Pew Research Proposal Form
Union University
Fall 2019

Cover Sheet

Name(s) of Applicant(s): **Jeremy D. Blaschke, M.S., Ph.D.**

Title of Proposed Project: **Using Theology and Science to Explore the Origin and Diversification of Parasites**

Primary Discipline: **Biology** Secondary Discipline(s): **Philosophy, Theology**

Has this proposal been submitted to another agency, publication, or program? **No**

If so, which one(s)?

Location of proposed research: **Union University, Jackson, TN**

Desired start date: **January, 2020**

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In consultation together, we recommend the approval of the proposal as an acceptable project and affirm that the applicant has the professional wherewithal to accomplish the project satisfactorily.

Chair of your department _____ Date: 10/18/19

Dean of your school: _____ Date: 10-18-19

PEW RESEARCH PROPOSAL

Title: Using Theology and Science to Explore the Origin and Diversification of Parasites

Statement of the end products

This research will be published in the peer-reviewed *Journal of Creation Theology and Science* and the *Answers Research Journal*. Selected topics will be presented at the annual meeting of the Creation Biology Society in 2020 and 2021.

Brief statement of the scholarly activity and goals

In this proposal, I attempt to allow theological assumptions to guide scientific investigations and thereby join these two fields—often perceived to be antagonistic—together in a single pursuit. Working within the theologically informed framework of a Young-Earth model of earth history, specifically the assumptions that 1) animals originated from a loving God in a recent creative event ~6,000 years ago and 2) there were no parasites in the original creation, I will scientifically examine the origin and diversification of the 200+ currently living lineages of parasites. Can the origin and diversity of modern parasites be explained according to a Young-Earth model? And if so, how?

I have three primary goals for this project:

1. Infer the ancestral state of each distinct lineage of parasites. A lineage refers to all descendants of a single common ancestor. Some parasite lineages include only a single species, others contain many thousands of closely related parasites. What kind of animals were the ancestors of these parasites? Does parasitism arise from relationships that were originally mutually beneficial? If so, how often?
2. Estimate species diversity for every group of parasites. How many species are found in the average lineage of parasites? How many species could realistically evolve from a single common ancestor ~6,000 years ago?
3. Interpret data according to a Young-Earth model of earth history. Could most (or all) parasite lineages have arisen in the last ~6,000 years? How does the scientific evidence inform theology and *vice versa*?

Theoretical framework and literature review

Trinitarian ecology

God is necessarily Love. Christian theology is unique in its belief in a deity who is three persons in one being. The profound mystery of the trinitarian nature of God reveals him to be an eternally loving and deeply relational being, and it is out of the overflow of this self-giving love that God creates and invites his creation into relationship with himself (Reeves 2012). God not only declares that he is love (1 John 4:8), but defines what love is (self-sacrifice, John 15:13), and then demonstrates that love through his own incarnation, death, and resurrection (Romans 5:8). What would a world look like that was designed by such a benevolent being? What kind of animals would such an intensely loving God create?

One could predict that such a profoundly relational being would create ecosystems filled with intricately interconnected relationships, and such a world is the one we inhabit! Ecology is the study of these relationships. Each of us depend on a host of other organisms for our continued existence. We could not breathe oxygen without it being produced by plants and marine algae, we could not digest our food without the helpful little bacterial companions in our guts, and we do not flourish apart from human society (Bäckhed et al. 2005). We too play our role in the interwoven web of ecology by continuously sustaining a myriad of other living things on and in our bodies, from mites that live on our eyelashes to tiny worms that consume our skin cells (Lacey et al. 2011). In fact, there are more non-human cells that make up a "human" body than actual human cells (Sender et al. 2016).

When two or more species benefit each other, as with humans and the fauna of our intestines, this relationship is called mutualism. When one species benefits but the other is unaffected, such as with humans and our common (but completely harmless) skin-eating worms, this relationship is called commensalism. The ubiquity of mutualism and commensalism in nature brilliantly reflects the character of the Trinity. And if such relationships were the whole story, the "Book of Nature" would present a compelling case for the existence of an omnibenevolent God who cares about relationship. However, there are certain interactions between species where the benefit one receives comes at the direct cost of harming the other. This interaction is called parasitism and seems distinctly opposed to the trinitarian nature of God.

The problem of parasites

Parasites invade our bodies, bore through our viscera, and consume our flesh and blood. At least half of the biodiversity on earth is composed of such creatures (Windsor 1998), and virtually every species on earth plays host to at least one unique parasite species (Dobson et al. 2008). One particularly troubling example is that of *Dermatobia hominis*, the human botfly (Powers et al. 1996). When botfly eggs sense the heat from a human host, the immature larvae immediately break through their shells and begin probing their victim. Special enzymes are secreted that degrade tissue and the larvae burrow into the flesh aided by two large spear-like mandibles. Once inside the host, the botflies rip into muscle tissue and blood vessels and imbibe the liquid nutrients. Over the next several weeks, the larvae grow over an inch long and cause severe pain to their host, eventually boring a large hole through the skin to pupate outside the host in the soil. In contrast to mutualistic organisms, whose existence increases biodiversity and the overall health of an ecosystem, botflies are not known to perform any unique ecological function—their existence appears to be cruelty without cause, and they are only one of >400,000 species of parasites alive today. The reality of a world filled with parasites contrasts sharply with the Christian belief in an all-loving and all-powerful Creator God. Could a truly loving God, the Trinity, intentionally create such distinctly harmful and "selfish" animals in their present forms? If not, how did they come to exist?

The traditional metanarrative of Christianity, Creation-Fall-Redemption, presents an ancient and powerfully compelling answer. This world as it exists today is not the way it is supposed to be, it is not the way God created it. Man, the caretaker of earth, rejected his role and rejected God, and humans, along with the environment they were responsible for, were subjected to decay (Gen. 2:15, 3:17; Rom. 8:20-22). The terrible things we see in the present are corruptions of the good that once was. Parasitism then, represents a corruption of mutualism and/or commensalism—a discordant note arising from within a harmonious melody.

This idea can be sourced back to the first parasitologists who were discovering new parasites and uncovering complex lifecycles at a time when the traditional metanarrative of Christianity held sway even over the sciences. According to them, God did not create parasites in the original creation. Neither did he create them after the Fall. Rather, organisms that are currently parasitic were originally created to benefit their host. The following quote from

Antonio Vallisneri, one of the early fathers of parasitology, communicates this idea in quite colorful language:

> *"It is not reasonable to suppose that God would have placed the first worm in [Adam's] body...Man was to be free of all kinds of diseases...Rather, these [parasites]...would by gently licking the [intestines] and by healing them, do their host a kindly office...But [after the Fall] these worms were made the Ministers of Divine Justice and raised an insurrection upon him." – Antonio Vallisneri (1733)*

Vallisneri's solution to the problem of parasites, that relationships within creation have deteriorated from beneficial to harmful, relies on a literal Adam, a literal Fall, and thus a reading of Genesis as historic narrative (Mortenson 2009). If taken as history, Genesis reveals that humans and animals were created at the same time, parasite-free, roughly 6,000 years ago (based on adding up ages in Adam's genealogy). In modern times, this philosophy is called Young-Earth Creationism (YEC). However, evolutionary biology tells us that the earth is very old, that humans arose long after other animals, and that parasites are an ancient reality—there has never been a time in earth's history where humans were present but parasites were absent.

Which of these philosophies is ultimately correct has important implications for how Christians should interpret both science and scripture. For many potential conflicts between science and scripture, thorough investigation usually reveals no inherent irreconcilable difficulties in finding agreement between the two (e.g. helio vs geocentricity) (Lindberg and Numbers 1986). However, the problem of parasites represents one of the few areas where conflict between science and theology is real and impossible to avoid (Terreros 2003), and thus provides an opportunity to explore how these two fields can interact constructively.

Rather than dogmatically choosing belief in one side or the other at the expense of potentially compelling evidence from the opposition, it is wise to use both paths to Truth—theology and science—to craft a response to the problem of parasitism. My goal for this project is to begin with the theologically grounded hypothesis that parasites represent recent adaptations to post-Fall life and examine the likelihood of that claim scientifically. If we examined the pattern of parasitism in nature, what would we discover about its origin? Is it possible for all of the parasites on earth to have arisen from non-parasitic ancestors in the last 6,000 years?

The origin and diversification of parasites

To examine the origin and diversification of parasitism within a YEC framework, two questions will be explored: 1) what is the ancestral state of each parasite lineage (i.e. what were parasites before they were parasites)?, and 2) how many species exist in each lineage?

Answering the first question will provide insight into the ecological state of the original creation. Did God create ecosystems filled with a combination of mutualists and commensals? Were there any parasites present? How does God's creation reflect his character and purpose for creation? The second question provides an opportunity to examine the likelihood of the enormous number of parasites we see today having evolved in a relatively short timeframe.

To infer the ancestral states of parasites before they were parasites, every parasite group included in the exhaustive list of parasite lineages from Weinstein and Kuris (2016) will be analyzed for species diversity and evolutionary history. Adaptive transitions from non-parasitic lifestyles to parasitic ones will be inferred using phylogenetic trees, or, in the absence of formal phylogenetic evidence, by relying on expert testimony from peer-reviewed journals. The well-curated online species database Catalogue of Life will be used to estimate initial species counts per lineage, which will then be verified through a review of recent taxonomic literature. The data from all lineages will be aggregated and the diversity of species represented in each parasite lineage will be used to infer the likelihood of that particular lineage having arisen in <6,000 years.

Parasitic groups with only a few species are easily accounted for within a YEC timescale. For example, the barnacle *Anelasma squalicola* is a parasite of lantern sharks where it embeds feeding tendrils into the soft belly tissue of its host (Rees et al. 2014). Most barnacles are sedentary filter feeders and use modified "arms" called cirri to comb the water for suspended particles. In *A. squalicola*, the cirri have degenerated into nonfunctional stumps and the attachment tendrils, used in other species to grip firmly onto the surface, have been adapted for penetrating and digesting host tissue. This parasite seems to have evolved from non-parasitic ancestors, most likely via an epizoic (living on other animals) intermediate stage, where the barnacle first adapted to living on the outside of the shark rather than attaching to rocks or logs as other barnacles do, then subsequently adapted to exploit the nutrient filled surface on which it now lives. A transition like this for a single species supports a YEC model of earth history quite

well. It takes little imagination to envision the transition of this single barnacle species from commensal organism to parasite in the last few thousand years.

However, more species-rich groups present a difficult challenge for YEC to explain. For example, the Neodermata, a group containing tapeworms, blood flukes, and their relatives, seem to all descend from a common ancestor, and thus represent a single lineage of parasites (Hahn et al. 2014). The path to parasitism most likely resembles that of the barnacle shark parasite described above. Over time, free-living marine worms adapted to an epizoic life on other animals where nutrients were more plentiful and eventually transitioned from an epizoic lifestyle to ectoparasitic (attached to the outside of host) as they began consuming tissue from their host itself. From an ectoparasitic lifestyle they eventually adapted to endoparasitism (inside of host) as their relationship with their host became more and more specialized (Kornakova 2018). The narrative here supports the hypothesis that parasitism arises from commensal ancestors. However, the Neodermata include >22,000 described species, with many thousands more undescribed and/or extinct. How could such incredible diversity be generated in only 6,000 years? There is currently no known biological mechanisms that could produce so many species in so little time.

The examples mentioned above represent only two of the 200+ lineages of parasites on Earth today and illustrate how the data may support or challenge my initial hypothesis that all parasites arose in 6,000 years. Including all other parasite lineages and analyzing the total combined data will allow me to discern if transitions from mutualism/commensalism into parasitism is or is not a consistent theme and to discover how common species-rich groups of parasites are in nature. Only when a significant number of lineages have been examined can I begin to interpret what the evolution of parasites reveals about the likelihood of a recent creation.

This kind of research encourages theology to direct and constrain specific scientific investigations and allows science in turn to present evidence for or against certain theological positions. As such, it highlights how both fields can interact positively and benefit each other even when apparent conflict exists.

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Essay on Christian faith and biology

I am a biologist because nature is captivating. I am enchanted by stories of invading armies of African Matabele ants who include within their ranks specialized "paramedic" soldiers that will treat wounded ants with antibiotic saliva during a raid on a rival colony. Or the "immortal" jellyfish, *Turritopsis dohrnii*, who has the ability to un-differentiate their adult cells back into stem cells—giving these tiny jellies the ability to *reverse their own aging*. Equally fascinating, but significantly more gruesome, is the complex relationship between botfly parasites and their bovine hosts. Cattle who have been brutally afflicted with botfly larvae living under their skin have learned to stampede at the first whisper of the adult botfly's distinctive wing beat, thus escaping infection. In response, botflies now avoid directly attacking their host. Rather, they find and capture a mosquito or stable fly in mid-flight and lay eggs on it so that when the unwitting courier alights on a bovine host for a blood meal, the botfly eggs are inconspicuously delivered as well. This tale is remarkably ingenious, and displays all the characteristics of being intentionally designed, but it ultimately ends in the pain and suffering of complex creatures. Should we delight in such things?

I am a Christian, at least in part, because of the intricate design readily apparent in nature. God has created a beautiful, interesting world that extravagantly displays His intelligence, creativity, complexity, and power. My own personal research into the biology of parasitoid insects (flies and wasps whose larvae consume their hosts from the inside out) has led me to the inevitable realization that nature is both beautiful and ugly, relational and destructive. Terrible pain is inflicted on innocent animals. They are born in it, live through it, and die by it. Parasites are part of the awe-inspiring complexity of nature, yet they cause suffering. They seem to be malevolent creatures interwoven into the fabric of a world that appears intricately designed and meticulously maintained. Are parasites created beings borne out of the overflowing self-giving love of the Trinity? Such an idea seems terribly dissonant with the character of God. On the other hand, if parasites did not arise from the creative work of the Trinity, where did they come from?

My faith and my vocation intersect at this question. I understand biology as a way to know God more fully. Exploring nature provides a path for me to better understand the character, purposes, and sovereignty of the Creator and Sustainer. When I study parasites, the *existence* of a designer seems obvious to me, but the *character* of the designer as revealed in nature is more difficult to interpret from within my discipline of parasitology. My proposed project is therefore

not merely an academic quest for knowledge, but also an honest pursuit of difficult questions that have important implications for my own faith and scientific practice.

Truth can be revealed to us through scripture. However, scripture says nothing about the origin or purpose of parasites. Even still, I can ground my philosophy of biology—what I should expect to see in nature and why—in the character of God as described in scripture. By believing that Jesus Christ is the image of the invisible God (Col. 1:15) and the exact representation of His being (Heb. 1:3), I can be confident that God is love (1 John 4:8–10) because Jesus clearly and routinely demonstrated what love is through his compassion, kindness, humility, and self-sacrifice (Matt. 14:14; John 3:16; Rom. 5:8; Phi. 2:8). In contrast, parasites are not kind, compassionate, or self-sacrificial. Therefore, I would not expect to see them abundantly distributed in a world created by a loving God. Two options are commonly proposed for synthesizing God's loving character (the theological evidence) with the often brutal elements exhibited by His creation (the scientific evidence): Evolutionary Creationism and Young-Earth Creationism.

The evolutionary creationist accepts the modern scientific consensus that all life arose from a common ancestor primarily through natural selection acting on random variation. Deep-time evolution, and all the suffering caused by it, must then be attributed to God as his chosen method of drawing forth beauty, complexity, and ultimately humanity from the dust of the earth. Therefore, parasites are good because they are a product of God's chosen creative process. This philosophy is attractive to me as a biologist due to the weight of scientific evidence in favor of an old earth and the universal common ancestry of life. However, this view opposes traditional interpretations of Genesis as historical narrative and ignites theological difficulties by casting doubt on the historicity of Adam and Eve and the reality of the Fall.

For the Young-Earth creationist, the pros and cons are opposite those of the evolutionary creationist. I believe the YEC position to be theologically and philosophically robust, but see it as lacking significant scientific evidence in its favor. And yet I am a scientist! I am in the perfect position to seek answers to specific scientific questions that arise from a YEC position, such as the one proposed here. Exploring the evidence for parasite evolution from a YEC perspective allows me to wrestle with challenging questions while also contributing novel data to the discussion that can inform opinions, provide support for hypotheses, and hopefully foster productive dialogue among Christians of all beliefs.