbed the "Plastisphere" across marine environments,[58] which could exert changes on land and ocean-based agricultural productivity.[59]

Plastics must be considered with regard to the health of future food systems. For example, plastic pollution is a barrier to restoring ecosystems; this effect hinders our attempts to conduct creation-friendly agriculture, where both wild and domestic species flourish. We need more and better research. Very few studies focus on terrestrial ecosystem damage caused by microplastics, despite the very high likelihood for some level of interference with ecosystem function.[60] Coral reef restoration may be stymied because corals may ingest microplastics from their environment,[61] leading to further decline of fisheries. In a study of blue mussels in Nova Scotia, farmed mussels had statistically significant higher concentrations of microplastics than did wild mussels.[62] Wild and especially farmed seafood, seaweed, and fish in marine environments may not be safe to consume due to plastic contamination. Even in land and seascapes that appear pristine, microplastic contamination is likely due to air currents.[63] Our knowledge is limited because we can see only the largest of microplastics, and very few studies have focused on nanoplastics.[64]

Plastic is in our food chain, including drinking water, and the long-term human and other creation health effects are unknown. Mortality from plastics consumption in livestock may present a food security threat,[65] particularly in the Global South where livestock graze in urban centers and in garbage. Microplastics have been found in the skin, gills, and guts of six different important fish species in China.[66] Microplastics floating in marine environments may serve as rafts for potentially pathogenic bacteria *Vibrio* species, since synthetic polymers degrade more slowly than natural materials.[67] European seafood consumers will eat 11,000 microplastic items per year according to results extrapolated from a study on blue mussel *M. edulis* and Pacific oyster *C. gigas*.[68] Pelagic microplastics concentrations in Lakes Superior and Erie are higher than concentrations reported in several ocean gyres.[69] The Great Lakes provide 30 million people with drinking water in the US and Canada.[70] Wastewater treatment plants in the US are releasing, on average, over four million microplastic items per facility per day,[71] so there is no easy solution to prevent microplastics from entering the environment—soil, water, and air.

Theological Reflections

Plastic brings ethical problems to the forefront in each of the steps in its production, use, and disposal. These include the use of fossil fuels in production and transport, justice issues related to labor, the placement of industrial plants, the uses of plastic, and, ultimately, the disposal of plastic. We reflect here mainly on plastic use and disposal, or the lack thereof. We do not fully understand the long-term ecological, biological, and human health ramifications of our plastic addiction; however, we believe

that the solutions will require robust theology and long-term commitment by the body of Christ, resulting in transformed people and places. This section offers only a few theological reflections of how the Christian faith might interact with the issues outlined in this article, but it highlights some of the major themes that can be reflected upon and applied.

Our culture prioritizes convenience and the ability to easily dispose of waste products, leading to literal mountains of trash that will exist for hundreds or thousands of years. Plastic waste is thus a symptom of a spiritual illness that causes us to seek comfort and convenience more than God's Kingdom.[72] We must consider where we will put all our trash, given the projected increases in human population and the land required to feed 11 billion of God's children. Plastic waste is outside the biological, biodegradable systems of creation. If we maintain production and management status quo, about 12,000 Mt of plastic waste will exist in landfills or in the environment globally by 2050.[73]

Psalm 104 has often been called the Ecologist's Psalm. The connections between abiotic and biotic creation alongside and interfacing with the built human world echo our ecological knowledge of food webs and the interdependence of all life. Richard Bauckham calls this interconnectedness the "Community of Creation."[74] While we alone among creatures are created in God's image, we are not the Creator; we are theological and ecological members of the community of creation. This has huge implications for our creation of plastic. The Psalmist says, "He makes grass grow for the cattle, and plants for people to cultivate—bringing forth food from the earth" (Ps. 104:14), and "All creatures look to you to give them their food at the proper time. When you give it to them, they gather it up; when you open your hand, they are satisfied with good things" (Ps. 104:27–28). This indicates that food webs ultimately were created by God and flow from his goodness to all creation, including us. Plastic subverts this system that God made by disrupting food chains and breaking the systems of nutrient recycling.

Christians have been given the "ministry of reconciliation" (2 Cor. 5:18): between people and God, among people, within individuals, and the reconciliation of humans and the rest of creation. We have seen previously how our relationship with plastic can be something that distracts from or hinders our relationship with God. We must reflect on these topics in light of how plastic is keeping us from the abundant life Jesus promised. What resources might be necessary to help people understand and reflect on these issues in light of their relationship with God?[75] Our plastic use negatively affects not only our relationship to God but also our relationship to our neighbors, a break that must be healed through appropriate action. We explore this in more detail in the following paragraphs. We also need internal reconciliation—the cross heals our broken mental and emotional health. The science in the first sections indicates that plastic pollution is likely to affect our health. How might Christians take this research into account in their ministry of reconciliation in this area? Much of what we have written in this section is part of the ministry of reconciliation between people and nonhuman creation. What exactly does it look like for image-bearers to be reconciled to nonhuman creation, and how do we know when or if that reconciliation is complete?

We live in the "already—not yet" time between the cross and the second coming of Christ, so while we are already reconciled through Jesus, the fullness of reconciliation has not arrived. Yet we can begin to understand how creation might have looked without the influence of plastic pollution. To a great extent, this is a value-driven exercise—our beliefs about what the world should be, indicate the end goal of our reconciliation. While the timeline of scripture and creation is always forward, in that our vision is toward the new creation and the New Jerusalem, we look to the past to give us indications of what is possible. In the case of habitats damaged by plastic, we can easily quantify plastic effects, but we can also imagine a plastic-free restoration. Science gives us pointers as to how species, habitats, and ecosystems function: science can help us set reasonable goals or reflect on how we might implement restoration with reconciliation as the ultimate goal. Therefore, we need to include plastic pollution in research, in restoration goals, in monitoring, and in educational engagement with the public. Church leaders, especially teachers and preachers, should speak toward reconciliation and restoration in the lives of Christians today, showing how these goals pertain to plastic pollution, guiding listeners to hopeful, place-specific application of these principles.

Food systems should preserve the praise of species, such that when looked upon from the outside, they exhibit some quality, albeit ever so subjectively, of beauty that reflects the God-bestowed value and worth of the animals and plants, and the land and seascapes where they are being produced. Plastic pollution mars the face of creation, which exists for the glory of God and speaks to the presence, divinity, power, and beauty of Yahweh (Rom. 1:20). Many do not realize that we are making the world a less beautiful place by polluting with plastic. We silence creation's praise to the Creator when we permit the loss of biodiversity and beauty, harming the general revelation of God to the world. We see throughout scripture that creation praises its Creator and that this does not stop in the new creation, but finds all creation "in heaven and on earth and under the earth and on the sea, and all that is in them" (Rev. 5:13) before God's throne, singing his praises.

Our misuse of plastic is not only silencing the voice of nonhuman creation today, but it is also influencing us in ways in which we do not realize. Children today are unlikely to visit a beach that is not polluted by plastic debris; when worse-than-before becomes the new normal, baselines are shifted and people never know what they are missing. This baseline shift is a detriment to the gospel, because fostering beauty is a signpost to the coming renewal of creation by the power of Jesus.[76] Even as we are considering plastic's impact on food systems, we must remember that food production, human use, and threats to human health and wellbeing are not the ultimate guide.

Plastic pollution is a gospel issue with justice implications. The Global North, the historical source of most plastic waste, has been pushing this waste onto the Global South, where proper recycling facilities are scarce. East Asian and Pacific nations are beginning to push back on the Global North's sending trash to them. Malaysia recently began sending 150 shipping containers full of plastic waste back to their countries of origin, including the seventeen sent back to the United States.[77] Surface currents and prevailing winds move marine plastics around the globe in and between the northern and southern hemispheres,[78] meaning that the ocean is connecting far-away places. Even the air is a great connector, making microplastics a global problem.[79] As the world attempts to curb climate change, it is possible that microplastics in soils are inflating soil carbon storage calculations,[80] because plastics are mostly carbon. Yet microplastics in soils provide none of the ecosystem services of true carbon storage, but instead pose as a long-term environmental pollutant.[81]

Plastic pollution also disproportionately affects the poor who often do not have the resources to remove plastic and other waste from their communities, leading to health problems.[82] This includes the lack of purchasing power to buy plastic-free food products and the need to purchase smaller quantities of heavily packaged products marketed by richer multinational companies.[83] Pope Francis, in his eloquent encyclical *Laudato Si'*, stresses that scripture consistently reveals God's heart for the marginalized, and that we must change structures and systems which unfairly affect the poor.[84] We must reflect on how we produce, distribute, and consume food, making sure that we exercise special concern for the most vulnerable.

We should follow the precautionary principle by halting plastic pollution before we know for sure how bad the problem could be. This is a scientific manifestation of the biblical wisdom literature, calling us to seek counsel, be patient, and not rush ahead lest we fall into a pit that we have dug. Let us fear the Lord as it relates to cleaning up our plastic mess, even as we continue using plastics in key sectors such as medicine. It will not be easy nor inexpensive to change our single-use plastic habits. Going a step beyond the precautionary principle, we must be humble, recognizing how many mistakes we have made in the name of solving a problem without properly testing or thinking through the consequences (i.e., DDT and the drug thalidomide).[85]

Finally, we think plastic pollution prevents us from properly loving God and our neighbors. In Colossians 1:15–20, Paul makes it clear that the life, death, and resurrection of Jesus is for the reconciliation of all things, whether in heaven or on Earth. By omitting creation care from the gospel, we tell an incomplete story at best, and a twisted narrative that pridefully elevates humankind beyond our position at worst. Do we love God if we dump our trash onto our neighbor's garden every week? We do this on a global scale with little thought, and we do even worse when we consider all the other ways we neglect to care for creation (climate change, deforestation, overharvesting, coastal development, etc.). Our neighbors both locally and globally depend on the fruitfulness of creation to survive and thrive. The

world's oceans and air currents not only connect us together, but they also transport our waste to others. If we are to love God and love our neighbors, we need to thoughtfully permit our Christian faith to permeate every corner of our lives, including how we use plastic.

Call to Reflective Action

We now live in a world where plastic impinges on every area of our lives. Microplastics are ubiquitous in our environment and both the known and suspected effects on food systems are significant and usually damaging. The Christian faith provides reason for hope in what is likely to be an increasingly costly experiment in the effects of plastic on our food systems. We must act, as Christ would act if he were here; in fact, he is here, working in and through us. Our intention of raising these issues is to generate thoughtful, probing scientific and theological questions. This article highlights many of the problems and reflects on the implications of our Christian faith. How will you be a part of the solution, and what will you do next? ◙

Notes

[1]"Plastics FAQs," FAQs, accessed January 5, 2020, https://plastics.americanchemistry.com/Plastics-FAQs/.

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ASA Members: Submit comments and questions on this article at www.asa3.org→RESOURCES→Forums→PSCF Discussion.

Call for Papers

PANDEMIC: FROM CHRISTIAN PERSPECTIVES

Pandemics are part of human life. We lived and died through the Spanish Flu, Ebola, and SARS, only to face Covid-19. What have we learned about how to deal with these assaults, and ourselves in the midst of them? What do we need yet to figure out? What insights might Christian perspectives bring to the table?

On the ASA and CSCA websites Luke Janssen, PhD, has written an essay that informs us about what we encounter in these outbreaks, how such pandemics have shaped our societies before, and some of the unique challenges of Covid-19.

He is well prepared to lead us on this topic as an accomplished member of the Department of Medicine (Division of Respirology) at McMaster University. He has pursued as well an MTS degree at the McMaster Divinity College to reflect on better integrating Christian faith with science. Those studies and his spiritual journey have already yielded an article for *PSCF* and three monographs.

Readers are encouraged to take up one of the insights or questions, or maybe a related one that was not mentioned, and draft an article (typically about 5,000–8,000 words) that contributes to the conversation. These can be sent to Luke Janssen at janssenl@mcmaster.ca. He will send the best essays on to peer review and then we will select from those for publication in a theme issue of *Perspectives on Science and Christian Faith.*

The lead editorial in the December 2013 issue of *PSCF* outlines what the journal looks for in article contributions. For best consideration for inclusion in the theme issue, manuscripts should be received electronically before **December 30, 2020**.

Looking forward to your contributions,

James C. Peterson
Editor-in-Chief

Book Reviews

Environment

EARTHKEEPING AND CHARACTER: Exploring a Christian Ecological Virtue Ethic by Steven Bouma-Prediger. Grand Rapids, MI: Baker Academic, 2020. 208 pages. Paperback; $24.99. ISBN: 9780801098840.

Steven Bouma-Prediger has provided us with another gem in this accessible, timely, and hospitable exploration of ecological virtue ethics. With gentle prose and storytelling, he invites readers to imagine themselves as the kind of people who are good and do good for the earth-system of which we are a part.

The book begins with a careful exposition of the title and intent of the book. There is a pithy explanation of virtue ethics and their relationship to other ethical approaches (deontological, consequentialist, etc.). He carefully dismantles criticisms of virtue ethics and lays out a framework for understanding ourselves as narrative-driven, imaginative beings. The rest of the book takes this idea seriously by engaging each of the ecological virtues through brief stories from his own life and from the lives of those who he feels embody the virtues, as well as from the larger narrative of scripture.

The book is packed with familiar voices: more-contemporary writers such as John Muir, Aldo Leopold, Wendell Berry, Annie Dillard, Bill McKibben; and those from deeper in our history such as Aquinas, Augustine, Plato, and Aristotle. This book points the reader to many other important thinkers and pulls together a broad swath of relevant ideas and themes from ecology, philosophy, and theology. As a result of reading this book, I have read more volumes from new authors as well as unfamiliar works by familiar authors. The appendices themselves are a useful resource. They include a brief and informative survey of Christian environmental virtue ethics, over twenty pages of notes from the chapters, a fifteen-page bibliography, a scripture index, and a subject/name index.

The virtues are engaged in pairs in chapters 2–5: wonder and humility, self-control and wisdom, justice and love, courage and hope. Each chapter starts with a story, moves into a survey of wisdom from across the ages, dives deeply into scripture and the history of the church, and ends with a description of someone who embodies the virtues addressed in the chapter.

In chapter 2 we are invited to live with "amazement and modesty." The book describes this as "the settled disposition to stand in rapt attention and enthralled amazement in the presence of the awe-inspiring natural world" (p. 43) and to "have a proper sense of who we are and what we know" (p. 45). To help us imagine this deeply, Bouma-Prediger opens a window into the life of John Muir as an embodiment of these virtues. Muir's exhilarating, reverent, and, at times, terrifying life, lived in wild places, is inspiring.

Chapter 3 describes what it means to live with "strength of mind and discernment." The author describes this as developing "the habitual disposition to control our desires when it comes to caring for the natural world" (p. 66). We can learn to say, "I am content; I have enough; I don't need more" (p. 66). We can develop "the disposition to make insightful and discerning judgments about our common home, the earth," to "recognize what the greatest good really is," and to acquire "the practical knowledge needed to attain it" (p. 66). Susan Drake Emmerich is presented to us as someone who has lived out these virtues in her engagement with the Tangier Island community in Chesapeake Bay and the transformation of their local ecosystem.

In chapter 4, Bouma-Prediger speaks of "living with respect and care." He describes this as "the disposition to act equitably" and "the ability to discern when to treat equals equally and unequals differentially … a kind of practical wisdom" (p. 92). We can live with "the settled disposition to care about our house (*oikos*) and its inhabitants—to promote the flourishing of all creatures" (p. 95). He then offers the example of Wangari Muta Maathai and her work creating the Green Belt Movement in Nairobi, Kenya. The planting of over 51 million trees and the training of over 30,000 women in associated occupations clearly connects the flourishing of people and place.

In chapter 5, we consider what it means to live with "fortitude and expectation." We are asked to imagine ourselves having "moral strength when fearful about real or potential ecological losses and steadfast endurance in the face of seemingly intractable ecological problems" (p. 117) and exhibiting the "settled disposition to yearn for and act to bring about … God's good future of shalom for all the earth" (p. 119). We are presented here with the work and life of Jane Goodall, who persisted in her ground-breaking, controversial, and illuminating work with chimpanzees despite serious conservation challenges, a skeptical academic community, and the pervasive sexism of the time.

This book is wonderful in that it makes earthkeeping approachable for everyone. Too many people feel overwhelmed by the enormity of the issues we face and do not really know how to proceed. By focusing first on being the kind of people who cultivate wonder, who leave a camp site clean and ready for the next camper, who tend a nest-egg grove, who grieve the violation or loss of beautiful places, we will gravitate toward the kinds of actions and ends that bring hope for our future. Ecological virtues are not sufficient, but they are orienting, shaping, and driving. Bouma-Prediger's book is convincing in this. It is clarifying and invigorating in the stories and examples provided. If you are looking

for a hopeful vision pointing toward a new creation, start here.

Reviewed by Jeff Ploegstra, Associate Professor of Biology, Dordt University, Sioux Center, IA 51250.

History of Science

SCIENCE WITHOUT GOD? Rethinking the History of Scientific Naturalism by Peter Harrison and Jon H. Roberts, eds. New York: Oxford University Press, 2019. 263 pages. Hardcover; $90.00. ISBN: 9780198834588. Ebook; $70.19. ISBN: 0198834586. Audiobook (Narrated by Sean Runnette); $19.99. ASIN: B07PDNRJHC.

Over the past half century, historians of science have done much to discredit popular myths so that, among other things, it is now clear that medieval Christians did not believe the earth was flat and Galileo was never imprisoned by the Inquisition. Among the more interesting is Ronald Numbers's critique of the thesis that science's success at explaining phenomena in terms of natural causes alone is necessarily corrosive of religious belief. In his 2007 essay "Science without God," Numbers notes that religious belief even motivated the development of naturalism as a scientific investigative tool in the sciences, even though the subsequent relationship between scientific naturalism and belief was not always one of unalloyed harmony. It is therefore fitting that further exploration of the complex relationship between naturalism and belief formed the topic of discussion at the 2013 conference celebrating Numbers's retirement from the University of Wisconsin-Madison. The papers from that conference form the basis for this volume, which bears the same title as Numbers's original essay and is edited by Jon H. Roberts of Boston University and Peter Harrison of the University of Queensland.

Harrison's introductory essay frames the collection, first by suggesting that the historical record problematizes a simplistic "connection between naturalism and human progress," in part, because ideas about what is natural and supernatural are "interdependent" and rest upon "deeper metaphysical or theological assumptions" (p. 6). It then introduces general features of the different views about naturalism and supernaturalism present throughout the volume and how these helped shape understandings of the laws of nature, the human person, and the human sciences (history, biblical criticism, and anthropology).

Harrison concludes his introduction with what may be taken as a fitting summary of the book, namely that the history of science is not one of naturalism supplanting supernaturalism but rather that "a version of naturalism flourished in the Middle Ages, to be replaced during the scientific revolution with a version of supernaturalism" (p. 18). The essays which form the bulk of *Science without God?* collectively document this shift and outline some of its causes and consequences. Daryn Lehoux explains how Greco-Roman natural philosophy generally presupposed some sort of divinely ordered cosmos with the only exception, Epicureanism, incorporating decidedly a nonnatural arbitrary swerve into its physics. Then, contrary to the claims of those who might think that the church suppressed naturalism in the Middle Ages, Michael Shank shows that "naturalist attitudes were already endemic and widespread and, for the most part uncontroversial in late-medieval learned culture" (p. 39). Next, Peter Harrison explores how early modern understandings of nature as governed by divinely ordained laws (Descartes) or behaving in lawlike ways due to divine consistency (Newton) were susceptible to theologically suspect if not wholly naturalistic interpretations. The latter issue is then further explored by Shank, who describes how Newton's physics could be co-opted by Enlightenment propagandists, to the point where even the pious (if heterodox) Newton was recast as a thoroughgoing naturalist.

The remaining chapters explore interactions between various shades of scientific naturalism and religion. A common theme is that science may be read naturalistically in different ways and often for reasons that have little or nothing to do with the science itself. Matthew Stanley points out that physics was only stripped of its theistic connotations in the Victorian era, due to the efforts of secular naturalists to ensure that physics students (and by implication subsequent generations of physicists) were taught only naturalistic views of the subject. John Hedley Brooke notes that chemistry too served as a locus of reverence for the devout chemists while sustaining the reductionist materialist views of irreligious ones, views that in turn commonly arose through consideration of such nonscientific factors as the problem of evil or clergy misconduct. Even then, when science was understood in naturalistic terms, it was often shaped in ways that reflected the religious context in which it was developed, as Michael Ruse points out in his engaging and lively argument for the existence of Christian undertones in modern evolutionary biology. Other chapters by Michelle Pfeffer, Jon H. Roberts, Nicolaas Rupke, Scott Gerard Prinster, and Constance Clark further illustrate the flexibility of naturalism, specifically in the context of Christian materialist conceptions of the soul, materialistic and reductionist tendencies in psychology, the relationship between the Bible and nineteenth-century geology, biblical criticism, and the development of anthropology as a discipline. These chapters also illustrate how different varieties of naturalism might be used in shaping science's development to reflect particular interests. As Bernard Lightman illustrates in the concluding chapter, even when these interests involved using naturalism as a tool for secularization, religious influences played a role. Thomas Henry Huxley, John Tyndall, and Herbert Spencer "were still thinking in Christian terms" as they crafted secularized natural theologies, theodicies, and eschatologies into what they saw as a "spiritually fulfilling" scientific naturalism (pp. 252–53).

There is much to commend about this volume, although a few weaknesses should be noted. The first is the collection's scope. With very few exceptions, the essays do not consider interactions between naturalism and religion outside a Western Christian context. Second, between the introductory essay's concern with debates over intelligent design and the paucity of references to the recent literature, it seems that the essays have been little updated in the interval between the 2013 conference and the book's 2019 publication.

Overall, however, the essays are characterized by thorough scholarship and present a rich mine of thought for anyone who wishes to think more deeply about naturalism, the relationship between science and religious belief, or the historical trajectories that contributed to how the natural and supernatural are viewed today. Academic libraries and serious scholars will want to add this impressive volume to their collection. Between the overall clarity of the writing and the care taken to clearly document the varieties of naturalism in play in a given historical episode, general readers and discussion groups should also find the volume an accessible source of intellectual enrichment. Although the volume's high price will likely ensure that it does not find wide distribution in ebook or printed form, those readers who do not need to make use of the extensive footnotes and index fortunately have recourse to a pleasantly narrated and modestly priced audiobook version.

Note

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SEVEN BRIEF LESSONS ON MAGIC by Paul Tyson. Eugene, OR: Cascade Books, 2019. x + 84 pages. Paperback; $13.99. ISBN: 9781532690419. Ebook; $14.00. ASIN: B081FKFRQC.

"This book is about the reality of magic in an age of science." That is the first sentence of philosopher Paul Tyson's *Seven Brief Lessons on Magic*. A more unpromising beginning for most ASA readers is hard to imagine—but wait, there is something here for us, because magic is not really what Tyson is talking about. What he means by magic is things that science "cannot see": nonscientific realities. His examples are poetry, love, thought, communication, friendship, justice, dignity, hope, purpose, joy, despair, truth, evil, goodness, and others. His message is that these things, while they cannot be measured by science and, thus, are often dismissed by radical secularists, are real. I suppose that practically every Christian scientist would agree with that.

Yet I find Tyson's terminology unfortunate. True, the German word, usually rendered as "disenchantment" in the extensive literature about secularization, could arguably be translated literally as "de-magicing"; but what an awkward and ugly neologism! Beyond linguistic aesthetics, another misleading aspect of the word magic is that in the past, magic and superstition were arguably primitive forms of technology. They represented the (largely ineffective) attempts by humans to control the seemingly uncontrollable, through the occult. Moreover, magic was explicitly forbidden in the Hebrew scriptures, presumably because of the idolatry that occult practices lead to. These resonances are the opposite of what Tyson wants to evoke. Instead, he hopes that using the word magic can somehow catch the coat tails of currently popular fantasy such as Harry Potter, and thereby gain the ideas a hearing. Maybe it will work; but I cannot bring myself to ignore these infelicities, so here I am going to use more neutral and unambiguous expressions such as "nonscience."

The case Tyson aims to make is that there are four main types of theory about nonscience: (1) animism, (2) Platonism, (3) identifying nonscience with supernatural, and (4) identifying nonscience with nonsense (he calls it the antimagical approach, and means reductive materialism, or more simply scientism). His view is (mercilessly boiled down) that theory 2 is the best theory we have, but that we have ended up with theory 4 becoming predominant in modern culture because science adopted and promoted theory 3.

Lesson One is that "We live in a High Age of Magic," in terms of the popularity of magical fantasy by authors such as Tolkien, Lewis, and Rowling, and that the yearning behind this fact may be a sign of the importance of the nonscientific, the human, etc., and of the poverty of reductive materialism. Lesson Two unpacks the four theories of nonscience, most notably identifying the idea of "*natura pura*" that is supposed to underlie the scientific revolution, as a move in ideas from animism and Platonism to a division of reality into nature and a separate supernature. Tyson sees that move as the fateful beginning of the slide into materialism, as supernature begins to be seen as superfluous. He regards "supernatural theology and anti-magic scientism" as "Mother and Child," and speaks of magic being "cast out" of nature by the supernatural theology (theory 3) that he asserts accompanies the growth of modern science.

Lesson Three presents the idea of disenchantment (meaning secularization) with reference to a few key authors, and Lesson Four critiques the philosophical incoherence of secularism in a few of its guises, concluding that "mythos and imagination are [still] profoundly active" so the myth of disenchantment is "deeply dishonest." Lesson Five argues for the importance of quality and purpose, neither of which can be discovered within the straight-jacket of scientism. Lessons Six and Seven outline the Platonic alternative, majoring on Plato's idea of Essence.

Now I have myself made the case that what I call scientism (the idea that science is all of real knowledge) is a widespread and pernicious philosophical error, frequently adopted unthinkingly by the anti-theists of this century and the last. So I welcome the critiques of scientism that Tyson offers. I also think it is good that a professional philosopher tackles these questions and explains them for a wider audience. Unfortunately, though, I do not think Tyson, in the end, makes a very convincing case.

First, he does not back up his assertions about how one idea follows from another by deep analysis of ideas or by substantial historical investigation. So I remain unpersuaded either that scientists of the sixteenth and seventeenth centuries adopted theory 3 (identifying nonscience with the supernatural), or that doing so led to a natural slide into reductive materialism (theory 4). Tyson seems in this respect to be promoting the slander that, whether Christian or not, scientists practice "methodological naturalism" by which its critics mean "doing science as if there is no God." I don't do that. And I don't think that Christian scientists down the centuries generally did.

Second, Tyson is a metaphysician. He emphasizes the importance of absolute presuppositions. That is all very well and good. But it can miss the point if it supposes that absolute presuppositions (metaphysical commitments) are adopted only for arbitrary or self-interested reasons, or that there is a stark exclusive choice to be made between "epistemological foundationalism" and "metaphysical foundationalism." In fact, there is, in the ideas of a culture and of an individual, a continuing cyclic relationship between metaphysics and epistemology. Events and experiences are interpreted within a framework provided by metaphysical commitments, but also metaphysical commitments are continually being evaluated (in those with an open and inquiring mind) in respect to their ability to make sense of experience and evidence. Modern science is enormously successful in making sense of the reproducible aspects of nature. That is one reason naturalism seems an attractive metaphysical option, because we understand nature much better today than did Plato and his followers up to the sixteenth century. It is also a reason why a full-blown return to Plato or Aristotle seems implausible to most moderns. A more balanced exposition of the strengths of Neoplatonism as well as, perhaps, its weaknesses might be more to the point.

We, Christ's followers who are interested and knowledgeable in science, have a more persuasive set of metaphysical commitments than naturalism. They uphold rather than undermine true science's epistemological persuasiveness, but they also lead us to see that there is more in heaven and earth than is dreamed of in the scientistic world view. In that, we agree with Paul Tyson; but I suspect that we arrive there mostly by different routes than his.

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Mathematics

MATHEMATICS FOR HUMAN FLOURISHING by Francis Su. New Haven, CT: Yale University Press, 2020. x + 274 pages, with questions for reflection, hints and solutions to puzzles, endnotes, and index. Hardcover; $26.00. ISBN: 9780300237139.

Mathematics is one of those subjects people unabashedly confess to being no good at, justifying their antipathy by claiming not to have much of a math brain, as if their mindset is caused by flawed genetics. Those of us who locate the origins of math anxiety more in the realm of nurture than nature—due to ill-advised and uninspired influences from parents, teachers, and peers—believe that there are effective ways to attract students (and adults) to explore and enjoy mathematics, even if they don't become mathematicians. For some, this means developing creative ways to present and relate significant mathematical ideas—going beyond worksheets, rote learning, and pedestrian applications—to engage students in imaginative recreational activities (e.g., see my review of Paul Lockhart's trilogy in the March 2019 issue of *PSCF*).

One way to reach out to those disaffected with mathematics is to connect it to their everyday lives and interests. This may involve problems, puzzles, and games, but it can also be done by situating mathematics within a larger social context—humanizing mathematics so that students experience it not as a cut-and-dried collection of rote techniques to be memorized but as a field that has been developed by human beings with desires and interests and roles within their culture. Connections can be made between mathematics and philosophy or astronomy or physics or biology or technology or business—there are many ways to link mathematics to other areas of life, because mathematics is so foundational to today's world. Mathematics can also be humanized by connecting it to literature, linking it to a poem, a song, a story, or even a dramatic presentation of some important mathematical idea or event. Studying relevant historical developments and the biographies of mathematicians provides still other linkages. The ways in which we currently calculate may be compared and contrasted with the methods used at other times and places. The rules and strategies for playing traditional games in different cultures can be analyzed using mathematical ideas.

While each of these ways reveals how mathematics is an integral part of our human experience, *Mathematics for Human Flourishing* takes a somewhat different tack.

Instead of concentrating on mathematical ideas and techniques, and showing how great mathematics is and what it can do (though some of these topics are also explored), Francis Su focuses more broadly on what human skills, habits, and dispositions—he calls them "desires" and "virtues"—are fostered by a wholesome pursuit of mathematics. His answer to the question "Why do mathematics?" is that "mathematics connects to our deepest human desires … [and so] helps people flourish" (p. 10). Su invites those who find mathematics cold, boring, and lifeless, and/or who have been demoralized and disenchanted by previous encounters with mathematics, to consider how "the proper practice of mathematics cultivates virtues" that enable one to live well, to experience shalom, to be fully human.

Su is an award-winning mathematical educator and writer and a past president of the Mathematical Association of America. He writes in an engaging manner, telling stories, making connections, explaining ideas, and posing thought-provoking puzzles and games in ways that open up new vistas for a broad audience. One might suspect, therefore, that his mathematical training and career were fairly smooth sailing. However, Su confesses that his path to mathematical success was not without considerable obstacles and disappointments. He occasionally had feelings that he didn't really belong, was once told by a professor that he would never be a successful mathematician, at times struggled with self-doubt, and for a while even considered dropping out of his PhD program. Dealing with adversity no doubt made him a stronger mathematician and communicator, and it also made him more sensitive to issues experienced by those who were having difficulty with mathematics and to the importance of addressing the human side of mathematics.

Chris, a federal prison inmate who was determined to learn mathematics on his own, corresponded with Su prior to and during the writing of this book. Excerpts of his letters and conversation are included at the end of each of the thirteen chapters and in the epilogue as illustrations of and responses to the themes and problems being discussed. As Chris is not due to be released for at least another decade, his interest and perseverance in pursuing mathematics was an inspiration for Su, convincing him that "mathematics has something to offer everyone" (p. 19). Su addresses his book, therefore, to a wide audience, especially to those who believe they are not "math people." For the most part, the level of mathematics assumed by the book is not very high, but that doesn't mean Su sticks to mundane topics ordinarily associated with elementary school mathematics. His hope is to expand his readers' idea of what mathematics is and does, "to imagine mathematics in a new way" (p. x). In this he has certainly succeeded, beyond what can be conveyed in a short review.

In advancing the idea that mathematics cultivates virtues, Su underscores that he is not saying that the pursuit of mathematics makes mathematicians more virtuous than other people. He is using the term "virtue" in the Aristotelian sense of "excellence of character that leads to excellence of conduct" (p. 10). This may not match our normal usage, but it fits into a trend in philosophy over the past half century in which "virtue ethics" has made a strong comeback.

So what are these desires and virtues that Su thinks the proper pursuit of mathematics can help promote? The book's chapters have one-word titles: exploration, meaning, beauty, truth, justice, love, and others meant to conjure up some basic human desires. Each chapter then examines various aspects of mathematics and relates them to particular virtues—for example, the chapter on exploration talks about mathematicians' use of imagination and creativity and their sense of joyful surprise and wonder at what they discover. The chapter on meaning discusses how abstract thinking can isolate and help understand key features of a situation, revealing the essential mathematical elements involved in disparate but similar phenomena; the chapter on truth emphasizes the need to think rigorously, to honestly acknowledge error, and to practice intellectual humility. Many of these virtues may be considered intrinsic structural features grounded in mathematical practice when it is done well—mathematics progresses through interactive exploration, benefits from perseverance when facing difficulties, requires abstract thinking and rigorous argumentation, and so on.

The chapters on power, justice, community, and love point out aspects of mathematical practice that probably come closer to what one would ordinarily associate with human virtues: the need to be humble, to respect human dignity, to have a heart of service, to show concern for the marginalized and oppressed, to be hospitable and loving toward others "through and because of mathematics" (p. 205). Unconditional love for those we interact with as we do mathematics, Su says, "has the promise of changing the practice of mathematics from a self-indulgent pursuit to a force for human flourishing" (p. 207). These virtues are less characteristic of mathematical practice per se and are more-human qualities one would like to see practitioners exhibit as full-orbed persons. While these may (should?) accompany mathematical practice, whether they do depends more on one's deepest commitments and aspirations and outlook on life (worldview) and not so much on one's excellence and competence in doing mathematics. At one point Su exhibits awareness that an underlying driving force must animate the virtues he discusses, saying that "every human longing contains at its core a question of ultimate significance" (p. 97). However, he never breaks out of the framework of mathematics long enough to explore this deeper religious foundation. He notes, for example, that the permanence of mathematical truths is grounded in mathematical reasoning, but does our "trust in reason" (p. 98) stand on its own, absolute, or is it grounded in something more

fundamental? Likewise, he repeatedly emphasizes that we should respect the dignity of all human beings, but he doesn't explicitly base this on humans being created in God's image. Su's decision not to delve into religious matters such as these may allow him to reach a wider audience, many of whom might find religious discussions off-putting.

Readers may still wonder whether Su's crediting mathematics with all the virtues he identifies does not claim too much for mathematics. Su admits that some might think he is making an idol of mathematics, something "to be prized above all other pursuits in life." There is a genuine temptation for someone who recognizes, as a participant, that "mathematics is a marvelous human endeavor" (p. 12) to wrongly make it "an ultimate thing" (p. 204). Su stresses, however, that mathematics is not "a panacea to address every ill. It won't solve every human problem, and it's not a spiritual answer to the ultimate purpose of humankind, [though] it does contribute in important ways to a life well lived" (p. 218). Su's ultimate loyalty as a mathematician and a human being is affirmed in the closing sentence of his acknowledgments: "as a follower of Jesus, I am grateful to the one who defends the dignity of all human beings and sustains my own experience of human flourishing" (p. 227).

In the end, then, Su's thesis is not that mathematics is the source of human flourishing but that it lends itself to being practiced in a way that promotes human flourishing. As he says in one of his public posts, "My book is about the elevation of human dignity, and how we are using math to raise people up or tear people down." At a time when character and virtue seem constantly under attack, a book showing how mathematics can support a lifestyle of love toward one's neighbor is refreshing. My recommendation: pick up a copy of Su's book and read it from cover to cover.

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Origins

THE GENEALOGICAL ADAM AND EVE: The Surprising Science of Universal Ancestry by S. Joshua Swamidass. Downers Grove, IL: IVP Academic, 2019. 264 pages. Hardcover; $17.00. ISBN: 9780830852635.

Like most things written on the topic of Adam and Eve, the ideas behind *The Genealogical Adam and Eve: The Surprising Science of Universal Ancestry (GAE)* have already proven controversial in a number of online fora and other venues. Happily, the published book presents the first truly complete discussion of the author's ideas regarding Adam and Eve as universal ancestors, including discussions of many of the questions raised prior to its publication.

The basic structure of the *GAE* hypothesis is not complicated. It stems from earlier work on the mathematical realities of deep genealogy: because of the exponential nature of ancestry, if we go back far enough in time, everyone who left descendants is the ancestor of everyone alive today.

The same mathematics can be used to demonstrate why we cannot detect genetic markers from ancestors who lived thousands of years ago. The fraction of DNA coming from any particular individual becomes twice as small for every generation back, until it is vanishingly close to zero. Swamidass devotes considerable space to the differences between genetics and genealogy, and stresses the fact that most of our ancestors are "genetic ghosts" as far as finding any trace of them in our own DNA is concerned.

The basic premise of *GAE* is to take these facts of genealogy and apply them to a couple who lived 6,000 years ago. Swamidass makes the case (which is not disputable) that all of us alive today are descendants of all the couples alive 6,000 years ago who had any descendants. If one of those couples were named Adam and Eve, then we are all descended from Adam and Eve (who may or may not have been specially created by God)—as well as from all the other couples alive at that time.

The author suggests that the substitution of genealogy for genetics in the scientific arguments about universal human descent might be useful in crafting a new theological origin story, consistent with biblical tradition. After all, from Genesis to Matthew, scripture is full of genealogies.

The book summarizes the range of interpretations of the Adam and Eve story. One of these, held by young-earth creationists (YECs) and others, is that Adam and Eve were an actual living couple from whom we are all descended. This "sole progenitor" understanding has two parts. First, all humans are descended from a single couple; and second, all people are descended *only* from them.

The book does not postulate this version as a possible scenario, since Swamidass agrees with the scientific consensus (based on modern genetic diversity) that it is not possible that a couple living 6,000–10,000 years ago could have been the first and only people on the planet. Swamidass, a specialist in computational and evolutionary biology, states that he will not put forward any idea that contradicts scientific knowledge. He presents his calculation that a *sole* progenitor couple could not be postulated later than 700,000 years ago, significantly before the dawn of *Homo sapiens*.

The proposed *GAE* hypothesis is that Adam and Eve could have been miraculously, *de novo* created by God in what is generally taken to be the biblical time frame, and that all human beings alive today (and even in AD 1, before the beginning of Christ's ministry on Earth) are

their descendants. We are also the descendants of all the other people who lived outside the Garden, and those people were the product of evolution. Since miracles are, by definition, outside of scientific investigation, nothing here contradicts scientific knowledge.

It is important to understand that Swamidass is more interested in whether this scenario is possible within a scientific world view than whether it is actually correct. Scientifically speaking, there is no point in arguing about the likelihood of the *GAE* hypothesis being true—it is something we can never know.

The author aims to raise questions more than provide answers, and to allow for a dialogue free from the instantaneous blockage produced by theological and scientific presuppositions. This book is not meant to convince skeptics or scientists that Adam and Eve were real people from whom we all descend, nor to prove to YECs that evolution is true, but to show everyone that it is possible to say (and not be scientifically wrong) that the evolution of humanity and the historicity of Adam and Eve can both be simultaneously true, thus addressing one of the apparent contradictions between traditional Christian theology and the scientific consensus on human origins.

However, one is ultimately left wondering: for whom is this new way of looking at Adam and Eve likely to provide a breakthrough and lead to rapprochement with those with divergent views? There have been diverse reactions to the book (and to the *GAE* hypothesis before publication) that suggest both hope and some doubt that Swamidass has succeeded in his goal.

Some who hold to a particular "literal" interpretation of Genesis and Romans reject the notion of people outside the Garden and insist on Adam and Eve's *sole* progenitorship. Some evolutionary creationists find the notion of inserting a miraculous creation of a single couple unnecessary concordism at best, and incoherent at worst. And many are still puzzled by some of the historical, theological, and moral implications of the *GAE* model.

If the objective is simply to rescue the miraculous story from being dismissed out of hand, that is probably worthwhile for many readers. Ultimately, I believe that Swamidass manages to provide Christians with a way to confess a belief in a literal *de-novo*-created Adam and Eve while still affirming evolution. Many nontheologians (including myself) do not need a precise and definitive hermeneutical explanation for the Adam and Eve story.

Of course, there is a danger to this approach. The hypothesis is not likely to be overturned on scientific grounds, but it has sparked a theological debate. That debate, if carried out with mutual respect and empathy, could be a positive force for improved dialogue. Alternatively, we could see a hardening of positions and no real progress.

One of the key parts of this book about the origin of humanity addresses the thorny question of what is a human being. Swamidass devotes several chapters to this critical question, from both scientific and theological perspectives. We know that every person alive today is a human being by any scientific definition of the term, and that this has been true for at least 30,000 years. But then questions abound. Were Neanderthals human? Were early *Homo sapiens* human? Are all members of the genus *Homo* humans? Swamidass tells us, correctly, that there is no precise scientific definition of human.

But the critical issue for the *GAE* hypothesis is the theological definition. In particular, were Adam and Eve and those outside the Garden equivalently human? Were Adam and Eve somehow "better" or more advanced? The author emphasizes that those outside the Garden were *biologically* equivalent to Adam and Eve. Adam and Eve are different, he argues, in that they (and their descendants) were "textual humans" in addition to being "biological humans." This doesn't really help, since the meaning of a "textual human" is not at all clear. From what I can tell, it simply means that Adam and Eve are mentioned in the text, while Jack and Shirley (who might have been Cain's in-laws) are not. In that case, what makes Adam and Eve special, and why does it matter if we are descended from them or not?

The *GAE* hypothesis holds that from 6,000–10,000 years ago, the number of people who could claim descent from Adam and Eve slowly grew to encompass all of humanity—but not all at the same time. Since this status depended on intermarriage between Adam and Eve's descendants and the descendants of those *others* living outside the Garden, some populations living in remote parts of the planet would have been latecomers to the united family of humankind.

For example, the island of Tasmania is known to have been isolated from the rest of humanity for long periods of time. Swamidass points out that genealogical isolation is quite different from genetic isolation. We know that it takes only one breeding individual from outside a population to rapidly convert it from genealogical isolation to unity with the outside. But this answer does not fully address the many issues that arise from the historical division of humanity into two categories—genealogical descendants of Adam and Eve, and those "not yet" their descendants. Was their birth, life, and death outside of the very theology that we are trying to rescue? Did they not matter to God? The author certainly does not affirm any such thing, but given humankind's experience with colonialism and racism, many have found the implications of this idea problematic.

Swamidass considers the issue of racism in great detail. He points out that human monophylogeny was not universally accepted in the past, and even today there are some who believe that human beings did not arise

from a single population but from different geographic locations (polyphylogeny). One of his arguments is that *GAE* is consistent with human monogenesis (all humans descending from a single ancestor) and roundly dismisses racist polyphylogenetic ideas. But since the timing of the "monogenesis point" is not as clear-cut with *GAE* as with the sole progenitor model, this issue may remain controversial for some readers. For those who seek clear, definitive answers to how we can easily reconcile the evolution of *Homo sapiens* with the biblical story of a single miraculously created couple who *alone* gave rise to humanity, this book will be disappointing, since such answers are probably not possible, and this was never the purpose of *GAE*.

I think that the important accomplishment of this book is the weakening of previously unquestioned presuppositions on all sides of the debate. Before publication of *GAE*, Christians could take various noncompatible positions on the origin of humanity, and dialogue was difficult. This book is proposed as a starting point, rather than as an answer. The author writes at the end of the book, "It is however a starting point for an exchange, a place where we might understand and embrace our differences."

Christians with opposing views on Adam and Eve may not come to an agreement, but new spaces for dialogue have indeed been opened up. For this, Swamidass deserves our appreciation, and the book deserves to be read by all.

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ON THE ORIGIN OF CONSCIOUSNESS: An Exploration through the Lens of the Christian Conception of God and Creation by Scott D. G. Ventureyra. Eugene, OR: Wipf & Stock, 2018. 324 pages. Paperback; $35.00. ISBN: 9781532655173.

As a philosopher with years of research in philosophy of mind and a Christian of many decades, I welcomed the invitation to review this book on the origin of consciousness "through the lens of a Christian conception of God and creation." However, I was also somewhat flummoxed as to what the book was to be about, as its title is less than transparent to any specific meaning. It turns out that this is a book about how theological and scientific research might fruitfully influence one another in the task of understanding the origin of embodied human consciousness.

The space allotted to this review is much too limited to do justice to the immense array of ideas densely packed into this volume. I shall instead offer very minimal summaries of chapters, highlight a few of the book's central themes, and conclude with two criticisms of the book. This, I believe, will be sufficient to give a good sense of what to expect from this book.

Ventureyra, in his Introduction, provides an overview of the science and religion dialogue, touching upon big bang cosmology, finely tuned laws of physics and the origins of life, objective morality, freewill, and consciousness, as well as the mind-body problem. He also discusses foundational ideas he will return to in more detail in his later chapters.

In chapter 1, he wrestles with methods and models of the science-religion relation, settling on his preferred model of the science-religion dialogue: a modified version of Robert John Russell's eight pathways of "creative mutual interaction." This model yields five pathways by which scientific research programs can influence theological research programs and three by which the latter can influence the former. The rest of the chapter critically appraises these pathways of bi-directional influences.

Chapter 2 shows that neither science nor theology can get along without philosophy; philosophy is operative in each and, as well, is a mediator between them. This chapter delves into philosophy of science, highlighting both the philosophical shortcomings of scientific materialism and the strengths of critical realism, and laying the theoretical bases for Ventureyra's own proposal of an evolutionary natural theology, what he calls the "cumulative evolutionary natural theological argument from consciousness."

Chapter 3 covers various models of evolution and creation, assessing their potentials of mutual compatibility and their possibilities of accounting for God's actions within his creation. Ventureyra favors "directed evolution," a theistic form of teleological evolution in which God intervenes in his creation throughout its history, not just front-loading initial conditions that over time output his eternal design. Indeed, Ventureyra suspects that God must interact with creation through its informationally porous nature—namely, by constraining/directing its eventual permutations and emergences at the quantum level.

Chapter 4 dives into the scientific theology of Teilhard de Chardin. According to Ventureyra, Teilhard espouses a "Christocentric panentheism" that entails a mild form of Creator-creation identity and lays the groundwork for a view of consciousness as an emergent property of evolutionary processes. As Teilhard expresses the import of this panentheism, "God does not make: he makes things make themselves" (pp. 127–28).

In chapter 5, Ventureyra explores a number of theistic arguments—from the ancient Kalam cosmological argument to contemporary fine-tuning anthropic and design-information-theoretic arguments. He believes these arguments establish the plausibility of belief in the Christian God "as the source of the origin of human self-consciousness" (p. 180). All of these arguments, in one way or another, contribute to Ventureyra's contention that God's ontological simplicity coupled with his

creation *ex nihilo* make it highly probable that an infinite conscious mind has always existed and is what best accounts for the evolutionary origin of finite human self-consciousness.

Chapter 6 brings systematic theology explicitly into Ventureyra's discussion of human capacities for higher cognitive functions and moral consciousness. These capacities, says Ventureyra, demonstrate the involvement of the Holy Trinity in our creation and brought forth the image of the Creator. This is the shortest chapter of the book, and the least valuable (in my opinion).

Chapter 7 is really the centerpiece of the volume. Here Ventureyra applies Russell's Creative Mutual Interaction framework specifically to the question of the origin of consciousness. As a key example of how theology can helpfully interact with science, Ventureyra contends that God's simple and eternal consciousness is a much better explanatory posit than the so-called "nothingness" out of which quantum cosmologists presume the big bang birthed the universe. Instead of seeking to milk the universe's undeniable rationality, life, and embodied consciousness[es] from an original fluctuation in a quantum vacuum, why not start with God's metaphysically simple "mind/consciousness as the primary candidate for grounding reality" (p. 205). With this small but monumental shift of original posit, the naturalists' utter befuddlement at the origins of these staggering cosmic anomalies gives way to an expectation of "information and consciousness [as] vital aspects of reality" (p. 205): "Consciousness begets consciousness" (p. 206). That is, God, as the eternally conscious Creator, nonphysically interacts at the quantum level with his informationally porous creation to direct its evolutionary contingencies ultimately to evolve finite, embodied, conscious image-bearers who interact with their own bodies nonphysically in accord with some scientific information-based theory of consciousness.

Chapter 8 covers three different views of consciousness expressed in the writings of Christian theists: J.P. Moreland's substance dualism, Bernard Lonergan and Daniel Helminiak's tripartite model, and Philip Clayton's emergent monism. These three views are nonreductive and, according to Ventureyra, "fit well with notions of God interacting through informational processes" (p. 278). Although he finds specific elements of their views problematic, he, nonetheless, identifies aspects of their positions, such that, when they are judiciously joined, demonstrate that "the classical Christian conception of God and creation is not only compatible but provides a plausible explanation for the origin of consciousness" (p. 269).

Ventureyra concludes his book somewhat modestly, admitting that "[m]uch of [his] book has been exploratory and speculative in nature" (p. 275), and that he has provided no answer to the question of "precisely how or by what process consciousness originates or emerges" (p. 271). Nonetheless, he claims that his book not only "plausibly explain[s] *why* [my emphasis] there are such things as self-consciousness, moral aptitudes, volition, etc." (p. 279) but also "plausibly affirms the Christian conception of God and creation" (p. 282). His parting wish is that this book will help to inspire further multidisciplinary "research into the origin of consciousness through the use of the Christian conception of God and creation" (p. 282).

Before closing with a few critical comments, I have collected three central claims that are assumed, asserted, or defended in Ventureyra's book.

1. Regarding the relation of science and religion:

   Science and religion are not in conflict; nor are they utterly incommensurable. When their relation is philosophically mediated and situated in the broader context of Christian theism, they can mutually support and constrain each other, such that they synergistically open up new metaphysical horizons for understanding non-empirical and nonphysical realities.

2. Regarding God and his relation to creation:

   God is the God of classical theism: a self-conscious, Trinitarian personal being who is omnified in the transcendentals and power, and whose existence and essence are one. God freely created an informationally porous reality in which he acts through manipulating, nonphysically, its quantum probabilities.

3. Regarding consciousness and God's relation to human consciousness:

   The emergence of consciousness is inexplicable without the pre-existence of mind. God is the ultimate cause of finite consciousness in all its forms and intensities. Human consciousness is inextricably linked to the image of God. God's simplicity of being is an analogue of the unity of human consciousness's first-person perspective. Human consciousness cannot be reduced to the physical functions of the brain, as consciousness is the product of the divine originator.

In closing, I will reserve my criticisms of the book to two: one dealing with form; and one, with content. Regarding form, Ventureyra's writing style is less than pleasant to read. It is highly repetitive, self-referential, passive, and vague. Moreover, it is rife with acronyms (41 to be exact) that force the reader to return continually to the abbreviation list at the front of the book. Regarding content, Ventureyra tends too simplistically to gloss over the problematic issues of Creator-creation and mind-body interactions by relying upon a reifying view of information that construes it as an intrinsically transcendent reality, able causally to traverse the ontological gaps he posits between nonphysical and physical realities. The only justification he offers for giving information this transcendent role is the fact that information is susceptible to multiple realization and thus irreducible to physics. However, at best, multiple realization and irreducibility do not bestow upon information the

kind of interontic causal agency he ascribes to it. Nor does it address the relevant antirealist readings of information that construe it as a perspective-relative artifact of highly selective abstract descriptions of physical events and relations.

Overall, Venturyra's book is worth reading, if only for further disclosing the failures of human intentions to capture within the a priori structures and functions of finite consciousness, what from outside them originates and sustains them.

Reviewed by Robert Doede, Professor of Philosophy, Trinity Western University, Langley, BC V2Y 1Y1.

JESUS LOVES YOU AND EVOLUTION IS TRUE: Why Youth Ministry Needs Science by Sara Sybesma Tolsma and Jason Lief. Minneapolis, MN: Fortress Press, 2019. 227 pages, including title pages and dedications. Paperback; $32.99. ISBN: 9781506439730.

Despite the best efforts of many scientists, theologians, biblical scholars, and historians, there are still many people in the general public who see science and faith as being at odds with one another. The conflicts that arise from this perspective can have unfortunate consequences. One possibility is that they can lead Christian young people to eschew the findings of modern science, but studies have also shown that these contentions cause some to leave their faith behind altogether. In *Jesus Loves You and Evolution Is True: Why Youth Ministry Needs Science*, Sara Sybesma Tolsma (a geneticist and cell biologist) and Jason Lief (a practical theologian) team up "to point out the transversal spaces that exist between theology and biology so that the Christian community might see how the science-and-faith issue is not an either/or choice" (p. 3). In alternating chapters, the book's authors elaborate on their areas of expertise, with Tolsma penning chapters on scientific issues and Lief expounding on various theological topics.

In her chapters, Tolsma touches on a wide range of scientific topics that often come up at the faith-science interface. In chapter 1, she discusses evolution, diving into some of the evidence for the evolution of life on Earth, as well as common objections to evolutionary theory. She also introduces evolutionary creationism as a viable position for Christians, a view that seriously considers both modern science and orthodox Christianity. Chapter 3 focuses on human origins specifically, including a genetic primer and expounding on how human genomes speak to human history, thus providing additional evidence for common ancestry. Chapter 5 takes a bit of a different turn, focusing on climate change and racism and revealing how our evolutionary connectedness should lead us to care well for one another and the nonhuman creation. In chapter 7, Tolsma attacks one of the central objections to the acceptance of evolution from a Christian perspective: the roles of death and suffering that are inherent to the process. She discusses the central role of death in the functioning of ecological systems, as well as the importance of cellular death for the immune system and other molecular processes to function properly.

Throughout her chapters, Tolsma tackles complex topics in ways that are clear, thoughtful, and scientifically accurate. She makes excellent use of analogies at various points, including a language analogy in chapter 3 to help explain the evolutionary inferences we can make from genetic differences. She also highlights excellent examples to illustrate particular topics. For example, a process called autophagy, which can help cells utilize worn-out proteins and organelles from dead cells in new ways, proves to be an excellent illustration of "[sacrifice] and destruction [making] room for us to build something that can flourish" (p. 189). While readers with strong backgrounds in science might be left wanting more details or wishing for a bit more nuance in certain places, Tolsma does an admirable job of unpacking the topics in a way that walks readers through the key points and provides enough details to illustrate why the scientific community has reached a consensus on these topics.

Lief's alternating chapters focus on his expertise: rethinking theology, with the influence of scientific findings, to meet the needs of young people. He begins his sections by indicating the importance of the doctrine of the incarnation, namely Christ as both God and human, to help people better understand the need to live an embodied human experience. He describes this doctrine as "the divine affirmation … and the embrace of our condition of becoming," citing influential spiritual leaders such as Karl Barth, St. Francis of Assisi, and Bonaventure to indicate that embodied spiritual life is nothing new to Christian thought and theology (p. 55). To Lief, however, the implications of such a way of thinking are more rewarding than what the current state of American Christian teaching offers young people, a topic that he explores in later chapters.

Lief begins with the doctrine of the Fall, the shift of humanity from innocent obedience to guilty disobedience. A modern assessment of the Fall, he writes, is more akin to an ancient Greek worldview of metaphysics, which prioritized the spiritual realm over the material. By contrast, Lief roots the doctrine of sin in the very notion of this disembodied abstraction: "[Sin] is about trying to become more than our material life" (p. 86). The death and resurrection of Christ, then, is the loving correction to the prioritization of the spirit over the body. It is the demonstration of a God whose interest lies in the purposes of salvation, in the laying down of one's finite existence for someone or something greater than oneself. Lief's description of God is of one who suffers alongside creation and, in so doing, demonstrates that love renders the universe meaningful. Throughout his reframing of the theological discourse, Lief consistently brings readers back to the implications of such openness to reinterpretation, namely permitting

young people "to explore how their bodies, their biology and psychology, shape their spirituality and their identity" (p. 101). By Lief's assessment, churches have failed youth by offering a hollow shell of the Christian faith that neither addresses their lived experiences nor equips them with the tools to "cultivate an imagination to make sense of the world" (p. 200).

Throughout the book, both authors hit their stride when they explore complex topics in their respective disciplines, using everyday language and illustrations that make their findings accessible to a broad audience. Furthermore, neither author sacrifices the accuracy of their findings for accessibility to the general public. Together, Tolsma and Lief illustrate how modern science and Christianity need not be at odds, but can instead be integrated with one another to craft a deep and robust faith.

However, they often treat the specific application to youth ministry like the essential glue that connects two disciplines that they have already demonstrated to be deeply interconnected. While their assessments of youth culture and youth ministry are accurate, there are relatively few specific applications of the book for a youth ministry context, especially given what one might expect from the book's title. Lief writes that the very point is to keep the conversation open-ended; however, one cannot help but wonder if setting the foundation with some fundamental action steps would have helped to make the topic of youth ministry feel more like the central focus of the book. However, with all that stated, if the intended audience is people who would like to see the church engage more with science, youth, and different theological perspectives, then *Jesus Loves You* certainly accomplishes this task.

Reviewed by Ryan M. Bebej, Associate Professor of Biology, Calvin University, Grand Rapids, MI 49546; and Chris Curia, Director of Youth Ministries at Fairway Christian Reformed Church and Young Life Church Partner, Jenison, MI 49428.

Technology

BORED, LONELY, ANGRY, STUPID: Changing Feelings about Technology, from the Telegraph to Twitter by Luke Fernandez and Susan J. Matt. Cambridge, MA: Harvard University Press, 2019. 464 pages. Hardcover; $35.00. ISBN: 9780674983700.

Many books and articles have been written about our current love-hate relationship with technology. This book explores this common theme in a novel and very helpful manner. The authors, a husband and wife team, explore the topics by first going back to the early days of America and examining how people wrestled with the new technologies of their time such as photography, the telephone, television, and the car. They proceed to track the varying responses from those early times up to and including the present.

Luke Fernandez is Assistant Professor in the School of Computing, and Codirector of the Tech Outreach Center, at Weber State University. Susan J. Matt is Presidential Distinguished Professor of History at Weber State University.

If you are interested in how we arrived at our current conditions, this book gives a rich and extensively documented explanation. The investigation is done in six parallel chapters: "From Vanity to Narcissism," "The Lonely Cloud," "The Flight from Boredom," "Pay Attention," "Awe," and "Anger Rising." About 80 pages of notes follow. The first half of each chapter explores the past and the second half explores our current context. These excerpts encapsulate this approach:

> Nineteenth-century Americans often saw virtue and value in solitude … Solitude is a hard sell—it resists being commercialized or packaged. In contrast, the networks that contemporary Americans often turn to in order to stave off loneliness are commercialized … (p. 11)

The authors suggest

> that human nature and emotions are not static categories; instead they change subtly as a result of shifting economic orders, vocabularies, ideologies, theologies, and technologies … feelings are, at least in part, historical artifacts … the culturally specific words and categories people use to understand and describe feelings actually affect, shape, and hone them. (pp. 17–19)

I found the historical exposition in each chapter to be the most unique and helpful contribution of this book. Frequent summaries, such as the following excerpt, help the reader clearly track the exposition.

> While boredom was now widespread in America, it had not always been. In the eighteenth century, it did not even exist yet as a feeling. In the nineteenth century, it was deemed a rarity in the United States, a feeling that was largely unknown to a nation of hard workers. However, in the twentieth century, with the spread of the word [boredom], and with a declining faith in the redemptive power of both industry and leisure, it had become a problem. Suffering through dull times no longer offered moral gifts; instead, it was a problem emotion in need of a cure. (p. 170)

This summary appears as the writers transition into a discussion of boredom in our age. As that discussion ensues, the reader encounters assertions such as "the class divisions that historically influenced how boredom was experienced and expressed have become amorphous" (p. 172).

The authors not only examined a large collection of printed documents, they also interviewed a substantial number of people from a variety of age, ethnic, and occupational backgrounds. The book contains many

first-person quotes, such as this one by a young woman named Alta, found in the boredom chapter.

> I find when I am doing homework I have to go put my phone in a different room and ignore it. Otherwise, if I get bored or I start mind wandering I'll grab it and start checking. So it wastes a lot of time. Not productive time. (p. 177)

The authors do not neglect the role of race, class, and religious faith in America. At the end of an exploration of the changing reactions to the advent of the telegraph (including examples of how views from the pulpit changed over time), the authors present this summary:

> Collectively, the dreams that Americans vested in the telegraph revealed deep longings to escape the inherent limitations of being human, of being separate, apart, sometimes lonely, and tragically finite. They optimistically believed that the telegraph, through its invisible but powerful connections, could join people across great distance, create a new community that was unbounded by the constraints of time and space, and break barriers between man and god, living and dead. The awe they felt expressed their belief that there were forces larger then themselves in the universe, forces that might bring true reunion and communion. (pp. 256–57)

They then proceed to note the disillusionment experienced when most people found the telegraph far too expensive to use except in times of crisis, such as a death in the family.

In the chapter on awe, the authors assert, "The awe that twenty-first-century Americans express has been redefined; it is a weaker and far more secular feeling, and therefore less likely to take them outside themselves, for the things that awe them today are their own creations" (p. 271).

The book carefully builds to the ideas that have been highlighted in these representative excerpts. The assortment of ideas explored in the six chapters present a rich collection that I found fascinating. We are told in 1 Corinthians 2:15, "Those who are spiritual discern all things" (NRSV). This book is a great resource to help us discern how we arrived in our current setting; it also provides helpful ideas that can assist us as we choose how to wisely use our technologies.

Reviewed by Eric Gossett, Department of Mathematics and Computer Science, Bethel University, St. Paul, MN 55112.

TECH·NOL·O·GY: Critical History of a Concept by Eric Schatzberg. Chicago, IL: University of Chicago Press, 2018. 344 pages including acknowledgments, notes, bibliography, and index. Paperback; $35.00. ISBN: 9780226583976.

Over three decades ago, I was coordinator of a Calvin Center for Christian Scholarship research team investigating technology [see *Responsible Technology: A Christian Perspective*, Eerdmans, 1986]. What would I have given to have had this book in hand as our team struggled to give definition to technology and map out our research strategy! Eric Schatzberg, the author of *Technology: Critical History of a Concept*, was a long-time faculty member of the History of Science Department at the University of Wisconsin-Madison. When this illustrious department merged with the university's larger Department of History in 2017, Schatzberg became chair of the School of History and Sociology in the Ivan Allen College of Liberal Arts at the Georgia Institute of Technology.

What Schatzberg presents in his book, a book many years in the making, is a detailed conceptual history. Granted that in our lives technology is everywhere. But what in the world is it? And how should we define it and live with it? Are there certain prime realities that categorize it, or must we be satisfied with more pragmatic solutions to technology's character? Schatzberg sets out to clarify that question by recounting technology's long history from the ancient Greeks to modern thinkers and technicians. Complicating matters has been the tension between scholars and practitioners throughout history in understanding technology.

Technology is layered: an introductory chapter and a concluding chapter (complete with a manifesto) sandwich eleven historical chapters, highlighting the shifting meaning of the concept technology. But, admirably, there is more than historical telling going on in Schatzberg's account. The overriding idea (amply reflected in the concluding manifesto) he wishes to advance is the need for a "cultural meaning of technology" in contrast to an "instrumental" meaning. Schatzberg maintains that if we are not clear about the conceptual history of technology and its different contextual meanings, we all too easily fall prey to accepting a reductionist take of technology, too easily seeing it as a deterministic force (or indeterministic force) in our lives. Schatzberg leaves no target untouched, whether it be Thomas Friedman or Jacques Ellul. He is particularly concerned with academic scholars who have a bias for theory over practice or principles over applications.

The eleven intermediate chapters take us on a journey: from Greek *techne* (skilled making of things) and the Latin *ars* (or art, slowly broadened to include all types of learning), to the medieval European conception of mechanical arts (viewed as being subordinate to the liberal arts), and to alliances generated in later centuries which kept privileging head over hand (pp. 48, 50). In the eighteenth and nineteenth centuries, the mechanical sciences were seen as applied science, and the often-intense discussions and debates between natural scientists and engineers ensued. Schatzberg also examines terms such as technologie and technics. The German locution, Technik, in the hands of the American social critic Thorstein Veblen, became determinative for early American reflection on technology. One could

eventually say technology as technology received its status only in the 1930s.

For our purposes, chapter 13, "Conclusion: Technology as Keyword in the 1960s and Beyond," is perhaps the most relevant. Schatzberg traces the modern senses of technology in the second half of the last century: technology as the industrial arts, technology as applied science, and technology as techniques. Subjects such as technology as innovation, technology and social change, and critiques of technology in the 1960s are briefly explored. Technology taken as an oppressive system of technical knowledge in Jacques Ellul, Herbert Marcuse, and Lewis Mumford is followed by a discussion of "contested technology" by Ralph Nader, Rachel Carson, Barry Commoner, and E. E. Schumacher.

What I found most interesting and valuable in this book, in addition to all the nuanced historical insights, is Schatzberg's effort to speak to the nature and future of technology. He ends with a two-page manifesto entitled "Rehabilitating Technology" that begins as follows:

> This book is not a neutral work of scholarship but rather an intervention in the present, a first step in rehabilitating technology as a concept for history and social theory, with an eventual goal of shaping technologies toward more human ends. (p. 235)

Schatzberg wants to rehabilitate technology from scholars who tend to reduce technology to instrumental reason or from determinists who view technology as being driven by its own ends. He wishes to give a cultural face to technology: one that is driven by human agency and choice, interested in reestablishing cultural links between the arts (in the old sense) and technology, open to reclaiming the crafts as an essential element of technology, and careful of the nature of application of science and technology.

Cultural values couched in human agency ride high: technology as the "creative expression of human values and strivings, in all their contradictory complexity" (p. 232). We need, Schatzberg argues, to change our view of technology, to think ethically, and to see it as an expression of human values. But, unfortunately, there is little mention of any normative considerations either in the evaluation of technology or in the design process integral to technology—something *Responsible Technology* attempted to articulate in its halting fashion and discussion of normativity in the design process. That would perhaps have meant writing another book.

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Letters

A Greater Degree of Discontinuity

"Rethinking Abiogenesis: Part 1, Continuity of Life through Time," (*PSCF* 72, no 1 [2020]: 25–35) by Emily Boring, J. B. Stump, and Stephen Freeland provides a fascinating and thoughtful view of the nature of evolutionary continuity, especially as related to the origin of life. There seems to be no question that evolutionary continuity (as Darwin originally proposed) is profoundly important and a generally accurate concept for most of the history of life. The authors correctly argue that when probing the details of the emergence of life, ignoring specific cases of continuity (as in the example they give of the appearance of the canonical set of amino acids) runs the risk of missing an opportunity for advancing our knowledge.

The same could be said, however, about ignoring those instances where an apparent discontinuity should lead us to a more in-depth exploration. We know that there are clear examples of discontinuity throughout evolutionary history that have been accepted by the majority of biologists.[1] These include such events as the origin of eukaryotes by endosymbiosis[2] and the origin of vertebrates, which appear to have involved at least one whole-genome duplication event.[3] Gould and Eldredge's theory of punctuated equilibrium is supported by a good deal of evidence for discontinuities in the evolutionary record.[4]

The authors argue that because of the continuity principle, the unequivocal identification of any particular event as the beginning of life is impossible. Extending the general evolutionary paradigm to the big bang, the authors state that "natural selection is not limited to acting only on what we take to be alive" (p. 30). That could be true, but natural selection is not the whole story of evolution. They go on to say that anything that leaves copies of itself can evolve if some of those copies are able to produce more copies than others. While that seems like a logical statement, it ignores a critical feature of biological evolution.

Stated simply, it is not enough to make copies of oneself (with variations). The copies made must be accurate enough so that whatever features natural selection acts upon are copied correctly through generations. If the copying mechanism is 100% perfect, there will be no variations and no possibility for evolution. But if the copies are only 50% accurate, and only half the features of the parent(s) are retained in the offspring, it is quite likely that any phenotypic features recognized by natural selection to be worth selecting will be lost, and evolution of the fittest will not happen. And if the replication accuracy is poor enough, the new cell or organism might not even survive ("error catastrophe").[5]

How accurate must the copying mechanism be? In all modern life, the answer is roughly 99.9999%. In order

to avoid an error catastrophe, the maximum replication error rate for an informational molecule such as DNA or RNA is equal to the inverse of the molecule length.[6] As the authors mention, an RNA ribozyme that can serve both as an informational storage and catalytic molecule must be at least several hundred nucleotides. But even a very small such molecule of, say, 50 nucleotides means that the replication error could not exceed 2%; that is, a 98% accuracy is required. This is far beyond the capacity of any such early replicator as far as we know at present.

While we can imagine a form of life that might not evolve yet still carries out various metabolic and even replication functions,[7] many biologists assume that "life" began when the process of biological evolution became possible. Some textbooks even use this as a definition for life.

The evolutionary process requires pretty much everything we see in the central dogma, including DNA as the informational storage molecule with highly accurate replication, transcription, and translational machineries.[8] Once we begin to have functional biological evolution (with high replication fidelity), we have reached a cell indistinguishable from the Last Universal Common Ancestor (LUCA). We have no good theories as to how life could have evolved before biological evolution, as we know it, was possible.

I am not arguing against the authors' overarching view of continuity in nature and the difficulty, if not impossibility, of determining any particular point at which a new feature of the universe began. For most purposes, continuity is a coherent and useful way to approach the reality of biology and all of nature, both scientifically and theologically. My goal is to stress the aspects of those natural processes, such as the origin of life, that show a greater degree of discontinuity than is seen, for example, in the evolution of life after LUCA. This includes the problem of the evolution of replication fidelity.[9] More attention on these questions is likely to produce interesting and perhaps even revolutionary new information on the mechanisms by which God's creation has come to be the marvel we know.

Notes

[1]Eugene V. Koonin, "The Biological Big Bang Model for the Major Transitions in Evolution," *Biology Direct* 2 (2007): 21, https://doi.org/10.1186/1745-6150-2-21; Walter Fontana and Peter Schuster, "Continuity in Evolution: On the Nature of Transitions," *Science* 280, no. 5368 (1998):1451–55, https://doi.org/10.1126/science.280.5368.1451; and Luciana Raggi, Jeffrey L. Bada, and Antonio Lazcano, "On the Lack of Evolutionary Continuity between Prebiotic Peptides and Extant Enzymes," *Physical Chemistry Chemical Physics* 18, no. 30 (2016): 20028–32.

[2]Lynn Margulis, "Archaeal-eubacterial Mergers in the Origin of Eukarya: Phylogenetic Classification of Life," *Proceedings of the National Academy of Sciences of the United States of America* 93, no. 3 (1996): 1071–76, https://doi.org/10.1073/pnas.93.3.1071; and William F. Martin, Sriram Garg, and Verena Zimorski, "Endosymbiotic Theories for Eukaryote Origin," *Philosophical Transactions of the Royal Society B Biological Sciences* 370, no. 1678 (2015), https://doi.org/10.1098/rstb.2014.0330.

[3]Jeremy E. Coate and Jeff J. Doyle, "Divergent Evolutionary Fates of Major Photosynthetic Gene Networks Following Gene and Whole Genome Duplications," *Plant Signaling and Behavior* 6, no. 4 (2011): 594–97, and Paramvir Dehal and Jeffrey L. Boore, "Two Rounds of Whole Genome Duplication in the Ancestral Vertebrate," *PLoS Biology* 3, no. 10 (2005): e314.

[4]Stephen Jay Gould and Niles Eldredge, "Punctuated Equilibrium Comes of Age," *Nature* 366 (1993): 223–27, https://doi.org/10.1038/366223a0.

[5]Manfred Eigen, "Error Catastrophe and Antiviral Strategy," *Proceedings of the National Academy of Sciences of the United States of America* 99, no. 21 (2002): 13374–76, https://doi.org/10.1073/pnas.212514799.

[6]Jack W. Szostak, "The Eightfold Path to Non-Enzymatic RNA Replication," *Journal of Systems Chemistry* 3, no. 1 (2012): 2, http://www.jsystchem.com/content/3/1/2; and Martin A. Nowak, *Evolutionary Dynamics: Exploring the Equations of Life* (Cambridge, MA: Belknap Press, 2006).

[7]Sy Garte, "Teleology and the Origin of Evolution," *Perspectives on Science and Christian Faith* 69, no. 1 (2017): 42–50.

[8]Ibid.

[9]Sy Garte, "The Continuity Principle and the Evolution of Replication Fidelity," manuscript submitted, 2020.

Sy Garte
ASA Fellow

Key Speculation

The major unsolved problem of life on Earth has been how life emerged from nonliving organic material. This problem has confounded scientists starting with Alexander Oparin in 1924, John Haldane in 1929, through the carefully controlled laboratory tests in 1953 by Harold Urey and Stanley Miller, and has continued to occupy biochemists, biophysicists, and synthetic organic chemists from 1953 until today, with no apparent success. In addition, *all these efforts to date have involved intelligent beings, i.e., human interaction, under carefully controlled experiments*.

One of the most recent efforts has been by Nobel Laureate Jack Szostak, who obtained microcapsule prebiotic samples in his laboratory. In "Rethinking Abiogenesis: Part 1, Continuity of Life through Time," (*PSCF* 72, no 1 [2020]: 25–35) by Emily Boring, J. B. Stump, and Stephen Freeland, I do not see any reference to Szostak.

Because the authors are committed to evolutionary creation, it is no surprise that their key speculation is summarized in paragraph 4, under the section entitled "Why Does the Perspective of Continuity Matter?" Given their presuppositions, they seek to avoid any and all discontinuities, even though, as C.S. Lewis aptly stated regarding biblical miracles, God is the author of

the natural and the supernatural, and *therefore can seamlessly interact [not intervene] with his creation*.

I hope that some of these important caveats will be addressed:

1. To date, replicating life in the laboratory from nonliving material has been unsuccessful since the Urey/Miller experiment.
2. Any and all efforts to date, have been done under controlled laboratory conditions.
3. All such efforts trying to create life in the laboratory involve *human interaction*.
4. According to most geophysicists, the atmosphere four billion years ago was oxidizing, not reducing, and thus inimical to the formation of complex molecular systems.

I recommend that the authors consult James M. Tour of Rice University, who is considered one of the world's top synthetic organic chemists. The authors do quote, in passing, Douglas Axe of Biola University, but they do not mention Tour. Neither Axe nor Tour support the authors' evolutionary position regarding life's origin.

Ken Touryan
ASA Fellow

"Rethinking Abiogenesis" Authors Respond

We thank both Drs. Garte and Touryan for taking the time to write with regard to our article, "Rethinking Abiogenesis: Part 1, Continuity of Life through Time" (*PSCF* 72, no 1 [2020]: 25–35). The honor of seeing our argument pass through peer review into publication in *PSCF* is exceeded by learning that it has engaged readers enough for them to respond.

In response to Garte's letter, we express direct gratitude for balancing our argument with the points he makes. We agree with the existence of one-way transitions into ever deeper states of feedback over the course of biological evolution; we perceive no "either/or" in suggesting that evolution is continuous. In other words, we perceive that a continuous evolutionary process may involve transition into higher rates of change over time. Our article's emphasis on continuity reflects our perception that, to date, this aspect of abiogenesis has been underexplored to the detriment of science. Our emphasis, as originally expressed, might well overstate the useful rebalancing that can occur to advance science. Both faces of abiogenesis deserve further research: we write with passion about the one which we perceive as currently lagging. For example, Szathmáry and Smith's seminal work on "major transitions in evolution" (including abiogenesis)[1] predates De Queiroz's "rediscovery" of concepts of continuity[2] by a decade, suggesting that the topic of continuity merits extra attention and research today to account for this lag.

Illustrating what we describe as this balancing act, we appreciate Garte's reference to Gould and Eldredge's theory of punctuated equilibrium as a case in which "an apparent discontinuity should lead us to more in-depth exploration" [quote]. Rather than a counterexample to our argument for continuity, however, we view punctuated equilibrium as illuminating the way in which perspectives of continuity vs. discontinuity have informed and honed one another toward deeper understanding. The theory of punctuated equilibrium arose as a challenge to a longstanding interpretation of the "notorious imperfection of the fossil record" as negative information. If written off as artifacts of missing data, seemingly "sudden" changes over evolutionary time could remain fully consistent with the prevailing theory of gradualism. Recasting the missing data as positive information in its own right, on the other hand, produced evidence for "geologically instantaneous origination and subsequent stability" of morphospecies. In other words, the theory of punctuated equilibrium emerged from a scientific moment in which the evidence at hand—a gap in the fossil record—could be interpreted in two different ways: one, supporting a steady rate of evolution; the other, supporting a view that morphological evolution can speed up to produce rapid change and slow down to produce seeming stasis. Over decades, considerable evidence has favored instances of the latter interpretation,[3] although active debate continues.[4] In this process, the scientific community has not rejected continuity but, rather, has been forced to define the concept of continuity in much more precise terms: the tempo vs. mode of evolution, characteristics of micro- vs. macro-evolution, and stasis in data vs. stasis in the processes that scientific data reflect.

The question in our present exchange of letters remains whether the difference between continuity and discontinuity is merely a product of the speed at which a process occurs, or a fundamental difference in type? We perceive in Garte's words a shared interest in this question and an alignment with our views.

To support the interpretation that different rates are not the same thing as discontinuities, we find a point of mutual agreement and interest with Garte in noting that "transition" should not be conflated with one, singular event labeled abiogenesis. As Garte points out, the emergence of eukaryotes is as much a paradigm of such one-way transitions as the emergence of the standard genetic code … and neither of these transitions involves abiogenesis except in our stated sense that abiogenesis is still underway and "as-yet-incomplete" (p. 25). In other words, we perceive a shared goal with Garte in continuing to balance "continuity" with "transition" in order to advance the science of origins.

While we appreciate the concerns in Touryan's letter, we find less common ground with his position. He writes of our "commitment to" evolutionary creation and our "presuppositions" as though these were chosen without

regard for evidence. The intelligent design community rightly objects to times when their ideas have been dismissed without a fair hearing. But it just doesn't follow from such incidents that all of us Christians who accept evolution do so for any reason other than having been persuaded by the evidence.

To support the idea that our emphasis on theistic evolution is a presupposition, Touryan also writes about the "failure" of origins research—and hints strongly that a more-balanced view would embrace the option of intelligent design. Here we must politely but clearly disagree. In words that one of us has written before on the topic:

> It is true that, at present, evolutionary science does not have a clear, detailed, and well-accepted explanation for how the central dogma of molecular biology emerged. But does that mean it is time to embrace ID as a better approach? By analogy, current medical science has not found the cure for cancer. Taken in isolation, this sound bite could lead to the misleading view that existing research directions, developed for decades, are best written off as a failure. This would miss an important context. Many aspects of cancer are now being treated with far greater effectiveness than ever before as a result of ongoing research. However, these cures are not robust (all-encompassing) enough to be summarized in the statement, "we have found the cure for cancer." This status is typical of big questions within science: failure to reach the sound-bite goal should not be mistaken for evidence that the research program has failed.[5]

Notes

[1]John Maynard Smith and Eörs Szathmáry, *The Major Transitions in Evolution* (New York: Oxford University Press, 1995).

[2]Kevin De Queiroz, "Species Concepts and Species Delimitation," *Systematic Biology* 56, no. 6 (2007): 879–86.

[3]O. G. Woodberry, K. B. Korb, and A. E. Nicholson, "Testing Punctuated Equilibrium Theory Using Evolutionary Activity Statistics," in *Artificial Life: Borrowing from Biology*, ed. Kevin Korb, Marcus Randall, and Tim Hendtlass (Heidelberg, Germany: Springer-Verlag, 2009), 86–95, https://doi.org/10.1007/978-3-642-10427-5_9; and Albert Somit and Steven A. Peterson, eds., *The Dynamics of Evolution: The Punctuated Equilibrium Debate in the Natural and Social Sciences* (Ithaca, NY: Cornell University Press, 1992).

[4]Kjetil Lysne Voje, Emanuela Di Martino, and Arthur Porto, "Revisiting a Landmark Study System: No Evidence for a Punctuated Mode of Evolution in *Metrarabdotos*," *The American Naturalist* 195, no. 5 (2020): 899–917.

[5]Stephen Freeland, "The Evolutionary Origins of Genetic Information," *Perspectives on Science and Christian Faith* 63, no. 4 (2011): 240–47.

Emily Boring, J. B. Stump, and Stephen Freeland

On "Galileo and Global Warming"

I look forward to perusing *PSCF* for new insights to encourage my faith and worship, and so I was shocked by the lead article "Galileo and Global Warming: Parallels between the Geocentrism Debate and Current Evangelical Skepticism about Anthropogenic Climate Change" by Rachel M. Roller and Louise Ko Huang (*PSCF* 72, no. 1 [2020]: 3–14) in the March issue. From the title and first sentence onward, the young authors prejudice their audience against scientists who disagree with their views on climate change. Evangelical Christians in America are free and diverse in beliefs and denominations. Comparing them to the autocratic, political medieval Roman Catholic Church is unreasonable. They introduce unnecessary prejudice into the discussion by likening critical analysis of causes of climate change to the persecution of Galileo.

Claiming "mounting scientific evidence that human activity is negatively impacting the planet" (p. 3), Roller and Huang present unsubstantiated claims of authority and consensus for their diagnosis of a human cause for global warming. A good source to document the lack of consensus and understand the manipulated and sometimes falsified CO_2 and temperature analysis is *Inconvenient Facts: The Science That Al Gore Doesn't Want You to Know* by Gregory Wrightstone (https://inconvenientfacts.xyz/, 2017). Aside from that, the big picture is what geologists never forget: The earth has experienced many cooling/warming cycles over geologic history, also many highstand/lowstand cycles of oceans. In historic time, we are emerging from the Little Ice Age.

Accusations fly: evangelicals accused of not caring for the environment, "behaving like the two men who refused to look through Galileo's telescope" (p. 9), lacking humility, and being driven by political views. Who is responsible for politicizing environmental science and the investigation of climate change? Could this not also be attributed to liberal parties and organizations, instead of blaming it on the conservative leanings of evangelicals? Augustine's maxim of Christian love should have been applied here.

Thank you.

Catherine Lewis
PhD Geophysics

"Galileo and Global Warming" Authors Respond

We would like to thank Catherine Lewis for her comments. One of our primary goals was to spark dialogue between people of faith on the topic of creation care, so we were encouraged that Catherine took the time to read and respond to our article, "Galileo and Global Warming."

Her critique boils down to four main concerns: (1) it is unfair to compare modern American evangelicals to the Roman Catholic Church of Galileo's day, (2) it is inaccurate to claim scientific consensus on the anthropogenic roots of climate change when alternative explanations based on natural cycles exist, (3) it is unbalanced to call out the conservative leanings of evangelicals without acknowledging the liberal parties and organizations politicizing environmental science, and (4) it is unloving to accuse evangelicals.

As to the first concern, Dr. Lewis points out that "Evangelical Christians in America are free and diverse in beliefs and denominations," and thus it is "unreasonable" to compare them to the Catholic Church in Galileo's time. We had no intention of denying the diversity of the evangelical community—as we acknowledge on the first page of our article, "evangelicals are a wide and varied group, so it would be unfair and inaccurate to imply that this trend [lack of environmental concern] applies to every evangelical" (p. 3). Moreover, we make no pretense of claiming that modern evangelicals are like the seventeenth-century Roman Catholic Church in every respect—in fact, we highlight several points at which they differ. Instead, our goal was to discuss three specific parallels (perceived lack of evidence, biblical literalism, and political complications) in an attempt to learn from the past.

Dr. Lewis's second concern is that we "present unsubstantiated claims of authority and consensus" for anthropogenic climate change, given the "big picture" of "cooling/warming cycles over geologic history." This is an excellent point—in rereading our article, we realized that we neglected to support our claim of "strong, even overwhelming, scientific consensus" (p. 4) by citing studies placing the percentage of scientists who subscribe to the idea of anthropogenic climate change around 97%.[1] This was a sincere oversight on our part, as we did our best to scrupulously cite any scientific, historical, and sociological claims that we made. As to Dr. Lewis's point that the earth has natural cooling and warming cycles, we fully agree. We do not deny the fact that the earth cools and warms of its own accord, yet based on current research findings, the effect of human-caused greenhouse gas emissions goes above and beyond natural cycles.

Third, Dr. Lewis asserts that we unfairly accuse conservative evangelicals of "being driven by political views" while ignoring the way "liberal parties and organizations" politicize environmental issues. Seemingly, people of all parties could politicize science. The reason why our article focuses on the conservative end of the spectrum is due to the results of multiple research findings.[2] Nonetheless, we fully agree with the spirit of Dr. Lewis's concern—as we point out in the article, environmental science (and science in general) should be considered on its own merit rather than bound to either end of the political spectrum.

Dr. Lewis's fourth concern is the most serious—that we violate Saint Augustine's "maxim of Christian love" by "blaming" evangelicals with "unnecessary prejudice" and "accusations." Given that our goal was to encourage a "hermeneutic of charity" (p. 9), this comment was deeply saddening. Both of the authors count ourselves part of the evangelical Christian community, and one of us was a climate change skeptic until very recently, so we had no intention of leveling accusations at our brothers and sisters in Christ. Given the highly divisive nature of the topic, we strove to write every word as sensitively as possible, "speaking the truth in love" (Eph. 4:15), as we attempted to engage in civil dialogue.

Dr. Lewis suggested we look into *Inconvenient Facts* by Gregory Wrightstone. After reviewing this resource, we found it can be helpful, although its contents fall outside the framework of our article. Our article is not an attempt to prove global warming, but rather a parallelism study regarding the tensions between science and faith during Galileo's and current times.

The increased engagement of more people of faith is beneficial to developing a holistic approach to the stewardship of God's creation. After all, isn't caring for God's creation a mandate for all his people regardless of political affiliations and definition of climate change? Additional research (natural/social sciences, theology, and others) is needed to understand the complexity of this issue. We are grateful to *PSCF* and the ASA for providing platforms to promote enriching dialogue.

Notes

[1]John Cook et al., "Consensus on Consensus: A Synthesis of Consensus Estimates on Human-Caused Global Warming," *Environmental Research Letters* 11, no. 4 (2016), https://iopscience.iop.org/article/10.1088/1748-9326/11/4/048002; NASA: Global Climate Change, "Scientific Consensus: Earth's Climate Is Warming," updated June 11, 2020, assessed June 16, 2020, https://climate.nasa.gov/scientific-consensus/.

[2]Philip Schwadel and Erik Johnson, "The Religious and Political Origins of Evangelical Protestants' Opposition to Environmental Spending," *Journal for the Scientific Study of Religion* 56, no. 1 (2017): 179–98, https://doi.org/10.1111/jssr.12322; David M. Konisky, "The Greening of Christianity? A Study of Environmental Attitudes over Time," *Environmental Politics* 27, no. 2 (2018): 267–91, https://doi.org/10.1080/09644016.2017.1416903; A. Leiserowitz et al., *Climate Change in the American Christian Mind: March 2015,* Yale Project on Climate Change Communication (New Haven, CT: Yale University and George Mason University), 4–25, https://environment.yale.edu/climate-communication-OFF/files/Global-Warming-Religion-March-2015.pdf; and Nicholas Smith and Anthony Leiserowitz, "American Evangelicals and Global Warming," *Global Environmental Change* 23, no. 5 (2013): 1009–17, https://doi.org/10.1016/j.gloenvcha.2013.04.001.

Respectfully,

Rachel M. Roller and Louise Ko Huang ◙

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