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Abstract

1. A natural regularity is defined as the context-dependent repetitive persistence of a natural phenomenon that conforms to induction-based prediction and is thereby scientifically accessible. Scientifically inferable novelty is defined as the objectively earliest appearance in nature of a specific and subsequently repetitive natural regularity.
2. Novelty, as distinct from regularity, is outside the explanatory remit of an empiricism-focused naturalism that restricts itself to what is verifiable through testable inductive prediction, because natural regularities form the basis for such predictions, whereas novelty refers to the singular instant of appearance of such regularities from an initial state of absence.
3. Novelty may be explained as the earliest actualization of a timelessly existing possibility within a causally closed sample space from which all of nature's events derive. But this requires an ontological commitment to the existence of a timeless entity outside nature itself (i.e. the sample space containing all the timeless possibilities, perhaps interpretable as a Platonic vision of the laws of nature, an idea in the mind of God, or equivalent). Such a commitment to deterministic causal closure steps outside ontological naturalism but is available to (for example) a Platonist or deist and gels well with a uniformitarian methodological naturalism.
4. Attributing a novelty to God's creative action violates causal closure of nature and divine self-consistency; if it involves direct intervention within the finite natural causes constituting the boundary conditions from which the novelty arose. However, some form of divinely induced novelty by *possibility creation* can coherently attribute scientifically inferable novelty to God without invoking a God-of-the-gaps. This amounts to a divine creative addition to the totality of possible natural regularities. This totality must exist outside of and ground nature, yet also be a function of natural time via God's temporal creative action. The novel possibility is then actualized by natural causes in the world, giving rise to a scientifically investigable natural regularity.

Contents

1. Introduction and Scope	5
2. Conceptual background	10
2.1 Nothing, time and change	10
2.2 Causation and explanation	12
2.3 Recurrence and recombination	14
2.4 Causal closure and the “laws of nature”	17
2.5 Subjectivity, cosmology and creative evolution	21
2.6 A God-shaped hole without a God-of-the-gaps?	26
2.7 Summary	28
3. Working Definitions	30
4. Novelty and the underlying causal structure of nature	34
4.1 Two interpretations of novelty: Empiricism-focused naturalism and causal closure of nature’s regularities	34
4.2 Novel possibility generation and responsible navigation of the God-of-the-gaps criticism	38
4.3 Conclusions	41
5. Summarizing remarks and future direction: Novel non-energetic information input?	43
6. Appendix	48
7. Bibliography	56

1. Introduction and scope

When perceptible amounts of new phenomenal being come to birth, must we hold them to be in all points pre-determined and necessary outgrowths of the being already there, or shall we rather admit the possibility that originality may thus instil itself into reality? William James, 1911¹

That the future will resemble the past in some respects but deviate from it in others is a universal *prima facie* feature of experience. Is it meaningful to ask “why?” this is true, or is this the sort of idea that must be presupposed in order for rational analysis to occur, rather than being the subject of such analysis? Are all effects contained entirely within their causes? Can systems of thought based on formal abstractions from the past explain that quality of the present that seems to differ from it? If the answer to any of these questions is ‘no’, where does this extra quality come from and how should we attempt to explain it?

The thread running through these various questions is novelty, or “newness”. Novelty is a subtle and potentially ambiguous concept, but it also pertains to a concrete pattern ascertainable from historical sciences; namely that nature has a history. The first hydrogen nucleus, the first star, the first planet, the first cell, etc, can all be positioned in a chronology of nature (figure 1.1) grounded upon empirical investigation into the physical world. In other words, for any scientifically investigable system, it is possible to identify, or at least infer within an error margin, a point in the past at which that system first “came to be”. This tendency towards the discontinuous appearance of qualitatively different kinds of system during natural history will be argued in this piece of work to reflect a real and incompletely explained feature of the cosmos. I will define “scientifically inferable novelty” as involving the context-dependent appearance of subsequently repetitive natural regularities that are amenable to scientific investigation.

¹ W.James. *Some problems of philosophy*. (U.Nebraska. Press, 1911). pp147.

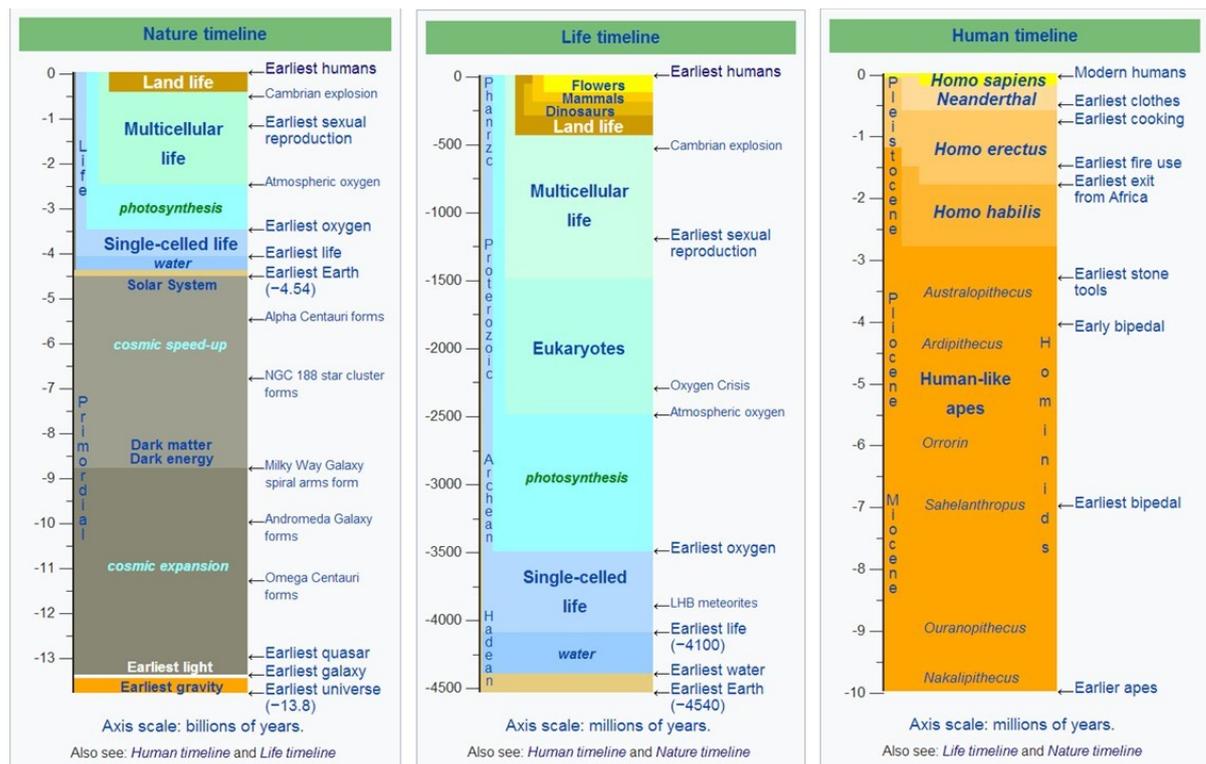


Figure 1.1. Chronology of nature based on contemporary historical sciences, Wikipedia (2018)

If this scientific conception of novelty is conceived of as being somehow connected to a creative impetus with metaphysical significance, novelty's relevance to science-religion discourse becomes clear. During *creatio ex nihilo* (creation from nothing), God causes an entity to come into existence without action upon any extant thing. Through *creatio continua* (continuous creation) God either extends the existence of an entity from the present into the future (conservation) or creatively acts upon an existing entity to produce a new entity derived from the first². (If one designates all entities as “new” at each new timepoint at which they exist, the distinction between continuous creation and conservation becomes semantic³). Novelty differs from *creatio ex nihilo* because it does not begin with an absolute-nothing and differs from conservation in producing something not previously there, rather than the renewed existence of a prior-existing entity. But if interpreted as suggestive of an underlying

² D.Van der Laan, Creation and Conservation. *The Stanford Encyclopedia of Philosophy* (Hereafter denoted SEP), (2017).

³ J.L.Kvanvig & H.J. McCann Divine Conservation and the Persistence of the World, in *Divine and Human Action*. (Cornell, 1988), 13-49.

creative influence, novelty unavoidably overlaps with both these uniquely theological concepts.

Deism posits that God exists and that nature's existence is the result of a single initial act of *creatio ex nihilo*, but that subsequently nature remains causally closed⁴ (all the world's physical/natural effects have only physical/natural causes from within the world). Naturalism is the view that nothing supernatural exists⁵, where in practice "supernatural" is normally understood as meaning any divine or "spooky" influence outside the investigative scope of the scientific method. Ontological/metaphysical naturalism constitutes an explicit commitment to non-existence of the supernatural, which normally amounts to the belief that the "laws of nature" insofar as they are discernible by science, constitute the entirety of existence. Methodological naturalism is the view that the only legitimate way in which to investigate nature is through methodologies predicated upon only naturalistic assumptions. Deists and ontological naturalists frequently agree that methodological naturalism is the only legitimate investigative approach, after agreeing to disagree about God's existence.

Theism presupposes that God's continuing action is necessary to maintain/sustain the laws of nature, within time, in addition to any initial act of *creatio ex nihilo*⁶ outside time, as well as allowing for providence, miracle and God's work in history. Thus, theism arguably sits more easily than deism with the sort of temporal variability that might (hypothetically) allow for novelty. But the question is "how?" and what the implications would be for science-religion discourse. The premise that God acts within time can be extended to allow for various divine action models⁷ describing a spectrum of scenarios for God's potential specific influence upon nature⁸. In many divine action models, the aim is to navigate the "causal joint"; the nexus at which a non-physical God interfaces with the physical world and its causal structure⁹.

⁴ M.Mahner. Science, religion and naturalism, metaphysical and methodological incompatibilities. *Int. Hdbok Res.Hist. Phil. Sci. Teaching*. 1793-1835. (2014).

⁵ K.J.Clark. Naturalism and its discontents ch1 in *The Blackwell companion to Naturalism* ed by K.J.Clark. (Oxford, 2016). Pp1-16.

⁶ W.L.Craig. "Creation and conservation once more". *Religious studies* 32(2). 177-188. (1998).

⁷ J. Polkinghorne The Metaphysics of Divine Action in *Chaos and Complexity: Scientific perspectives on divine action* ed by R.J.Russell, N.Murphy & A.Peacocke, CTNS. (1997).

⁸ T.F. Tracy Particular providence and the god of the gaps, in *Chaos and Complexity: Scientific perspectives on divine action* ed by R.J. Russell, N.Murphy and A. Peacocke, pp289-324. (1995)

⁹ A.Farrer. *Faith and speculation*.)London: Adam and Charles Black 1967).

The “God-of-the-gaps” fallacy refers to a situation in which a phenomenon is attributed to divine influence solely because a naturalistic/scientific explanation for it is lacking¹⁰. Perceived appeals to a God-of-the-gaps (GOTG) are dismissed by naturalists as fallacious arguments from ignorance. The GOTG is also unacceptable to most theologians, whose attitude is epitomized by Bonhoeffer:

If...the frontiers of human knowledge are being pushed further and further back...then God is being pushed back with them, and therefore is continually in retreat. We are to find God in what we know, not what we don't know.¹¹

I will develop a detailed definition of scientifically inferable novelty and describe how it might be interpreted differently according to the degree of commitment to empiricism, causal-closure or a form of creative divine action. I will argue here that novelty has a unique relationship to the GOTG fallacy. I will suggest that criticism of a theological argument as invoking a GOTG obliges the critic to precisely specify the system containing the epistemic gap, and explain why, in principal, that gap could be filled by the future advance of scientific knowledge. When epistemic gaps pertaining to nature's *regularities* are connected to God, the GOTG-criticism is reasonable. But because novelty refers to the appearance of a natural system from an initial state of absence, then before novelty there is no system there to contain an epistemic gap, so the GOTG-critique cannot apply. On this basis I will argue that the distinction between natural regularity and natural novelty can function as a filter separating reasonable and unreasonable use of the GOTG-critique by the naturalist. I will speculate that, in some circumstances, responsible and restrained attribution of some aspects of novelty to God need not necessarily cultivate conflict between theology and science. What is meant by “responsible and restrained” will pertain to the difference between possibility and actuality, which will be discussed. Obviously, any attribution of theological significance to novelty may (entirely reasonably) be rejected by the naturalist for reasons unconnected to the GOTG, most obviously an explicit commitment to causal closure.

I will adopt a pragmatic and empiricism-focused understanding of science, loosely in line with a “constructive empiricist” philosophy of science, whereby adhering to a

¹⁰ H.Drummond, *The Lowell Lectures on the Ascent of Man*. (Hodder and Stoughton, 1904)

¹¹ D.Bonhoeffer. *Letters and papers from the prison*. (SCM, 1971).

scientific theory entails only its adequacy to describe an empirically observable phenomenon¹², and an informal adherence to a realist correspondence theory of truth (the world objectively exists, and our thoughts and language are directed at it¹³). However, the aim of this work is to promote dialogue more than comprehensively defend a fixed philosophical position. I intend to derive a conceptual framework, within which participants in science-religion discourse with incompatible views but a shared interest in novelty, can, at the least, clarify precisely what it is that they disagree about.

¹² B.van Fraassen, *The Scientific Image*. (Oxford, 1980).

¹³ M.Glanzberg, *SEP* (2016).

2. Conceptual background

This section will introduce the key ideas necessary to understand the arguments that follow. The statement in bold at the end of each section summarizes the implications of that section's arguments for our understanding of novelty.

2.1 Nothing, time and change

It is impossible to picture absolute nothing, which probably explains why the documented creation stories of at least sixteen separate human tribes presuppose a primordial chaos, rather than anything like the *nihil* to which *creatio ex nihilo*¹⁴ refers. The problem defining nothing has not gone away. Whatever low-energy “quantum vacuum” state the big bang may have derived from, it is a stretch to call this state “nothing”¹⁵. Plato's *Timaeus* describes a demiurge who creates by moulding an eternal chaotic matter, to which the demiurge is equal in ontological rank, rather than creator of¹⁶. Theologians debate whether the texts of the Bible unequivocally support *creatio ex nihilo*, and it is plausible that the Christian adoption of the concept was partly motivated by differentiating the second century Christian church from the Platonic-Gnosticism¹⁷ that threatened to absorb it. Novelty occurs within time, therefore cannot be explained by a single primordial *creatio ex nihilo* act. Metaphysically significant novelty is plausibly closer to the idea of a “new” instance of form being created by a (potentially evil) demiurge acting on eternal chaos.

Novelty involves change, thus to ask what novelty is, we must plausibly first ask what change is, which raises change's essential but paradoxical combination of identity and difference. If change involves something coming into existence from a state of non-existence, then the above problem of defining non-existence arises. Consequently, the foundational assumption that Parmenides's ontology was that change is axiomatically impossible:

being is uncreated and imperishable, whole, unique, unwavering and complete.¹⁸

¹⁴ S.L.Bonting. *Creation and double chaos*. (Fortress Press, 2005). pp62-63.

¹⁵ F.Close. *Nothing: A very short introduction*. (Oxford, 2009).pp128-145.

¹⁶ G.May *Creatio ex nihilo*. (T&T Clark, 1994)pp4.

¹⁷ Bonting, *ibid*.

¹⁸ Barnes, Jonathon. *The early Greek philosophers*. Harmondsworth, Penguin. (1987). pp129-142.

On this view there cannot be anything outside existence, from which an addition to existence could possibly come, or to which a subtraction from existence could possibly go. North notes how western thought has never deviated far from Parmenides's closed vision of nature:

...The assumption that invariance is fundamental, while novelty and change are merely epiphenomenal, is itself an invariance that links Parmenides, at the beginning of Western philosophy, to Wittgenstein at the end.¹⁹

But if change is either unreal or inadmissible within a rigorous system of thought, what then of time, given that time's essential quality is generally presupposed to be that it admits of the possibility of change²⁰? There is a seemingly irreconcilable disconnect between the flow of time presented to our consciousness, and the seriality of the "physics time" with which we attempt to objectively describe change in the world. McTaggart²¹ illustrated how this disconnect manifests in two different forms of temporal language that do not translate into each other. Time's flow between *past*, *present* and *future*, admits of categorical and monadic statements such as "*X is present*" (the "A-series"). Describing time's serial movement from *earlier to later* necessitates dyadic and relational statements like "*X₁ is earlier than X₂*" (the B-series). Event-position relations in the B-series must be fixed to be meaningful (something cannot be "earlier than" something else at one time but not another without "earlier than" being rendered nonsensical). Therefore (McTaggart argued) the B-series cannot admit of real change. Real change is plausibly admitted by A-series events transitioning between *X is future* → *X is present* → *X is past*. But A-series event-position relations are not fixed at a specifiable point on a B-series timeline, so do not retain their identity during change. Attempting to rectify this produces questions like "When is X present?", thus answers like "X is present in the present, but X was future in the past", which might be met with a question like "when in the past was X future?", producing an arbitrarily long regress into nonsensical language. The only way out of this regress is to write something like:

"(*X is future*)_{t₁} & (*X is present*)_{t₂} & (*t₁ is earlier than t₂*)"- i.e. to presuppose a

¹⁹ M.North. *Novelty: A history of the new*. Chicago. (2013) pp22.

²⁰ P.Turetsky, *Time*. Routledge (1998). pp11-29.

²¹ J.M.McTaggart. *The unreality of time* *Mind*. 68. 457-474. (1908).

way of translating “earlier-later” relations to “past-present-future” relations, without *deriving* or defining such a translation method.

The linguistic disconnect is indicative of the ineffable and unanalysable quality to time that was highlighted by Augustine:

What then is time? If no one asks of me, I know. If I wish to explain to him who asks, I know not.²²

McLure argues that the reason Augustine cannot “know” what time is by means of his reflection, is that what-time-is is part of the conceptual “hardware” apparatus by means of which reflection upon anything occurs²³. This converges to some degree with Kant’s²⁴ classification of time as an *a priori* form of sensible intuition. The key point then, is that we cannot hope to determine what novelty is by analysing time or change, because these concepts are plausibly unanalysable in themselves. The best that can be done is to note that not all changes involve novelty:

Novelty pertains to the content of specific changes rather than the general nature of change or time.

2.2 Causation and explanation

To explain a feature of the world, one must define a system that does the explaining. This requires that certain assumptions are taken as axiomatic, such that the process of explanation works by comparing these assumptions to the thing being explained. Novelty cannot be allowed to encroach on these axiomatic assumptions (e.g. a sequence of calculations would quickly become nonsensical if one added new rules of arithmetic along the way). Thus, novelty must be at least partly excluded from any explanatorily useful system of thought. Along these lines it tends to be presupposed, as Luhmann notes, that novelty is:

...ontological nonsense. Something is, although and because it is not what was before.²⁵

²² Augustine, *Confessions Book IX Ch14*. (Oxford World Classics, 1992)

²³ R.McLure. St-Augustine and the paradox of reflection. *Philosophy* 69(269),317-326 (1994).

²⁴ I.Kant, *Critique of pure reason*. (Cambridge, 1998, 1781).

²⁵ N.Luhmann, *Art as a social system*. (Stanford, 2000). pp199.

But if novelty is necessarily excluded by the foundational assumptions of a rigorous system of thought, the whole explanatory process would seem to boil down to one's choice of foundational assumptions. But one has no grounds to make such a choice without a coherent system of thought, there is no way for explanation to get off the ground.

A pragmatist or empiricist would, obviously, argue that the way out of such self-referential theorizing is to focus on explaining the external world by means of natural causes. Explanation refers to interpersonal communication, causation to relations within nature²⁶, but the two are always close when nature is the subject matter. A cause is that which is sufficient to make the difference between an effect's happening and not happening²⁷, and Aristotle's traditional categorization²⁸ of the causes of a change ground this "difference making":

- i. The material cause, which refers to the composition of the changing thing.
- ii. The efficient cause, which refers to the thing that immediately interacts with the changing thing to elicit the change.
- iii. The formal cause, which refers to the relative internal arrangement of the changing thing.
- iv. The final/teleological cause refers to the end or purpose underlying the change; that for the sake of which an effect occurs.

A significant part of science-religion discourse focuses on the difference between the final cause and the other three. Teleological causation can be understood as involving the choice of one path of efficient causation over another, on the basis that the chosen path uniquely serves a purpose or leads to a desired outcome. Whether this can happen without intention is ambiguous²⁹, which means that teleological explanations of natural events provide a pretext for connecting them to God, and have consequently been forbidden in science since Francis Bacon's 1620 work *Novum organum*³⁰.

²⁶ P.F.Strawson. 'Causation and explanation'. Ch9 in "Analysis and metaphysics: An introduction to Philosophy". Oxford. (1992).

²⁷ J.Schaffer. 'The metaphysics of causation'. *SEP*. (2016).

²⁸ A.Falcon. 'Aristotle on causality' *Stanford Encyclopaedia of Philosophy (SEP)*. (2015).

²⁹ T.Nagel. 'Mind and Cosmos: Why the materialist Neo-Darwinian conception of nature is almost certainly false'. Oxford. pp93. (2012)

³⁰ J.Klein, 'Francis Bacon' *SEP* (2016).

Suppose a novelty occurs (defined informally as some unprecedented event) and is described coherently by all Aristotle's four categories of causal explanation (even, for argument's sake, up to and including teleological actualization of the will of God). Suppose the same change that was initially novel is now repeated. Do any of these categories of causal explanation apply any less well, once this change is an instance of repetition rather than novelty? If the same change happened for the same reason, it seems impossible for the various explanatory categories to be any less applicable. This illustrates how:

Novelty refers to a relationship between a change and the totality of history, not solely that change's isolated properties. Thus, novelty cannot be comprehensively explained by the isolated causes of a change.

2.3 Recurrence and recombination

There is some sense in which novelty is the origin of recurrence/repetition. Repetition allows prediction based upon induction, thus forms the basis for science. We assume that induction is a legitimate basis for predicting the future because the present (except when it contains novelty) resembles the past. Hume's problem of induction³¹ highlights how the fact that a sequence of events has held in the past cannot be taken to prove that the same sequence will hold in the future. Hume thus undermined any distinction between causation and "mere" temporal/spatial association between events. Theological dispensationalism argues that God acts differently at different times³², thus in some senses this turns Hume's problem of induction on its head by noting that it need not apply to God.

The perceived limits of repetitive causality motivate Crosby's³³ argument that novelty is not something to be explained in terms of causality, but rather on the same ontological level as it:

...present occurrences...construct themselves out of their causal pasts
[but]...are not wholly contained within those pasts and...are not the inevitable

³¹ L.Henderson, The Problem of Induction. *SEP* (2018)

³² P.Harrison. Newtonian science, miracles and the laws of nature. *Journal of the History of ideas* 56. 531-553 (1995)

³³ D.A.Crosby. Novelty. *Lexington*. (2005).

or only possible outcomes of those pasts...novelty is the difference between cause and effect...³⁴

Crosby goes on to argue that this disconnect between cause and effect is both the essence of novelty and essential to the flow of time. For Crosby, “chance” is undirected novelty, whereas freedom is novelty directed by teleological intention; *Novelty = Chance + Teleology/Freedom* and *Time = Novelty + Causality*.

Crosby’s outlook broadly converges with that of Boyle³⁵, who distinguishes two types of change; repetitive (consistent in time) and chaotic (temporally inconsistent). But in another way (and in agreement with the definition of novelty used here), Boyle goes in the exact opposite direction, absorbing novelty into causation itself by defining instances of novelty as the origin of specific causation patterns:

Novelty is the existence of discontinuity in the distribution of cause-effect relationships over time...novelty is the first instance of operation of a specific, subsequently repetitive, cause-effect relationship...Novelty results from the interaction between distinct systems with similar function but different structure. This is very close to saying that nature is inherently symbiotic, in the widest possible sense.³⁶

This reference to symbiosis (living-together of biological species) falls into the category of recombination; whereby something new happens when different entities are combined in a “new” way. The juxtaposition between such recombination and recurrence has been the only way in which novelty has been explained since Parmenides closed the causal structure of nature:

...there came to be but two ways around philosophy’s foundation scepticism about the very possibility of novelty. One of these, recurrence, has the advantage of seeming to offer the sanction of nature, but the disadvantage of not seeming to offer any real novelty. The other, recombination, seems to offer unlimited novelty, but only if unprecedented relations between existing elements can be considered truly new entities.³⁷

³⁴ Crosby, *ibid*, pp16-17.

³⁵R.Boyle *Natural Novelty: The newness manifest in existence* (University Press of America, 2016)

³⁶ Boyle, *ibid*, pp1-35

³⁷ North, *ibid*, pp7

There is an overlap between recombination and the contemporary concept of emergence, which also has a subtler relationship to causality. A property is emergent if it is exhibited by a combination of entities but could not be exhibited by any one of these entities alone. Emergence is closely related to supervenience. Property A supervenes on property B if an entity is *A in virtue of* being B (e.g. an individual is good in virtue of possessing good properties such as generosity)³⁸. The “argument from composition” states the only real properties in nature are “realizer” properties, which determine that individual entities with these properties have “powers” that are “individuating” of these realizer properties³⁹. The argument from composition normally involves a reductionism in which all “realizer” properties are taken to be microphysically determined. “Weak emergence” accepts (only) that emergent properties exist (e.g. no water molecule alone can exhibit wetness). “Strong emergence” accepts weak emergence but goes on to claim that “causally efficacious” emergent properties “condition” lower level individual properties (e.g. biology conditions the chemistry occurring in living systems, without contravening the laws of chemistry). “Ontological emergence” accepts the first two types and further argues that (at least some) emergent properties are *not realized from below but are causally efficacious*. Whether there are real examples of ontological emergence is contentious, because the issue boils down to the question of whether causation can work from the top-down as well as the bottom up, such that some higher-level property of a collection of things entities can “over-ride” the causal constraints operating on those things as individual entities. The theological implications of such top-down causation are explored by Peacocke, who argues that God provides a plausible impetus for such top down control⁴⁰.

Thus, by the traditional argument for novelty by recombination, one could appeal to the occurrence of new combinations that produced new emergent properties (and if one wished, one could connect this to some top-down causation pattern grounded upon God). The problem with this is that emergent properties are also observed during repetition (wetness is as much of an emergent property of a collection of water molecules today as it was yesterday). The difference between novelty-producing

³⁸ S.Blackburn, *The Oxford dictionary of philosophy*. (Oxford, 1994). p355.

³⁹ Gillet, Carl. The hidden battles over emergence, ch47 in *The Oxford handbook of religion and science*, ed by P.Clayton & Z.Simpson. (Oxford, 2006). Pp801-818.

⁴⁰ A.Peacocke *Theology for a scientific age*. (SCM Press, 1990, 1993).

emergent properties and repetitive ones pertains to whether the combinations of individual entities are unprecedented, and whether unprecedented relations between existing entities can be considered novelty.

Novelty is intimately connected to causation, but causation encompasses repetition therefore is in some senses novelty’s polar-opposite. Even if presupposed to be real, recombination, emergence and top-down-causation all produce repetition as well as novelty.

2.4 Causal-closure and the “Laws of nature”

The distinction between ontological indeterminism and epistemic unpredictability it is at the heart of many science-religion discussions⁴¹: An event is indeterminate if its outcome is not fixed before it occurs, an event is uncertain if successful prediction of it is not possible. Laplace⁴² proposed that a “demon” with sufficient intelligence and knowledge of nature’s laws and their impact upon nature’s constituents would be able to predict all future events with perfect reliability. Thus, Laplace’s demon symbolizes the idea that there is no ontological indeterminism, merely epistemological uncertainty. A causally deterministic vision of nature involves all events being fully determined by its antecedent events and prescriptive laws with “modal force”⁴³.

This proscriptive, universally applicable vision of the laws-of-nature sits easily with divine omnipotence and the “clockwork universe” or “world as machine”, which is historically exemplified by Newtonian physics and strong Cartesian reductionism (and arguably amounts to a “deification” of nature’s laws themselves). The historical alternative to the world-as-machine is the Aristotelian vision of the world-as-organism⁴⁴, imparting a degree of autonomy to nature’s entities, and invoking locally habitual regularities that may evolve over time. Aristotelian habits are more amenable to Aquinas’s vision of God’s function through secondary causes. A contemporary

⁴¹ F.Watts, Concepts of Law and probability in theology and science, Ch1. in *Creation, Law and Probability*. (Ashgate, 2007).

⁴² Laplace, Pierre-Simon, A Philosophical Essay on Probabilities, translated by Truscott, F.W. and Emory, F.L., (Dover, 1951).

⁴³ C.Hoefer, Causal Determinism, *SEP* (2016).

⁴⁴ P.Harrison. The development of the concept of the laws of nature. Ch2 in *Creation, law and probability*, ed by F.Watts. *Ashgate*. (2007).

example of this perspective is Cartwright's⁴⁵ discussion of multiple local "causal powers" and "mechanisms" with potentially overlapping jurisdictions. Another is Hempel's background-condition-dependent and descriptive "covering laws"⁴⁶.

But how much can be said to be explained by a given picture of nature's laws, and how much can be coherently attributed to chance? Modern science itself rejects the strict determinism of the form invoked by Laplace, for three main reasons:

- i. Under the widely held Copenhagen interpretation of quantum mechanics⁴⁷, measuring certain entities is impossible without the state of those entities being affected by the act of measurement. This implies that to measure one property of a thing, one must accept that one will inevitably affect another property of that thing, therefore will be unable to measure both simultaneously. Thus, accurate determination of certain pairs of quantities (momentum/position and energy/time) is impossible; the product of the uncertainty of both members of the pair is a constant.
- ii. Any measurement contains an error, and if a measurement is used to predict the later behaviour of something impacted upon by the thing initially measured, the initial error is propagated, making such prediction impossible. This is the "n-body" or "billiard ball problem": Predicting the direction of billiard balls after multiple sequential impacts between them is eventually rendered impossible by error in the angle of the initial impact of the first ball⁴⁸.
- iii. A component of any error may be impossible to eliminate even with perfect measurement, because it is introduced by the motion of the entity being measured relative to the gravitational field of the rest of the universe⁴⁹. (This final factor implies that even Laplace's demon would need to step outside of nature, i.e. to literally be God, to gain perfect predictive power).

⁴⁵ N.Cartwright. Contingency and the laws of nature. *Studies in the history and philosophy of biological and biomedical sciences*. 58. 56-63. (2016).

⁴⁶ C.Hempel. *Philosophy of Natural Science*. (Prentice Hall, 1966). Pp47-69.

⁴⁷ J.Ismael, Quantum Mechanics. *SEP* (2015)

⁴⁸ M.Berry. Breaking paradigms of classical physics from within *Cercy Symposium. Logique et Theories des Catastrophes*. (1983)

⁴⁹ J.P.Crutchfield, J.D. Farmer, N.H.Packard & R.S.Shaw, "Chaos", *Scientific American* December (1986), pp48-49.

Even the above considerations leave the distinction between indeterminacy and unpredictability ambiguous (e.g. deterministic “hidden variable” interpretations of quantum physics⁵⁰ still argue for unknowable ontological determinism underlying epistemic uncertainty). But the key point is that there are certain events that, pragmatically, could very well be ontologically indeterminate, not merely epistemically uncertain.

Physicalist interpretations of probability refer to the relative frequency of (what are presupposed to be) real chance events, whereas Bayesian interpretations allow any event whatsoever to be assigned a probability according to the investigator’s subjective confidence in the event’s occurrence⁵¹. A Bayesian interpretation, combined with an awareness of the obvious reality of stochastic processes within nature, might be taken to support a crude argument that our inability to predict with certainty what *will* happen, means that we are also unable to refute the proposition is interpreted as an inability to refute the proposition that anything *could* happen, at arbitrarily low probability. If this argument were accepted, the reality of novelty (or indeed anything else) would be no surprise, because, in effect, nothing should be a surprise. But such an argument (and therefore any associated refutation of novelty) is fallacious, because it confuses indeterminacy and causal closure.

For example, the individual throws of a die are indeterminate but will always be a number between one and six. The spin-orientation of an electron might be genuinely indeterminate before the act of measurement⁵², but relative to a given measurement axis it can only be oriented “up” or “down”. The precise time at which a nucleus radioactively decays may be un-determined, but at any given time it would either have decayed or not decayed. And so forth. In other words, events within stochastic natural systems may be *individually ontologically indeterminate*, but this is entirely compatible with these events being drawn from a *finite and causally closed underlying sample space*, i.e. such that no new events are introduced to this sample space over time. This has the effect that despite their indeterminacy, such systems can still be modelled statistically, because their behaviour falls within fixed limits.

⁵⁰ D.Bohm. *Wholeness and the implicate order*. (Routledge, 1980).

⁵¹ A.Hájek. Interpretations of Probability, *SEP* (2012).

⁵² J.Berkovitz, Action at a Distance in Quantum Mechanics., *SEP* (2016).

From a different viewpoint, under the assumption of causal closure, novelty could be merely an event that took a long time to happen in view of its low probability but was “always there” in nature as a possibility. But any permanently existent possibilities must refer to non-actualized future events, thus the sample space containing such possibilities must have some sort of existence outside time, therefore outside nature.

An equivalent combination of indeterminate events from within a causally closed sample space is extended beyond nature entirely by the anthropic principle. This refers to the argument that because we observe the world, we necessarily find ourselves in the observer-permitting region of the space describing “possible worlds”, and we have no basis for the assumption that this region is representative of the underlying possible-world-sample-space⁵³. It might therefore be argued that novelty is plausibly a prerequisite for complex observers, thus necessarily exists in our world given that we are present to observe that world. Like the appeal to a low probability event that “always existed” in a timeless possibility space, this invokes the existence of an entity outside nature (in this case a multiverse⁵⁴ containing the sample spaces of possible worlds).

The anthropic principle is a truism and confuses an explanation of the fact *that* something occurred with an explanation of exactly *what* occurred and why. The famous comparison is between anthropic explanations and surviving a 50-man firing squad but dismissing the matter on grounds that “If they hadn’t all missed then I shouldn’t be considering the affair”⁵⁵. Thus, I argue that an appeal to anthropic bias is a re-assertion of what is to be explained, combined with an appeal to abstract, arguably non-existent, probability spaces – not an explanation.

Plantinga⁵⁶ argues that contemporary science-theology discourse implicitly accepts a uniformitarian and causally closed picture of nature whilst failing to notice that uniformity and causal closure are properties applicable to controlled, local, experimental systems, but not necessarily to God’s relationship with nature. It is also worth noting that there is neither a naturalistic nor scriptural pretext for the autonomy

⁵³ H.Halvorson & H.Kragh, *Cosmology and Theology*, *SEP* (2017)

⁵⁴ M.Tegmark. Are parallel universes unscientific nonsense? *Scientific American*. February 4th 2014.

⁵⁵ J.Leslie. *Universes* (Taylor & Francis, 1980). pp13-20.

⁵⁶ A.Plantinga. “What is intervention?” *Theology and Science* 6(4). 369-401. (2008)

of nature and its laws⁵⁷. But Plantinga does not explain how the assumption of causal closure might be relaxed in a manner conducive to constructive dialogue with science. Novelty's status in relation to the concept of causal closure is ambiguous and requires further analysis.

Novelty could be explained as the occurrence of an event that was always a possibility within the sample-space(s) of nature and/or possible worlds- but may have been delayed due to a low associated probability. But this requires the presupposition of the existence of some extra-natural entity that is the locus of such predetermination.

2.5 Subjectivity, cosmology and creative evolution

It is obvious that different individuals could observe the appearance of the same pattern at different points in time. But assumption of the legitimacy of a collective pool of human knowledge and even a modicum of scientific realism, decisively supports the basic observation of the discontinuous appearance of natural systems over time (i.e. figure 1.1). For instance, it is entirely possible that the origin of life (a tangible example of an objective natural novelty), from which we derive may not have been the earliest such event anywhere in the universe⁵⁸. But for this to indicate that there was no origin of life at all, life must have existed timelessly. More generally, an argument to the effect that *all* novelty is subjective would require that every distinct natural system or scientifically detectable pattern, which appears within nature having apparently been initially absent, has always existed: i.e. an absolute steady state universe.

The cosmological debate between steady state and big bang cosmology mirrors differing theological emphases on relative importance of continuous and *ex nihilo* creation⁵⁹. Theoretical predictions of a universe that was expanding out of a primordial explosion were initially made by (Catholic Priest) Lemaitre, were countered by a steady state cosmology based on the “perfect cosmological

⁵⁷N.Saunders. *Divine Action and Modern Science*. (Cambridge, 2002). pp8.

⁵⁸ Hoyle, F. and Wickramasinghe, N.C. *Evolution from Space*. (Simon & Schuster, 1981), ch3 pp. 35–49.

⁵⁹ P.Hodgson. *Theology and modern physics*. (Ashgate, 2005).pp 176.

principle”⁶⁰; which states that over a sufficiently large scale the universe is uniform in both space and time. But big-bang cosmology was decisively confirmed by “red shift” produced when the observable wavelength of light increases as the light source (in this case another galaxy) moves away from the point of observation, the presence of cosmic microwave background radiation and the precise relative abundances of various isotopes. Oscillating universe cosmologies (involving eternal cycles between big-bangs and “big crunches”) would require the mass (therefore gravitational pull) of the universe to be sufficiently large to slow the expansion of the galaxies, and the universe’s actual mass is estimated to be several orders of magnitude too small⁶¹. Radical and revolutionary overhauls of scientific understanding have, of course, occurred repeatedly during the history of scientific enquiry⁶², but big bang cosmology has proved robust to criticism, and a steady state universe seems implausible.

Life is, of course, the most creative of nature’s phenomena. Life’s variability is what qualitatively distinguishes it from the physical processes on which it depends, geochemist Vernadsky describing life as:

...the most variable part of the thermodynamic field of the biosphere.⁶³

It is biological evolution, more than any other observation from nature, that makes novelty’s objectivity pragmatically undeniable. Awareness of temporal change in the form and species composition of the living world arguably dates to the pre-Socratics, with allusions to biological change in Thales, Anaximander and Empedocles⁶⁴. But the rise of Platonism ushered in the idea of fixed species-essences (as eternal ideas in the mind of God, which persisted all the way to Darwin) as Mayr remarks:

The rise of modern biological thought is, in part, an emancipation from Platonic thinking⁶⁵.

By the 19th century Lyell’s powerful exposition of the concept of deep geologic time⁶⁶ had been combined with exploration of biodiversity on a global scale, making the

⁶⁰ H.Bondi & T.Gold. The steady state theory of the expanding universe. *Monthly Notices of the Royal Astronomical Society*. 108. 252. (1948).

⁶¹ Hodgson, *ibid*, pp184.

⁶² T.S.Kuhn. *The structure of scientific revolutions*. (Chicago, 1962, 1970, 1996)

⁶³ V.Vernadsky. *The biosphere*. (Oracle AZ Synergetic Press, 1926, 1986)

⁶⁴ H.F.Osborn. *From the Greeks to Darwin*. (New York, 1929).

⁶⁵ E.Mayr. *The growth of biological thought*. Harvard (1982) pp51.

⁶⁶ C.Lyell. *Principles of Geology*. (John Murray, London. Vols1-3, 1830-1833).

need for a theory of biological change apparent to Blyth, Buffon and Chambers⁶⁷. But such a theory only gained traction once Darwin and Wallace (independently) noticed that over-production of offspring, leading to a Malthusian⁶⁸ struggle for existence, could drive the proliferation of an indefinite variety of new species by differential survival/reproduction⁶⁹.

Darwin and Wallace's theory presupposed an indefinite amount of variation present in the living world, prior to the operation of selection or random demographic factors. In 1918 Fisher showed mathematically how indivisible "atoms of heredity" (experimental evidence for which had been previously provided by Mendel) could support indefinite evolutionary change by avoiding a "blending inheritance" in which variation in fitness is diluted out at each generation⁷⁰. The 1956 discovery of DNA completed the "neo-Darwinian synthesis" by providing a physical basis for the atom of heredity; i.e. the gene as a "fitness-difference-maker"⁷¹. Since then biology's place in science-religion discourse has been to motivate an ontological naturalism fiercely attributing novelty generation to pure chance, as Monod remarks:

chance mutations constitute the only possible source of modifications in the genetic text...chance alone is the source of all creation in the biosphere.⁷²

Evolutionary theory is ontologically neutral with respect to the question of the existence of God⁷³, and the suffering inherent to the evolutionary process provides a heightened (but not unique) example of the problem of evil. But appeals like that of Monod, to the absolute hegemony of chance in the grounding of biological explanation have had the effect that:

⁶⁷ Osborn, *ibid.*

⁶⁸ T.R.Malthus. *An essay on the principle of population.* (J.Johnson, 1798)

⁶⁹ A.R.Wallace & C.Darwin. On the tendency of species to form varieties" & "On the tendency of varieties to depart indefinitely from the original type *Proc. Linn. Soc. Zool.* 3(9):53-62. (1858).

⁷⁰ R.A. Fisher. On the correlation between relatives on the supposition of Mendelian inheritance *Proc.Roy.Soc.Ed.* 52. 399-433 (1918).

⁷¹ J.Lennox, 'Darwinism', *SEP* (2017)

⁷² J.Monod. *Chance and necessity: An essay on the natural philosophy of modern biology.* (New York, 1972). Pp112-113.

⁷³ Sober, E. 'Evolution without Naturalism' in "*Oxford studies in philosophy of religion volume 3*", Kvanvig, J.L. ed., *Oxford Scholarship online*, doi 10.1093/acprof:oso/9780199603213.003.0010 (2011).

Darwinism became the banner of those who would overthrow what they saw as an irrational, superstitious view of human origins...The theory of evolution became the focus of the confrontation between science and religion.⁷⁴

What Monod means by “chance”, is that random changes in DNA, resulting (via transcription of RNA, or some change in gene regulation) in changes in protein sequence, produces (via the “genotype-phenotype map” and its interaction with the physical environment) all the variation in phenotype and fitness that drives evolutionary change. This is the central aspect of evolutionary biology that connects the discipline to the concept of novelty more generally: *the origin of the variation upon which natural selection must act, prior to any such action.*

Protein folding proceeds hierarchically through folding domains that influence the subsequent path of the folding process, and “prediction” of protein shape is a heuristic search process requiring a sufficiently similar-shaped protein as an initial template⁷⁵. Contrary to popular belief, *a priori* prediction of even the shape (let alone function) of a protein based on its amino acid sequence (which is what the DNA sequence determines) is not possible. Modern “systems biology” paradoxically grounds its research programs on resolving such uncertainty, whilst providing the pretext for positions like that of Monod above. This situation is summarized by Sheldrake:

There is a vast gulf between rhetoric about the powers of genes and what they actually do. Investors in biotechnology are swept along by the metaphors, as are the readers of popular science...Weismann, who made the determinants an active agency...In effect...endowed a special kind of matter, the germ plasm, with the properties of the soul... we know what genes actually do. They code for the sequences of amino acids that are strung together in polypeptide chains, which then fold up into protein molecules. Also, some genes are involved in the control of protein synthesis. DNA molecules are molecules. They are not “determinants” of particular structures, even though biologists often speak of genes ‘for’ particular structures or activities...They merely code for the sequences of amino acids in protein molecules⁷⁶

⁷⁴ R.Wesson. *Beyond natural selection*. (Cambridge/MIT, 1991).

⁷⁵ K.A.Dill & J.L.McCallum. The protein folding problem: 50 years on, *Science* 338. 6110. 1042-1046. (2012)

⁷⁶ R.Sheldrake *The Science delusion*. (Coronet, 2012).

This is the problem of whether “biological information” is real or metaphorical, which can be extended to information more generally, thus forming an important part of a wider theological discussion⁷⁷. Hypothetically, some form of Platonism, in which information has a distinct existence from matter/energy or causation, could be interpreted as plugging the above “information gap”. But can such a speculation ever be anything else than a gratuitous dualism, and/or a flagrant invoking of the GOTG? I argue that perhaps it can, if strictly focused on the *origin of the variation in fitness*, i.e. prior to the operation of selection, and if this is conceived of as a biological example of a more general novelty generating impetus in nature.

A likely counter argument is an appeal to the long evolutionary timescales and large population sizes involved in evolutionary change. Explaining the origin of variation in fitness (before the operation of selection) by appeal to the long evolutionary timescales involved was deemed the “Fallacy of eternity” by Wallace:

...the idea that positing eternity for matter or organized life renders their existence at all intelligible...arises from a want of real thought about what eternity means...an eternity of progress...should have produced an infinite result⁷⁸

Thus, I argue that the idea that random changes in DNA, long evolutionary timescales and large population sizes, the genotype phenotype map, and the power of natural selection and demographic factors, explains biological novelty *in entirety*, is in fact a prior commitment to an ontological naturalism invoking the causal closure of nature. Whilst such an ontological commitment is reasonable and logically coherent, it is commitment rather than an empirical result.

For all novelty to be subjective, a radical steady state vision of nature would be required, which is decisively refuted by both big-bang cosmology and (in particular) biological evolution. The widely held view that evolutionary biology “proves” that all novelty is attributable solely to

⁷⁷ P.Davies and N.H.Gregersen. *Information and the nature of reality*. (Cambridge, 2010).

⁷⁸ Wallace, A.R. *The World of life: A manifestation of creative power, directive mind and ultimate purpose*. (Chapman & Hall, 1910)

chance is in fact an ontologically naturalistic commitment to the causal closure of nature.

2.6 A God-shaped-hole without a God-of-the-gaps?

The concept of *variable* divine action is the ultimate source of the God-of-the-gaps (GOTG) critique. God could plausibly exert a uniform influence on all nature's cause-effect chains, which could explain *that* such cause-and-effect chains exist, whilst leaving scientific enquiry to explain precisely *what* they consist of. But God's *temporally and spatially focused* action implies the existence of criteria that distinguish such action from "normal" natural causes. If these criteria are taken to be subjective then divine-action in the world is relativized to the point of triviality. If they are taken to be objective, a divine self-inconsistency is implied, in which God violates of the very laws of nature that he sustains.⁷⁹

Key issues include whether divine freedom is compatible or incompatible with the natural causal order. Compatibilism takes God's action to transcend nature's causal structure without contradiction (for instance via a separation between divine primary and natural secondary causation, derived from Aquinas). In-compatibilism postulates a tension between divine intervention and causal closure: An in-compatibilist taking nature to be causally closed would label special objective divine action as "interventionist". An in-compatibilist without a commitment to causal closure might deem God's special objective action as "non-interventionist"⁸⁰, if restricted to natural systems that are interpretable as not entirely causally closed, via non-interventionist objective divine action (NIODA)⁸¹.

NIODA models tend to restrict God's action to natural systems with scientific characterizations that are interpretable as compatible with the idea that God can, as it were, make up a deficit in causal determination. Postulated causally open systems may, it is argued, include those exhibiting indeterminacy⁸², emergence and/or "top-

⁷⁹ Saunders, *ibid*

⁸⁰ R.J. Russell Quantum physics and the theology of non-interventionist objective divine action, ch34 in *The Oxford Handbook of religion and science*, ed by P. Clayton & Z. Simpson. (Oxford, 2006). pp579-596

⁸¹ T.F. Tracy. Theologies of divine action, Ch 35 in *The Oxford Handbook of Religion and Science* ed by P. Clayton & Z. Simpson. (Oxford, 2006) pp596-611.

⁸² Russell, *ibid*.

down causation”⁸³. But an unresolved uncertainty concerns the extent to which it is explanatory or significant to postulate that God fills a “casual-gap” (e.g. indeterminacy) for which he himself is creatively responsible. As Griffin notes:

Theologians seem to be faced with a dilemma. On the one hand, if they refer to some feature of the world as being inexplicable apart from divine influence, they are accused of a God-of-the-gaps. On the other hand, if that, perhaps through nervousness at being so-accused, do not point to any feature of the world that seems to require divine influence, the reason for their continuing to speak of God becomes puzzling for those accustomed to basing their affirmations on evidence.⁸⁴

For instance, God might act as a “determiner of indeterminacies”, defining the precise state connecting each member of an entangled pair of particles, at the instant at which this state is determined during measure-induced quantum wave-function collapse⁸⁵.

But this begs the question as to why God set up non-deterministic natural systems requiring his influence to determine them, or whether (in this example) measurement-induced wave-function collapse can occur without God.

Griffin himself argues that Alfred North Whitehead⁸⁶'s God, exerting a persuasive but non-compelling lure within nature, provides a “God shaped hole without a God of the gaps” within which “Divine causation is never an interruption of the pattern of natural causation, but rather an essential factor in that pattern”, and that pattern implicitly points to God. Whitehead’s perspective is subtle, and his lexicon is notoriously elaborate and arbitrary, but his essential idea is that there is a ubiquitous and ultimate creativity at the foundation of existence. Whitehead argued that the stuff of existence is an overlapping collection of temporal processes termed “actual occasions”, each of which receives past causal influences via a “objective pole”, internalizes these influences via a “subjective pole”, then exerts causal influence into the future. This amounts to saying that every entity receives causal influences objectively but contains and embodies a subjectivity through which these influences may be acted upon with a degree of freedom. In other words freedom is foundational as well as creativity. God

⁸³ Gillet, *ibid*, Peacocke, *ibid*.

⁸⁴ D.R.Griffin, *Religion and scientific naturalism: Overcoming the conflicts*. (New York, 2000).

⁸⁵ Russell, *ibid*.

⁸⁶ A.N.Whitehead. *Process and reality*. (New York, 1978, 1928)

is an interactive *participant* in an underlying creative process, not an omnipotent dictator of that process:

At the heart of the metaphysical principles is creativity, which Whitehead calls the category of the ultimate. Creativity is the twofold power of every actual entity to exert both final and efficient causation...every actual occasion creates itself out of the causal influences received from prior actual occasions, then exerts subsequent upon subsequent occasions.⁸⁷

In some instances, God may act as a localized “lure” towards the actualization of certain outcomes without compulsion. The problem is that Whitehead never precisely explains how this lure works. Final causation is localized to a multitude of individual actual entities, but this is achieved by attributing a degree of subjectivity and creativity to everything in existence. The problem with imparting a degree of creativity to everything in nature is that it fails to distinguish between the novel and non-novel features of nature. Nonetheless, the distinction between a God-shaped-hole (GSH) into which nature’s causal processes flow, after the contours of this hole are set up by God is, I argue, a useful one. In what follows I will attempt to express this concept with sufficient precision to allow an empiricist-naturalist to assess it fairly.

Imparting a degree of novelty to every entity in existence fails to define any distinction between novelty and its absence. A “God-shaped hole” without a God-of-the-gaps requires focus on a specific feature of nature that cannot, even in theory, be explained by future scientific examination of finite causes.

2.7 Summary

The above discussion serves to illustrate how the concept of novelty sits at the boundary between the applicability of scientific and theological explanatory approaches. Novelty points to uniquely theological concepts of creativity, but the primary evidence for novelty’s reality is derived from historical-scientific investigation into natural history. Novelty would be impossible without time, but refers to the content of events within time, not the general nature of time or change. Novelty is deeply intertwined with causation, but it is a matter of opinion whether

⁸⁷ Griffin, *ibid* pp96

novelty is the origin of a pattern of causation, or a disconnect between causes and their effects that is essential for time's flow. Explaining novelty by appeal to recombination between existing entities fails to explain why some such recombination also produces repetition. Interpreting novelty as the earliest instance of actualization of an event that was always a possibility within a causally closed stochastic sample space (but simply took time to occur) requires an explanation of where such a timeless sample space is, and on what basis its causal closure is presupposed. Attributing novelty to a creative impetus from God requires a precise explanation of what this is supposed to mean, why an empiricist should pay attention to the idea, and how, even in theory, natural events could derive from such an impetus. There is clearly a need for precise terminology. I will begin with some definitions, before moving on to discuss:

- i. What exactly is scientifically inferable novelty?
- ii. What if anything does novelty indicate about the status of a causally closed vision of nature?
- iii. Can novelty provide a God-shaped-hole without invoking a GOTG?

3. Working Definitions

This section will define the key concepts that will feature within the subsequent discussion. An appendix is included at the end of the dissertation, for the benefit of the reader requiring more precision, and expands upon each definition using a simple logical formalism (and also contains a table of all abbreviations used). Indented bullet points after each definition describe additional notes relevant to the concept but not an essential part of it.

Definition 1: Natural regularity

A specific, context-dependent repetitive natural phenomenon that conforms to induction-based prediction.

- i. A natural regularity persists from one timepoint to the subsequent one during an observation interval and is scientifically accessible, such that multiple investigators can objectively agree about the content of testable hypotheses of the form “*Regularity_x exhibits property P at present, thus will exhibit P in the future*” and thereby build scientific theories about the regularity.
- ii. There exists a set of boundary conditions that are (within a spatial context and time interval of interest) individually necessary and collectively sufficient for that regularity to occur.

Definition 2: Scientifically inferable novelty:

The objectively earliest appearance, anywhere in nature, of a specific, subsequently persistent and scientifically accessible natural regularity.

- i. Scientifically inferable novelties and natural regularities are definable in corresponding pairs, such that there exists a timepoint before which the regularity did not occur anywhere in nature, and after which it does occur (in at least one spatial context within nature).
- ii. The requirement that novelty be the objectively earliest appearance of a regularity reflects the idea that if a regularity disappeared from nature because its boundary conditions ceased to be realized anywhere, but then re-appeared

once those boundary conditions were again realized somewhere, this would *not* be a novelty, because the regularity would have previously existed.

- iii. Note that this contextual definition does not preclude talk of the “laws of nature” in the stereotypical universally applicable sense. If the “novelty” in question refers to the initial instantiation of gravitational attraction, it occurred at or shortly after the big-bang and the “context” within which the corresponding regularity applies is the entire universe. If the novelty is the origin of a biological species, the context is the relevant ecological range, and the regularity’s persistence is until the species’ extinction.
- iv. Assuming a degree of habituality and temporal evolution within nature, there is no reason to suppose that natural regularities will remain identical to the boundary conditions corresponding to the novelties from which they arose, but rather may “evolve away” from these boundary conditions (e.g. the boundary conditions necessary to support many existing forms of life plausibly differ from those in which the origin of life occurred).

Definition 3: The totality of possible natural regularities TPNR:

A natural regularity is possible if all that is necessary for this regularity to occur within a context is the simultaneous realization within that context of all the necessary boundary conditions. A natural regularity is impossible if there is no list of boundary conditions anywhere in nature, the combined realization of which would cause that regularity to occur.

Definition 4: The underlying constraints upon nature’s regularities UCNR:

A collection of law-like constraints, operating in a prescriptive manner across nature (i.e. within some ultimate underlying causal structure of nature), that has the effect that some natural regularities cannot be actualized, regardless of which boundary conditions are realized. There is a key difference between a natural regularity that has never actually occurred in nature but is nevertheless possible, and a natural regularity that is impossible. A natural regularity that is possible but has never happened has been prevented from occurring by a lack of realization of various contingent boundary conditions. A natural regularity that is impossible has been prevented from occurring by the fact that it is incompatible with some aspect of the underlying causal structure of nature.

Definition 5: Novel-possibility generation NPG:

The appearance at a specific timepoint of a specific possibility within the totality of possible natural regularities that was not present at any previous timepoint, without any violation of the underlying constraints upon nature’s regularities. In other words, the “addition” of a new possibility to the totality of possible natural regularities, that is an *extension* of the pre-existing underlying causal structure of nature’s regularities, rather than a transgression or violation of that structure. The extension of the totality of possible natural regularities into this space, without violation of the underlying causal structure of nature, is novel-possibility generation.

- i. This invites the idea that there is some form of intermediate space between natural regularities that are possible (and only require natural causes to lead to realization of the relevant boundary conditions) and those that are impossible (are precluded by the underlying causal structure of nature). In between these two extremes, there exists an ambiguous space of natural regularities that are neither possible nor impossible.
- ii. There is a loose similarity between this idea and the (strictly scientific/mathematical) idea of an “adjacent possible”⁸⁸ from within the science of complexity theory, which (roughly) refers to possibilities that are somehow incrementally close to the possibilities that already exist.

Definition 6: Empiricism-focused naturalism (EFN) with respect to novelty

The view that either talk of possible natural regularities (as distinct from actual natural regularities) or talk of an underlying causal structure of nature (as distinct from immediate empirical observation of nature), is groundless and therefore nonsensical.

Definition 7: Causal closure of the totality of possible natural regularities (CCPNR):

The view that any natural regularity that is possible at any point in time, was/is necessarily timeless possible, because novel-possibility generation does not occur. (i.e. the view that the number of possibilities within the totality of possible natural

⁸⁸ S.Kauffman. *Investigations*. (Oxford, 2000).

regularities is fixed across time, and this totality is closed to the addition of new possibilities).

Definition 8: Divinely induced novelty by possibility creation:

The idea that scientifically inferable novelty results from novel-possibility generation resulting from an intentional act of possibility creation by God, but one that is compatible with the pre-existing underlying causal structure of nature's regularities.

Definition 9: Divinely induced novelty by intervention:

The idea that a scientifically inferable novelty was caused by God's intentional transgression of the underlying causal structure of nature, with the intention of causing the occurrence of a novelty. The most obvious example of this would be God's direct/ "miraculous" intervention into the finite natural causes of the relevant boundary conditions to cause a novelty to occur.

4. Novelty and the underlying causal structure of nature

The definitions given above allow an analysis of the following key question:

Q₁ “Supposing that an objective novelty occurs, subject to relevant boundary conditions, and produces a corresponding natural regularity, does the occurrence of this novelty indicate any significant change in the underlying causal structure of nature?”

Answering Q₁ in the affirmative would correspond to definition 5; novel possibility generation (NPG). Answering Q₁ in the negative would correspond to definition 7; causal closure of nature’s regularities (CCNR). Declining to answer would correspond to definition 6; an empiricism-focused naturalism (EFN) regarding novelty. I will consider these options in reverse order, by imagining how an adherent to each of these positions might respond to the question.

4.1 Two interpretations of novelty: Empiricism-focused-naturalism and causal closure of nature’s regularities

The EFN-advocate’s likely answer is, I argue, plausibly representative of the view of a good proportion of working scientists and philosophers of science with empiricist leanings:

A₁: EMPIRICISM FOCUSED NATURALISM (EFN):

“The question is poorly formed. The “underlying causal structure of nature” cannot be meaningfully discussed in any general sense distinct from nature itself. Those features of nature that are investigable by science can be said to have a “causal structure” insofar as science has predictive-power over them. Predictive-power and scientific-accessibility require that phenomena exist or have previously existed, thus is restricted to what you term a “regularity”. I accept that at least some instances of what you term “novelty” are objective, in that most or all of nature’s systems can be credibly argued to have not existed at some point in natural history, implying their appearance at some time. However, I do not find the distinction between “novelty” and “regularity” particularly useful.”

If there is such a thing as an “underlying causal structure of nature” it amounts to some sort of constraint upon nature from the outside. Therefore, any such structure cannot be dependent upon nature for its existence. For instance, an “underlying causal structure of nature” might refer to a platonic vision of the laws of nature, or some constraints imposed upon natural causes by God. But this phrase cannot really be taken to refer to a scientifically verifiable entity within nature, therefore cannot be anything other than groundless from the viewpoint of EFN.

Crucially however, I argue that naturalistic commitments are much less of a barrier to answering the same question when it is redirected at regularity rather than novelty:

Q₂(REGULARITY): “When regularity occurs and persists into the future, does this reflect a metaphysically significant change in the causal structure of nature?”

A₂: EMPIRICISM FOCUSED NATURALISM (EFN): “No. The phrase “causal structure of nature”, insofar as it is meaningful at all, pertains to the features of nature amenable to scientific investigation. The regularity, by definition, occurred at the previous timepoint and can, with reference to scientific investigation into its properties, be expected to occur at the next timepoint under the same boundary conditions. Any meaningful talk of the “causal structure of nature” made with reference to this regularity would thus apply equally well to its previous occurrence.”

This answer is perfectly available to the EFN-advocate, despite their discomfort with any distinction between “nature” in a scientifically accessible sense, and an “underlying causal structure of nature”. The reason for this is that in the case of a natural regularity, a scientifically accessible phenomenon exists at an earlier and a later timepoint. Thus, the EFN-advocate has access to something that can (by empiricism-focused standards) be spoken about both before and after the supposed “change” that *Q₂* refers to. Even the staunchest empiricist could say something like:

“The scientifically investigable properties of the regularity were the same across the time interval of interest. Interpret this how you will, I regard any additional statements as groundless.”

By contrast, in the case of novelty, a natural regularity appears at a timepoint that was previously absent. To assess whether a change in an observable feature of nature reflected a change in the “underlying causal structure of nature”, one would need to assess what that change was, and make certain assumptions about what it might mean for such an underlying structure. But novelty is not a *change in* an observable feature of nature, but the *appearance of* such an observable feature from a state of initial absence. The EFN-advocate can only say that something “exists” once an empirically verifiable phenomenon is present (which is only the case after the novelty has happened). They are (I argue) obliged to remain silent about the first timepoint, which prevents them interpreting it (or not) as the first part of a change in the underlying causal structure of nature. This is a consequence of the fact that empiricism can only apply induction-based prediction to natural regularity, not to novelty.

This illustrates how novelty demarcates the boundary of what can legitimately be predicated upon science in an immediate, empirical sense. The problem for empiricism-focused naturalism is not so much the reference to a concept (the underlying causal structure of nature, as distinct from immediate observations from nature) that cannot, strictly speaking, be grounded evidentially. The problem for EFN is the focus on novelty.

I argue that there is a loose to a parallel with Hume’s treatment of miracle, in the sense that the (evidential) basis for answering the question is defined out of existence by the nature of the question’s referent. Hume’s definition of miracle:

Nothing is esteemed a miracle, if it ever happen in the common course of nature⁸⁹

rules out the possibility of a miracle’s being verifiable within any system of thought based on a reference to this “common-course of nature”. Analogously, the definition of novelty as the onset of regularity rules out its explanation within a system of thought in which regularity is all that it is meaningful to talk about, which, I argue, encompasses a strong-empiricist form of naturalism.

This conclusion is strengthened by the contrast with the likely response to Q_1 based on a commitment to a view corresponding to definition 7 above; causal closure of

⁸⁹ D.Hume. *Of Miracles* (Open Court Classic,1985).

possible natural regularities, CCPNR. Whilst EFN rejected the premise that an underlying causal structure of nature could be spoken of in a distinct way from immediately scientifically observable phenomena, CCPNR accepts this premise, but explicitly commits to the view that this underlying structure contains within it a timelessly existing possibility space from which all scientifically inferable novelty derives (see definition 7):

A₁: CAUSAL CLOSURE OF POSSIBLE NATURAL REGULARITIES (CCPNR)

“No. The underlying causal structure of nature is fixed and timeless. Even if one takes nature’s stochastic features to be ontologically indeterminate (rather than epistemically inaccessible), these features are still ‘pre-determined’ in the sense of necessarily deriving from a causally closed and finite sample space. All that occurred temporally to induce the novelty was the realization of the boundary conditions, which in turn occurred due to efficient causes traceable back to the origin of the universe and instantiation of the laws of nature. The natural regularity produced by this novelty previously existed timelessly as a possibility. If one wishes, one can interpret this as consistent with the general laws and locally contingent regularities of nature having a timeless existence (e.g. as ideas in the mind of a God who is outside of time and created nature but does not intervene within it). If one prefers to avoid such theological suppositions, one can nevertheless commit to the idea that no qualitatively new causal influences enter nature from the outside within time.”

CCPNR differs crucially from the emphasis on direct empirical verifiability in EFN above, in that the CCPNR-advocate is willing to appeal to the existence of some entity outside nature. This entity is a fixed, causally closed, timelessly existing totality of possible natural regularities TPNR (definition 3).

There is a natural affinity between this view and the long tradition of science-focused deism, in the sense that God could be the grounding for such a timelessly existing possibility space but would not be required to intervene within nature after an initial act of *creatio ex nihilo*. Novelty would, on this view, amount to the actualization of a natural regularity that God had created as a possibility with a timeless existence. This actualization would be due solely to finite natural causes associated with realization of

the corresponding boundary conditions and would not invoke any change in the underlying causal structure of nature. CCPNR might also be compatible with a theism admitting of a God who is responsible for uniformitarian general maintenance of the laws of nature, and who acts secondarily, through natural causes.

Thus, this view requires an explicit commitment to the existence of some entity outside scientifically accessible-nature, the existence of which cannot be verified empirically, thus is not compatible with ontological naturalism. However, it fits perfectly well with a methodological naturalism taken to be consistent with the assumption of such an “extra-natural” entity.

4.2 Novel possibility generation and responsible navigation of the God-of-the-gaps criticism

The final possible answer to Q_1 is in the affirmative, and is connected to the idea of novel-possibility generation (NPG, definition 5, also see definitions 8 and 9):

A₁: NOVEL POSSIBILITY GENERATION (NPG) “Yes. The underlying causal structure of nature includes constraints on which natural regularities are and are not possible. This set of constraints on possible regularities can change over time, such that addition of a new possible regularity may induce a new actual regularity, i.e. novelty. The same boundary conditions would not have resulted (and perhaps actually did not result) in the instance of novelty at an earlier point in time. If one wishes, one can interpret this as the total set of possible natural regularities having an existence outside nature in the mind of God. On this view, God is eternal and not dependent upon time, but may interact with nature within time to update the possibilities of which nature admits, via a creative divine act producing the possibility of the novel regularity. This is not a “violation” of nature’s laws/regularities comparable to Hume’s understanding of miracle, but rather an addition to them.”

In terms of the underlying causal structure of nature, this change could be the addition of a new possibility to the totality of possible natural regularities (divinely induced novelty by possibility creation DINPC, definition 8). Alternatively, this change could be some other reorganization of nature’s causal structure, up to and including some form of divine intervention in the finite causes necessary to realize the relevant

boundary conditions (divinely induced novelty by intervention DINI, definition 9). Clearly these are very different concepts with different implications for science-religion discourse and the GOTG-critique.

DINPC is an appeal to God to explain the fact *that* the novelty occurred, i.e. an invocation of God as the final cause of this novelty. DINI is an appeal to God to explain exactly *what* the novelty was, i.e. an invocation of God to explain the specific efficient/material causes involved in realizing the boundary conditions preceding the novelty. It is therefore obvious that DINI is a miraculous intervention that would violate both divine self-consistency and would be scientifically/naturalistically objectionable. By contrast, DINPC would amount to an extension of the totality of possible natural regularities by God, rather than transgression or violation of the constraints on what is possible.

DINI would make productive dialogue between its advocates and scientists/naturalists impossible, because it amounts to a license to arbitrarily invoke God's action to explain the unexplained. Consider a DINI-advocate's likely attitude to an experimental attempt to recreate a novelty after its natural appearance:

DIVINELY INDUCED NOVELTY BY INTERVENTION (DINI_(GOTG)) : "Without divine intervention (within finite causes by means of which the boundary conditions were realized) the novelty would not have occurred. The regularity nevertheless remains in existence. Thus either:

- i. The regularity depends upon the same boundary conditions as the novelty, and God is continuously sustaining these boundary conditions.*
- i. Somehow the regularity has come to depend on different boundary conditions from the novelty in which it arose.*

In either of these cases, an experimental attempt to recreate the novelty, i.e. to cause the regularity to appear from initial conditions in which it is absent, are destined to fail- because no experiment can recreate the necessary divine influence."

One could not imagine a more flagrant invocation of a GOTG. For instance, suppose biochemists are experimentally manipulating autocatalytic RNA molecules, or some potentially autocatalytically closed network of chemical reactions (or equivalent

system), in order to attempt to recreate the transition between life and non-life (i.e. the novelty). The DINI-advocate would take the origin of life to be essentially a miracle, arguing that either (i) life's persistence requires God because its origin did, or (ii) life's persistence can occur by natural cause's but life's origin entailed divine intervention and thus cannot be reproduced. The damaging impact of either assertion upon scientific investigation is obvious. By contrast, consider the likely attitude of the DINPC-advocate to a scientific attempt to recreate an instance of novelty:

DIVINELY INDUCED NOVELTY BY POSSIBILITY CREATION (DINPC_(¬GOTG)):

“Before creative divine input into the possibility space underlying nature’s regularities, at the timepoint of novelty, it was impossible for the same set of boundary conditions to produce the novelty in question. Now, after the occurrence of this novelty, and given that the regularity exists and is therefore possible, comprehensive scientific explanation of the finite causes constituting this regularity is entirely possible and may well succeed.”

Thus, in terms of the origin of life example, the most scientifically un-productive statement that a DINPC advocate could make is (for example) is the idea that experimental recreation of the origin of life was impossible until about 4 billion years ago; clearly a comparatively benign claim. Ultimately, DINPC attributes the fact that an experimental recreation of a novelty is possible to God's prior creation of that possibility during the actual novelty. But DINPC but does not challenge the premise that such an experimental recreation is possible, or science's potential ability to uncover the finite natural causes involved.

Thus, DINPC involves an appeal to an extra-natural totality of possible natural regularities (definition 3) to which God adds within time. The existence of such an entity is, obviously, not a naturalism-friendly commitment. But DINPC is nevertheless compatible with methodological naturalism in in terms of its implications for scientific claims. That said, an implication of DINPC (see definitions 1 and 2) is that realization of the same set of boundary conditions at one point in time is sufficient to produce a natural regularity, but not sufficient to do so at an earlier time prior to the act of possibility creation. This could be connected to testable scientific claims, thereby potentially creating a conflict with advocates of DINPC if falsified in the negative.

For instance, suppose a historical-scientific attempt was made to falsify the idea that a regularity was possible at one time, but impossible earlier, under the same contextual boundary conditions. Suppose a (strictly scientific) hypothesis along these lines was successfully falsified in the negative (i.e. the same set of boundary conditions appeared to give rise to the appearance of a regularity uniformly across natural history, in contrast to what DINPC would suggest). This would disprove any prior claim to the contrary by a DINPC-advocate, in a way that is arguably analogous to falsification of GOTG-invoking claims. However, assuming any such claim had been framed in an appropriately restricted scientific way, this would have no negative impact on the scientific process, and is not a GOTG, because it does not claim that a feature of nature is scientifically unknowable. Thus, provided that the concept of DINPC is handled with care, such a situation appears no more hazardous than (say) a theological interpretation of big bang cosmology in terms of *creatio ex nihilo*.

4.3 Conclusions

Conclusion 1: An empiricism focused naturalism EFN taking the perspective that only what is immediately empirically verifiable can legitimately be spoken about, cannot get to grips with novelty as distinct from regularity, nor can it deal with the concept of an “underlying causal structure of nature” as distinct from what is immediately observable within nature. Thus, this perspective must remain agnostic about any connection between novelty and an underlying causal structure of nature.

Conclusion 2: An explanation of scientifically inferable novelty as the earliest instance of actualization of a timelessly present possibility requires the assumption that there is some timeless entity containing such possibilities; Causal closure of possible natural regularities (CCPNR). Such an entity cannot exist within time therefore cannot exist within nature. Consequently, this explanation of novelty is unavailable to an empiricist or naturalist but is available to (for example) a deist.

Conclusion 3: Divinely induced novelty by possibility creation (DINPC), by connecting novelty to God only through possibility creation rather than an interventionist act, attributes scientifically inferable novelty to God without invoking a GOTG. DINPC argues that before the divine act of possibility creation there was no possibility of any natural regularity therefore no system to contain epistemic gaps.

Afterwards, the regularity is entirely accessible to scientific investigation, therefore a GOTG cannot be predicated upon DINPC.

5. Summarizing remarks and future direction:

Novel non-energetic information input?

Divinely induced novelty is compared to other conceivable relationships between God and nature in table 5.1, which summarizes the above arguments, and illustrates the very different implications of DINI and DINPC for science-religion discourse.

Table 5.1 Comparison between divinely induced novelty and other imaginable relationships between God and nature

Type of hypothetical divine influence within nature	Potential problems and counter-arguments
Miraculous divine action	Places theology in direct conflict with science, stereo-typically characterized as a transgression of previous regularities/laws of nature. Contradicts immediate experience.
Subjective divine action	God's influence in the world is trivialized and arbitrary to the point of meaninglessness.
NIODA within a scientifically well characterized system	If God exists he must have created and must sustain the system in which his action occurs, so such action is arguably unremarkable. Hypothetical divine action is realistically likely to be restricted to a causally undetermined and/or epistemically inaccessible part of the system.
NIODA within a scientifically poorly characterized system	Future scientific progress will reveal either that the attribution to divine action invoked a God-of-the-gaps, or lead to the (above) issues referring to NIODA in a well-scientifically characterized system.
DINI	All the objections to miracle apply. Additional fact that the regularity remains in existence so is scientifically

	investigable, invokes a severe GOTG that impedes scientific progress.
DINPC	No danger of GOTG with direct scientific attempts to recreate past novelties. Fact that experimental recreation is possible is attributed to prior divine-possibility creation, but no challenge to science’s ability to uncover relevant natural causes.

Table 5.2 highlights how the focus on the distinction between novelty and regularity helps clarify the precise basis for any claim to future explanatory power over a natural phenomenon. Suppose such a phenomenon is a regularity. The EFN-advocate (definition 6) cannot claim that science will inevitably explain the feature in question, unless willing to explicitly commit to the premise that science can, in principle, explain every natural regularity in existence. There is nothing illogical or unreasonable about such a commitment, but it is a prior ontological commitment (to the causal closure of nature and the comprehensibility of natural causes by science) rather than an empirically grounded statement. I argue that without an explicit ontological commitment to the existence of a timeless and causally closed set of possible natural regularities (CCPNR, definition 7), this amounts to a mirror image “naturalism of the gaps”.

In other words, when it comes to an unexplained natural regularity, if a theist attributes an unexplained feature of this regularity to God, but this feature could theoretically be explained by the future advance of science, this is a God of the gaps. When an empiricist naturalist attributes an unexplained feature of the same regularity to “that which will be rendered comprehensible by the future advance of science”, this is a naturalism of the gaps, until it is explicitly linked to an ontological commitment to causal closure of nature’s possibilities, in which case the claimant is no longer a naturalist at all, but closer to a deist or Platonist.

Ontological commitment to causal closure is entirely reasonable, but it is a commitment rather than a scientific result⁹⁰. CCPNR presupposes a timeless entity

⁹⁰ Plantinga, *ibid.*

outside nature, therefore cannot be grounded upon naturalism, but sits most easily with a deism in which novelty within nature is “not novel to the mind of God”, but still objectively novel *within* nature. A focus on novelty may help foster either agnosticism about the ontological status of unexplained phenomena (which I argue is the best response to novelty under EFN), or explicit commitment to a causally closed view of nature (i.e. CCPNR).

Table 5.2 The status of the claim to future explanatory power over a currently unexplained natural phenomenon from the key perspectives discussed.

Perspective justifying future claim to explanatory power	Regularity	Novelty
EFN	“naturalism-of-the-gaps” without explicit commitment to CCPNR.	Cannot reasonably comment on the novelty as distinct from the regularity it produces.
CCPNR	Claim is reasonable but only when commitment to an entity outside nature, containing the predetermination is made explicit.	Plausibly explained as actualization of a possibility with timeless existence outside nature.
Divine influence	GOTG in all cases	GOTG if DINI because divine influence acts on finite natural causes. No GOTG if DINPC, because possibilities outside nature are not directly scientifically accessible.

The distinction between novelty and regularity also acts as a filter separating claims that will always invoke a GOTG (namely invoking God to explain an unexplained feature of an existing natural regularity) and claims that need not (namely DINPC, providing the possibility of a natural regularity that arose during a past instance of novelty). DINI raises all the worst problems posed by miracle and would lead to a harmful GOTG if focused on the object of scientific enquiry, because God's action occurs in the physical causes constituting realization of the boundary conditions necessary for the novelty. Thus, DINI provides a license to invoke God to explain any rare or poorly explained natural instance of novelty and to claim that it is outside the explanatory scope of science (e.g. the claim that the origin of life required some form of supernatural intervention to arrange the self-replicating molecules appropriately therefore will never be reproduced in the lab). DINI is therefore GOTG-invoking and anti-scientific.

By contrast DINPC is suggestive of a temporality in the possibility space underlying nature which, though a theological interpretation, is consistent with the scientifically grounded appearance of novelty during natural history. Crucially, God's having created the possibility of the natural regularity in the past is compatible with that regularity's experimental reproducibility in the present. Thus, there is no danger of a GOTG with DINPC, because God's creative action occurs in this underlying possibility space, not chains of scientifically accessible natural causes themselves.

A potentially fruitful direction for future thought may be the application of the novelty/regularity distinction to the concept of non-energetic, non-causal information. The proposition that information is a relational concept, distinct from matter-energy or causation is broadly compatible with the arguments I have suggested here. The idea is perhaps also amenable to some sort of rediscovery of a kind of "temporal-Platonism" in which information is understood in the classical/etymological⁹¹ sense of "imparting-form" (to matter) in a time-specific manner. The iconic example of non-energetic information within science-religion discussion is Polkinghorne's⁹² idea active non-energetic information input sways potentially chaotic initial-condition-

⁹¹ R.Capurro & B.Hjørland, "The Concept of Information," in Blaise Cronin (ed.), *Annual Review of Information Science and Technology (ARIST)*, 37 (Chapter 8), 343–411 (2003).

⁹² Polkinghorne, *ibid*

sensitive dynamical systems towards order. The concept's wider philosophical implications are also highlighted by Suppes's remark that:

...many of the dilemmas about free will are now replaced by dilemmas about information is introduced into a causal system...⁹³.

The free will issue also mirrors the relationship between the compatibility of God's intentional freedom to act in the world, and the world's physical causes, in the sense that if free will is not internally constrained by with deterministic relationships between brain particles, God's free action need not be constrained by relations between finite causes in the world⁹⁴.

I tentatively suggest that non-energetic information, whilst an intriguing concept, will always potentially invoke a GOTG (or Platonism of the gaps) when applied to nature's repetitive regularities, because future scientific advances might reveal what we thought was caused by non-energetic information input to be attributable to finite natural causes. By contrast, the more restricted concept of the *time-specific input of novel non-energetic information* might (via some conceptual framework like table 5.2) explain why these regularities exist only at and after a given time. It would also align directly with what I have described here as the creation of the possibility of a natural regularity, in this sense of this possibility corresponding to a non-energetic information pattern that exists outside nature but somehow undergirds the natural (and scientifically investigable) instantiations of that pattern. Thus, the novelty-regularity distinction might allow the development of a future metaphysics of information that complemented science without invoking a GOTG.

An appropriate metaphor for how DINPC provides a God-shaped-hole without invoking a God-of-the-gaps might be the idea that the chains of cause and effect within nature are analogous to a body of water, flowing over an impermeable rock surface (analogous to the limits on the totality of possible natural regularities). DINPC is analogous to the opening-up of an "oceanic trench" in this underlying rock layer (the totality of possible natural regularities) by God, into which the "water" (nature's cause-effect chains) then flows; to realize newly possible natural regularities (the new currents flowing into the opening). This opening up of new spaces for nature's causes

⁹³ P.Supes. *A probabilistic theory of causality*. (North-Holland Publishing Company, 1970).pp95.

⁹⁴ A.Flew. Compatibilism, free will and God. *Philosophy*. 48 (185). 231-244 (1973)

to flow into is divinely induced novelty by possibility creation; DINPC. The key reason that this metaphor is appropriate is that if an oceanic trench opens on the seabed and the overlying water flows into a new space, there is nevertheless no change in the fundamental features of water or of oceanic circulation. Analogously, perhaps DINPC creates new spaces for natural chains of cause and effect to flow into, thereby producing novelty and subsequent regularity, but it does not alter the underlying constraints on nature's causal structure. Thus, scientifically inferable novelty can be combined with theological commitments to provide a "God-shaped-hole" resulting from God's opening-up of new possibilities.

6. Appendix: Formalization of definitions given in section 3

There now follows a more precise exposition of the above definitions using a few symbols borrowed from set theory. Please see table 3.1 for the meaning of all symbols and table 3.2 for meaning of all abbreviations.

Definition 1: Natural regularity

$Regularity_X$'s being a member of the set of total natural regularities TNR entails the existence of a natural phenomenon X , the presence of which at one timepoint during an observation interval implies its presence at the next timepoint. $Regularity_X$'s being describable by a scientific theory that allows testable predictions to be made about it, and the existence of a set of contextual boundary conditions $(Boundary\ Conditions)_{Regularity_X}$, realization of each of which is individually necessary, and of all of which in combination $TBCR_{Regularity_X}$ (total boundary condition realization) is sufficient for the actual occurrence of $Regularity_X$.

$$\exists Regularity_X \in TNR \equiv$$

$$\exists X | (X_{(t_i)} \rightarrow X_{(t_{i+1})}, \forall t_i | t_i \in \Delta t_{OBS}) \& (Scientific\ accessibility_X)$$

$$Scientific\ accessibility_{Regularity_X} \equiv Theory_{Regularity_X} : Regularity_X \rightarrow Testable\ Predictions_{Regularity_X}$$

$$\exists (Boundary\ Conditions)_{Regularity_X} | BC_i \in (Boundary\ Conditions)_{Regularity_X} \rightarrow \neg BC_i(context, t) \rightarrow \neg Regularity_X(context, t), \forall i$$

$$\& (TBCR_{Regularity_X}(context, t) \equiv (\exists BC_i(context, t), \forall i)) \rightarrow$$

$$\exists Regularity_X(context, t) \tag{3A1}$$

Definition 2: Scientifically inferable novelty

A specific novelty is a member of the set of total natural novelties if and only if there exists a timepoint before which it did not exist anywhere in nature, and the regularity appears at and persists after this timepoint. This is equivalent to a sequence in time and causal dependence of the form “total realization of boundary conditions”, “novelty”, “persistence of corresponding regularity”.

$$\begin{aligned}
& \exists \text{Novelty}_X(t_N, \text{context}_N) | \text{Novelty}_X \in \text{TNN iff:} \\
& \neg \left(\exists \text{Regularity}_X(\text{context}, t_{\text{prior}}) \right), \quad \forall \text{context}, \forall t_{\text{prior}} < t_N \\
& \& \exists \text{Regularity}_X(\text{context}_N, t_N) \& \exists \text{Regularity}_X(\text{context}_N, t_{\text{subsequent}}) \\
& \quad \forall t_{\text{subsequent}} | (t_{\text{subsequent}} > t_N) \& (t_{\text{subsequent}} \in \Delta t_{\text{OBS}}) \\
& \left(\text{TBCR}_{\text{Regularity}_X}(\text{context}_N, t_N - 1) \right) \rightarrow \text{Novelty}_X(t_N, \text{context}_N) \rightarrow \\
& \left(\text{Regularity}_X(\text{context}_N, t_{\text{subsequent}}) \right) \tag{3A2}
\end{aligned}$$

Definition 3: The totality of possible natural regularities TPNR

A natural regularity Regularity_X is possible, i.e. is a member of the totality of possible natural regularities TPNR, if and only if total boundary condition realization for that regularity implies its occurrence. A regularity is not a member of TPNR if this implication is not true.

$$\begin{aligned}
& \text{Regularity}_X \in \text{TPNR iff: } \text{TBCR}_{\text{Regularity}_X}(c, t) \rightarrow \exists \text{Regularity}_X(c, t) \\
& \neg(\text{Regularity}_X \in \text{TPNR}) \text{ iff: } \neg(\text{TBCR}_{\text{Regularity}_X}(c, t) \rightarrow \exists \text{Regularity}_X(c, t)) \\
& \tag{3A3}
\end{aligned}$$

Definition 4: The underlying constraints upon natural regularities UCNR

A constraint K is a member of the set of underlying constraints upon natural regularities if it prevents the occurrence of a regularity even after total boundary condition realization for that regularity:

$$\begin{aligned}
& K \in \text{UCNR iff:} \\
& \left(\text{TBCR}_{\text{Regularity}_X}(c, t) \& K \right) \rightarrow \neg \exists \text{Regularity}_X(c, t) \\
& \& \left(\text{TBCR}_{\text{Regularity}_X}(c, t) \& \neg K \right) \rightarrow \exists \text{Regularity}_X(c, t) \\
& \tag{3A4}
\end{aligned}$$

Definition 5: Novel possibility generation NPG

Novel possibility generation is the appearance at and after a specific time of a possible natural regularity (i.e. in TPNR) that was not a possibility at any previous timepoint, but that is not prevented by any underlying constraint upon natural regularities. The generation of the novel possibility at timepoint t_N makes total boundary condition realization sufficient for the appearance of the regularity in question at and after this timepoint, whereas this was not sufficient before.

$$\begin{aligned}
NPG \equiv & \neg(\text{Regularity}_X \in \text{TPNR})_{t < t_N} \ \& \ (\text{Regularity}_X \in \text{TPNR})_{t \geq t_N}, \forall t \\
& \& \ \neg(K \in \text{UCNR} | K \rightarrow \neg \text{Regularity}_X) \\
& \& \ \neg \left(\text{TBCR}_{\text{Regularity}_X}(c, t_{\text{prior}}) \rightarrow \exists \text{Regularity}_X(c, t_{\text{prior}}) \right), \forall t_{\text{prior}} < t_N \\
& \left(\text{TBCR}_{\text{Regularity}_X}(c, t_{\text{subsequent}}) \rightarrow \exists \text{Regularity}_X(c, t_{\text{subsequent}}) \right) \\
& \forall t_{\text{subsequent}} \geq t_N
\end{aligned} \tag{3A5}$$

Definition 6: Empiricism focused naturalism EFN

The intersection between what is possible and what is non-actual is empty or meaningless to discuss; (i.e. there is no such thing as possible natural regularity that has never actually occurred in nature, because possibility and actuality are identical).

$$EFN \equiv \text{TPNR} \cap \text{TNR}^c = \emptyset \tag{3A6}$$

Definition 7: Causal closure of possible natural regularities CCPNR

A regularity's being possible (in TPNR) implies that it is timelessly possible (in TPNR for all time).

$$(\text{Regularity}_X \in \text{TPNR}) \rightarrow (\text{Regularity}_X \in \text{TPNR})_t, \forall t \tag{3A7}$$

Definition 8: Divinely induced novelty by possibility creation DINPC

Novel-possibility generation exists and is the result of a creative divine addition to the totality of possible natural regularities at a specific time, which subsequently causes that regularity to actually appear in an instance of natural novelty:

$$\begin{aligned}
DINPC \equiv & \exists NPG \ \& \ (\text{Divine influence}) \rightarrow NPG \\
& \neg(\text{Regularity}_X \in \text{TPNR})_{t < t_N} \ \& \ (\text{Divine influence}) \rightarrow
\end{aligned}$$

$$\begin{aligned}
& ((Regularity_X \in TPNR)_{t \geq t_N}, \forall t > t_N) \\
& \rightarrow Novelty_X(t \geq t_N, context_N) | Novelty_X \in TNN \tag{3A8}
\end{aligned}$$

Definition 9: Divinely induced novelty by intervention DINI

A natural novelty was the result of realization of boundary conditions that would not have occurred without a specific divine influence, such that this influence was not part of the set of underlying constraints upon natural regularities.

$$DINI \equiv \exists Novelty_X \in TNN$$

$$\begin{aligned}
& (TBCR_{Regularity_X}(context_N, t_N - 1)) \rightarrow Novelty_X(t_N, context_N) \rightarrow \\
& (Regularity_X(context_N, t_{subsequent}))
\end{aligned}$$

$$(Divine\ influence) \rightarrow (TBCR_{Regularity_X}(context_N, t_N - 1))$$

$$| \neg(Divine\ influence) \rightarrow \neg(TBCR_{Regularity_X}(context_N, t_N - 1))$$

$$\& \neg((Divine\ Influence) \in UCNR) \tag{3A9}$$

Additional concepts not directly referred to in section 3:

Definition 10 The Totality of scientifically accessible or inferable nature (TSAIN).

Something is part of the totality of scientifically accessible or inferable nature (TSAIN), if a naturalist with strong empiricist leanings would be comfortable classifying that thing as natural and not super-natural. Thus, TSAIN would contain any actualized natural regularity, but not possible but non-actualized natural regularities, and any underlying constraint on nature's regularities acts upon nature/TSAIN from the outside, rather than being contained within TSAIN:

$$\neg(TNR^C \in TSAIN) \& ((TPNR \cap TNR) \in TSAIN) \& \neg(UCNR \in TSAIN) \tag{3A10}$$

Definition 11: The causal interface between the underlying causal structure of nature and scientifically accessible nature/TSAIN.

The question therefore becomes how something outside “scientifically accessible nature”/TSAIN could plausibly impact upon nature, without direct violation of causal closure CCPNR. The premise that novel possibilities are generated (NFG) within time

and impact upon nature implies the existence of a causal interface CI, itself outside nature/TSAIN, connecting the totality of possible natural regularities TPNR to the totality of (actualized) natural regularities TNR, such that the number of entities in the latter set is a function of time (because novelty adds new possibilities to this set).

$$\exists NPG \rightarrow \exists CI | \neg(CI \in TSAIN) (CI: TPNR \rightarrow TNR) | CI \rightarrow (card(TNR) = f(t))$$

(3A11)

Table A1. Symbols used	
Symbol	Meaning
≡	“is equivalent to”
:	“mapping” or “relates to” e.g. “ $f: X \rightarrow Y$ ” means “function f relates entity X to entity Y ”
→	“implies that”
∀	“for all”
∃	“there exists”
	“such that”
¬	“negates” (e.g. $X \rightarrow \neg Y$ means the truth of X implies the falsehood of Y)
≥	Greater than or equal to
>	Greater than
∈	“is a member of the set” (e.g. $X \in Y$ means that the entity X is a member of the set Y)
∋	“contains as a member of itself” (e.g. $X \ni Y$ means entity Y is a member of the set X)
∩	“intersection of” e.g. “ $Z = X \cap Y$ ” means entity Z contains all the things that are contained in both entity X and entity Y .
X^C = $1 - X$	the complement of X ” i.e. refers to a situation in which X is a set of entities and its complement X^C refers to all the entities not in X .
<i>iff</i>	“if and only if”
= $f(t)$	“is a function of time”
∅	“the empty set”, i.e. $S = \emptyset$ means set S contains no entities within it.

Table A2 Labels	
Label	Meaning
<i>TNN</i>	The totality of natural novelties; i.e. all instances of novelty that have occurred within nature.
<i>TNR</i>	The totality of natural regularities
<i>TPNR</i>	The set comprising the totality of possible natural regularities.
<i>UCNR</i>	The underlying constraints on nature's regularities.
<i>Scientific accessibility_X</i>	Scientifically accessibility of natural phenomenon <i>X</i>
<i>EFN</i>	Empiricism-focused naturalism.
<i>NPG</i>	Novel possibility generation
<i>Regularity_X</i>	"Natural regularity" involving persistence of observable natural phenomenon <i>X</i>
$X_{(t_i)} \rightarrow X_{(t_i+1)}$	Observation of natural phenomenon <i>X</i> at timepoint t_i implies its observability at the next timepoint $t_i + 1$.
Δt_{OBS}	Time interval of observation/scientific accessibility.
<i>Theory_{Regularity_X}: Regularity_X</i> \rightarrow <i>Testable Predictions_{Regularity_X}</i>	Use of scientific theory <i>Theory_{Regularity_X}</i> to make testable predictions about <i>Regularity_X</i>
BC_i \in <i>(Boundary Conditions)_{Regularity_X}</i>	Boundary condition BC_i is a member of the set <i>(Boundary Conditions)_{Regularity_X}</i> of boundary conditions that are individually necessary and collectively sufficient for the occurrence of natural regularity <i>Regularity_X</i> (in a context and at a time).
$TBCR_{RegularityX}(c, t)$	Total boundary condition realization for <i>Regularity_X</i> in context <i>c</i> at time <i>t</i> .

$Novelty_X(t_N, context_N)$	The instance of novelty corresponding to the appearance of $Regularity_X$ in context $context_N$ at time t_N .
$TSAIN$	The totality of scientifically accessible or inferable nature.
$UCSN$	The underlying causal structure of nature.
CI	Causal interface CI connecting UCSN to TSAIN.

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