

Whitehead's 'Big Science' of Process

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Abstract

The recent publication of students' transcribed notes from his Harvard Lecture series adds a further dimension to Whitehead's *Nachlaß* containing a whole new class of insights into his 'Big Science' as well as material not to be found in his published canon. Repudiating his earlier work on Boolean Theory which still forms today the basis of the bottom-up models of mainstream Big Science, Whitehead in effect inaugurated the postmodern regime of top-down metaphysics of process thought. His cosmology of events replaces the 'Big Bang' on which very recent observations by the new James Web Space Telescope also cast some doubts. Logic has shifted from local Boolean to the global intuitionistic internal language of Aristotle's *topos* as subsequently revived by Grothendieck. Although Whitehead in his time could only express such informally we now have the formal rigour of Category Theory to demonstrate in this paper how all relationships throughout the World are one of adjointness. Adjointness is fundamental for research in important areas of research such as in formal biology and topics allied to process. It may be of significance that Whitehead pays little attention to some contemporary topics considered important in mainstream Big Science such as quantum theory which might be relevant to theoretical biology.

Big Science

Twenty-first Century developments in hardware have resulted in much greater processing power leading to the dawning of today's Age of Big Data. Besides the obvious never-ending generation of large quantities of information available in digital form, the notion has been carried over to modern 'Big History'² and by further analogical extension to denote mainstream science beginning from the Big Bang as 'Big Science'. The idea of the Universe as a Data Process³ has an early provenance stretching back at least to the pre-Socratics⁴ which it is important to recall need not mean before Socrates but rather free from the direct influence of Plato. However the philosophy of Process itself has had little prominence in plain sight from his times until revived in the last century by William James (1842-1910), Henri Bergson (1859-1941) and especially by Alfred North Whitehead (1861-1947). More recent development by Gilles Deleuze (1925-1995) on postmodern organisational management has acted as a catalysis for some new work in the present century⁵. Many attribute the origins of postmodern philosophy to Whitehead. He would no doubt deny this just as he did not consider worth attending the conference on his own work held during his lifetime.

1 Michael Heather sadly passed away on 20 September 2022. He had already made a very substantial contribution to this work.

2 Craig Benjamin (July 2012). *Recent Developments in Big History*. History of Science Society. 41 (3).

3 Heather, M A, & Rossiter, B N, *The Universe as a freely generated Information System*, ANPA 26, 357-388 (2005). <http://nickrossiter.org.uk/process/anpa05cproc.pdf>

4 Heraclitus *Fragment* no. 41. <https://www.philaletheians.co.uk/study-notes/hellenic-and-hellenistic-papers/heraclitus-fragments.pdf>

5 Ajit Nayak, *On the Way to Theory: A Processional Approach*, Organization Studies 26, 173–190 (2008) <https://doi.org/10.1177/0170840607082227>

The transcription of the notes of various students and faculty staff who attended his lectures at Harvard recently published as HL1⁶ & HL2⁷ for the Edinburgh Critical Edition of his Complete Work adds further dimensions to Whitehead's *Nachlaß*. It may well provide lower grade information as indirect and secondary and may therefore need to be treated accordingly. Rather than primary evidence it is 'hear say' and would not be legally admissible to be adduced in a Court of Common Law. Furthermore there are two subclasses of information. Whitehead's Seminars unlike the 3b Lectures are discussions and therefore the notes of the students may record comments by other speakers not distinguishable from the words of Whitehead himself.⁸ However the publication of the Harvard Lectures far from provide closure to Whitehead's *Nachlaß*. For 70 years it has been believed that Whitehead requested all his unpublished papers be destroyed on his death. In January 2022 it became known that his family still had a quantity of Whitehead's papers in their possession. It has since been further suggested that Whitehead's request is apocryphal and put out by the family to stop Whitehead's biographer Victoria Lowe from continually pressing them for further materials.

Whitehead is always thought of as a mathematician because of the *Principia* with his student Bertrand Russell but it should not be forgotten that he followed the full course on the classics side at Sherborne School⁹ although allowed to miss some classes probably in verse composition¹⁰ to do extra mathematics. Hence as a scholar of Classical Greek and a student of Plato his best known quotation is that all philosophy is a mere footnote to Plato. His quite close study of the Greek vocabulary of philosophical terms less apparent from his published works can now be gauged from HL1 & HL2. HL1 is quite detailed in the use of Greek¹¹ for instance singling out the mention of the fairly obscure ἐφαμοί¹² meaning congruence. These show close attention to the meaning of the original Greek vocabulary throughout HL1 but rare in HL2¹³ which suggests a deliberate shift in policy by Whitehead as his lectures proceeded in order to adjust to the more modern North American culture than he was accustomed to in England where in his young days every educated 'gentleman' would be familiar with the classics.

His High School knowledge of Greek was probably better than Shakespeare's¹⁴ but Whitehead is still likely to have relied on translations and not the original texts for his study of Greek Philosophy¹⁵. For his Greek mathematics it's clear he relied on the assistance of a contemporary Fellow at his Cambridge College Trinity, Sir Thomas Little Heath DSc (1861-1940). Heath may well have been more able than Whitehead at Mathematics as well as Classical Greek having achieved a double first in both the classics and Mathematics parts of the Cambridge Tripos which Whitehead did not achieve. Later references to Greek methods in the Harvard Lectures were from

6 The Harvard Lectures of Alfred North Whitehead, 1924-1925, *Philosophical Presuppositions of Science*. Edited by Paul A. Bogaard, Jason Bell (2017).

7 The Harvard Lectures of Alfred North Whitehead, 1925-1927, *General Metaphysical Problems of Science*. Edited by Brian G. Henning, Joseph Petek, George Lucas (2021).

8 as the editors point out at HL2 footnote p 371

9 where apparently for the New Testament reading in Chapel every morning the original Greek text was used although that is a simpler form than Classical Greek.

10 that is the translation of English poetry into Latin or Greek verse which was a regular part of the classics curriculum in the Victorian period, optional and only taught at a few elite academic Public Schools like Winchester College but now abandoned along with prose composition and no longer offered by examination boards this century.

11 Robson, Mark Ian Thomas (2008). *Ontology and Providence in Creation: Taking Ex Nihilo Seriously*. Continuum.

12 at HL1 478 where Whitehead also parenthetically lets slip his typical curiosity of a classicist to look up in Liddell & Scott which other classical authors use the same term.

13 because of its scarcity the editors of HL2 have not continued in HL2 their practice in HL1 of indexing Greek vocabulary in Greek script.

14 Shakespeare had 'little Latin and less Greek,' according to Ben Jonson, *Centurie of Prayse*, 2nd ed 1879 p. 151, but the interpretation is disputed by some.

15 For example in HL1 433 Whitehead directs his audience to "Read Ross' *Aristotle*: the translation of Aristotle's Nicomachean Ethics by Sir David Ross.

Heath's publications: three in HL1 from the translation of the eleven books of Euclid's elements and two inferences by the editors of HL2 of allusions to the Treatise of conic sections by Apollonius of Perga from published translations by Heath.

The reputation of Trinity as the leading Cambridge College for Classics was shifting to Mathematics around the time they were both Fellows together. No doubt twenty five years as Fellow of Sir Isaac Newton's old College, Trinity at Cambridge, must have had some effect on Whitehead. Until very recently the College was chosen for the education of Royalty including the soon to be crowned Charles III. The character of the college may be well judged by its motto: *Semper Eadem* 'always the same'¹⁶. In 1884 Whitehead was also elected with others from Trinity to the exclusive Society of Cambridge Apostles¹⁷ which met Saturday evenings for sardines on toast to discuss some deep philosophical topic¹⁸ selected by lot.

Plato had ushered in over two millennia of reasoning that diverted away from pre-Socratic process to fixed data after the style of Parmenides with static entities relying on Euclidean Geometry of a rectangular grid founded on the natural numbers¹⁹ often based on some graphical representation of set theory such as Venn diagrams. That approach reached its zenith in the formal meticulous exposition by Plato's great adherent Whitehead but Whitehead came to repudiate it all in his latter period — not expressly but by his conduct in abandoning bottom-up mainstream science, turning rather to the philosophy of top-down metaphysics at Harvard and developing his own cosmology of events based on process which might be termed his alternative 'Big Science' for he realised science has to be treated in its entirety by 'discerning System'²⁰. Yet he realised process could not be expressed in the mathematics of his *Principia* and he had to resort to informal descriptions both in writing and in his lectures for which we are fortunate to have access though second hand through notes recorded by students and other faculty members.

However Whitehead's Big Science is quite at odds with much of mainstream Big History but Whitehead's style in his later period was just to press ahead in presenting his metaphysical cosmology of organism regardless and ignoring any need to discuss, justify or reconcile any of the sharp differences with mainstream. The same disregard for the large differences seems to continue among process scholars today.

Mainstream interest in formal scientific theory has already assayed physics and chemistry at great length and to a great depth throughout the last century but this century the main attention has shifted to biology as the important contemporary subject for scientific inquiry. However biology introduces new additional problems of some complexity arising from the nature of life. One is the specific topic of panpsychism, firstly whether it exists at all and then if so there is the more general problem that pervades biology of how to treat it formally. The move from physics and chemistry with the use of well established mathematical methodologies applied to biology are scarce and quite a giant leap for mankind perhaps even greater than the historic stepping out on the moon. The theoretical biologist Robert Rosen (1934-1998) is one of the few to make any attempt to tackle the vexed question of the nature of life. He proposed²¹ the use of Category Theory having been an early student of its co-developer Sammy Eilenberg. This is another subject where the applications of Whitehead's theory of Process diverges sharply from mainstream Big Science. Furthermore the very origins of the latter in the Big Bang has been knocked off course by

16 The ironic translation by the current Astronomer Royal and former Master of Trinity of the motto is 'change is good but no change is better'.

17 Named from the 12 original number of members.

18 There was a strong influence from English type humour. Wittgenstein resigned immediately after election when he found the topic at his first meeting was 'the hearth rug' but rejoined in later years.

19 A curious misnomer as the 'natural numbers' are not natural. Compare Heather, Michael, & Rossiter, Nick, *Really Really Real Numbers*, ANPA 2021, 12-14 August (2021). <http://nickrossiter.org.uk/process/heather%20rossiter%20anpa%202021.pdf>

20 'Logical puzzle then that you can't know anything without knowing everything' according to Whitehead. HL1 p 306.

21 Rosen, R, *Life Itself, A Comprehensive Inquiry into the Nature, Origin, and Fabrication of Life*, Columbia University Press, New York (1991).

observations lately obtained from NASA's James Web Space Telescope. These show very mature galaxies existing not much later than the accepted age of the Universe. Although not settled the commonly accepted date of its inception had been taken as about 13.8 billion years ago. It now appears that that date even though authenticated by a wide range of independent twentieth century methods may really be a positivist value influenced by reference to the limit of the velocity of light as postulated by Einstein. For the query is: how could Space expand faster than the velocity of light? That limit itself is therefore now subject to doubt even as to its existence.

Perhaps of some significance are topics that his lectures omit or did not pursue that might have been expected from his insightful mind and which we should therefore suspect did not form part of his 'little science'. One important topic hardly touched on by Whitehead in his lectures and therefore under suspicion is quantum mechanics, now upgraded with little justification to be given the title 'quantum theory'. It would seem a necessary component of formal biology. For an impasse is building up as science moves to deal with higher forms of complexity as in the life sciences. These appear now to be controlled by quantum processes which require a mathematics that is both constructive and free of axioms. For reliance on any axiom invokes the axiom of choice which 'collapses the wave function' in quantum mechanical terms. However topos theory now promises to breach the impasse for it is free from natural numbers which require the axioms of Peano and it has the internal structure which supports the Brouwer-Heyting-Kolmogorov interpretation of intuitionistic logic for which Whitehead was just too early to appreciate.

The authors are investigating the Category of the Ultimate in P&R²² in terms of formal category theory and have presented a paper to ANPA²³. Strangely, in view of their predominance in P&R, Whitehead makes only a few mentions of categories in his lectures HL2 just a few years before P&R was published. Those he does make are unfavourable to the concept, as he links them to negative comments about Aristotle. For instance²⁴ "The Aristotelian hard and fast classification which led to muddle in philosophy", amplified in note 2 below by "The Aristotelian categories which separate so hard and fast, qualities, relations and substance have been a great source of error in philosophy" (Roethlisberger, spring semester, p.5) and²⁵ "Aristotle did harm by his categories, philosophy took categories naively". Yet shortly afterwards in P&R p.21 Whitehead says that "This Category of the Ultimate replaces Aristotle's category of 'primary substance' ". It may be that Whitehead had found for his process metaphysics that he needed a container for his entities and objects, in a similar mechanism to that in category theory where objects are embedded in categories. Whitehead does use more frequently a similar concept to category *predicate*²⁶, in the sense of an abstraction or as a unifying force, particularly in perceptual functioning: the relation between perceived and percipient.

The Category of the Ultimate is defined in P&R p.22 with eight accompanying Categories of Existence: Actual Entities (also termed Actual Occasions); Prehensions or Concrete Facts of Relatedness; Nexus; Subjective Forms; Eternal Objects; Propositions; Multiplicities; Contrasts, or Modes of Synthesis. We determine progress below in Whitehead's thoughts on the Categories of Existence between the lectures HL2 and the book P&R.

Whitehead changes from actual occasions to actual entities in his preferred terminology between HL2 and P&R. Whitehead uses the term 'actual occasion' to refer only to purely temporal actual entities, those other than God (P&R p.135). In his lectures HL2 he refers to apprehension rather than the less common form in natural parlance *prehension* which dominates in P&R; prehension is used though by Whitehead as a synonym for apprehension for instance²⁷: "Blind apprehension (prehension) -- synthesis is ultimate fact. Nature of perceptivity is knowledge of ultimate fact which is

22 Whitehead, Alfred North, *Process & Reality: An Essay in Cosmology*, corrected edition, edd D R Griffin, D W. Sherburne, New York, The Free Press (1978). <https://archive.org/details/AlfredNorthWhiteheadProcessAndReality> (originally published 1929 both in New York and Cambridge, UK).

23 Rossiter, Nick, & Heather, Michael, *Logic and Emotion: Whitehead's Category of the Ultimate*, ANPA 2022, Liverpool University 8-12 August 2022. Abstract <http://nickrossiter.org.uk/process/anpa%202022%20whitehead%20categories%20abstract.pdf> Full paper submitted.

24 HL2 p.123

25 HL2 p.266

26 HL2 p.378

synthesis of data". Synthesis is the creative process by which "[a presentational object] P is apprehended by [object] A by systematic status in community, and by a mode from eternal data". Two diagrams are drawn showing how P is apprehended by A. This seems to be a preliminary version of the prehension of P&R pp.19-23 with A being the subject and P the prehended data with the subjective form, which is how that subject prehends that datum, omitted. Prehensions of eternal objects are termed conceptual prehensions in P&R so we appear to be dealing with this form rather than physical prehensions, where actual entities are prehended. Whitehead's early definition of prehension as uncognitive apprehension explicitly separates conscious or cognitive experience from the more rudimentary activity of sentient experience.²⁸

Concrescence and concreteness appear in a number of places in HL2, for example²⁹, with ingression of an eternal object leading to concrescence of an actual entity, a similar meaning to conceptual prehension in P&R p.23. Nexus has not yet emerged as a concept in HL2 though the social behaviour of entities is discussed³⁰: "Every entity is social" and entities of the same class are discussed in the context of union operators, much the same way as in P&R p.24 where a nexus comprises a union of entities of a class. Contrast appears in HL2³¹ as "Each occasion is a microcosm (a little world). Each microcosm has same principles (with limitations) of macrocosm ... Actuality is a synthesis of a contrast into a unity". This alludes to contrast as in P&R p.22 where higher-order categories of categories are created. Multiplicity appears in HL2³² "Science appeals to arbitrary facts which universe exhibits as there, but not as inherent in its being the universe that it is". This is consistent with the collection of diverse entities forming a multiplicity as in P&R p.24.

Adjointness

Aristotle introduced in the Organon his collection of works on logic the concept of the TOPOS³³ as a metaphysical place where arguments reside. Grothendieck (1928-2014) in modern times adopted the concept and applied it within formal Category Theory. A free Topos has an exponential structure with self closure at the monadic third level that mirrors the process structure of the World. Its natural internal language is intuitionistic logic based on adjointness between the intension and extension that holds the Universe together. Whitehead clearly had an intuitive appreciation of the importance of the adjunction which he described in HL1 as:

"two events that are separated & yet joined"³⁴

but in HL2 as:

"Relation of Adjunction:- When two events which do not overlap together form a dissection of one event"³⁵

Whitehead in the lines below attempts a mathematical view but the use of Venn diagrams, more suited to set theory, is not appropriate, and it is not clear that his expression in item 5 captures the spirit of arrow-based category theory:

xKy : there is a z so that $xK_{ad}z = yK_{ad}z$

27 HL2 pp.108-9

28 Leemon B. McHenry, *Whitehead's Panpsychism as the Subjectivity of Prehension* <https://scholarworks.calstate.edu/downloads/0k225f08d> (1995).

29 HL2 p.196

30 HL2 pp.120-121

31 HL2 p.101

32 HL2 p.176

33 See the discussion at <http://www.noahgreenstein.com/wordpress/2010/01/19/> Aristotle's Theory Of TOPOS (Place) with Noah Greenstein

34 HL1 p 478.

35 HL2 p 144.

Whitehead does acknowledge that the “Idea of Point contact [is] difficult to define”. It might be noted that there is some slight advance in sophistication from the description in HL1 to that in HL2 as well as between the two respective Venn diagrams drawn on the board at the time. This dissection in its full form is adjointness which cannot be properly represented in Venn diagrams³⁶ but can now be formally understood in Category Theory which was not available to Whitehead having only been introduced a few years before his death in 1947. As a higher order structure an adjunction³⁷ cannot be represented formally in first order Set Theory. It is nevertheless a profound subject in logic and the basis of process physics as Whitehead was aware³⁸. However the concept of an adjunction is not treated in his published writings. This shows the value of having access to his oral lectures as provided by HL1 & HL2.

However, Whitehead does get closer to the concept of adjointness later in HL2, without explicitly mentioning its name, through raising the tension in two-way relationships between presupposition and anticipation. These further Interesting relationships in HL2³⁹ between actual entities A and B are found in these quotes:

- A) A causally related to B, no reason why B shouldn't be causally related to A;
- B) A precedes B, A and B are compresent, then B presupposes A and A presupposes B;
- C) B immediately succeeds A when:
 1. B presupposes A and A anticipates B;
 2. B presupposes every entity which A presupposes;
 3. Every entity which B presupposes is presupposed by A, either compresent with A or in A's past.

These statements are all in accordance with adjointness if we introduce functor arrows F, G between categories A, B in which case transforming the above to category theory::

- A) $F: A \rightarrow B; G: B \rightarrow A;$
- B) The functor category $F \dashv G$ with F left adjoint to G, G right adjoint to F
- C) Illustrate with example of $F: I \rightarrow E, G: E \rightarrow I$, where I is intension (that is A above, Aristotle's second substance) and E is extension (that is B above, Aristotle's first substance).

F (intension anticipates extension) \dashv G (extension presupposes intension)

Whitehead appears to be clearly alluding to adjointness⁴⁰ with B and A forming a tightly-coupled pair (compresent) connected by two-way adjoint functors F and G. In the intension-extension example F is the free functor generating instances B from the definition A; G is the underlying

36 Blackboard diagrams are an important feature of the transcribed notes of the lectures and much more prolific than in Whitehead's publications. According to the editors there are over 300 freely drawn diagrams to be found in HL1.

37 See: Rossiter, B N, Heather, M A, & Sisiaridis, D, *Process as a World Transaction*, Proceedings ANPA 27 Conceptions, 122-157 (2006). <http://nickrossiter.org.uk/process/anpa064.pdf>

38 'Logic can't be treated apart from metaphysics' HL2 371.

39 HL2 pp.262-265

40 Sisiaridis, Dimitris, Heather, Michael, & Rossiter, Nick, *The Contravariancy of Anticipatory Systems*, 8th BCSCMsG International Symposium on Computational Self-Organised Emergence, organised Peter J. Marcer, The British Computer Society Cybernetic Machine specialist Group, IJCAS, Edited D M Dubois 27 181-202 (2014). <http://nickrossiter.org.uk/process/27-2-2-101-sisiaridis-heather-rossiter-CASYS11-IJCAS-21pp.pdf>

functor relating instances B to their definition A. As is usual with adjointness the functors F and G are contravariant with the domain of one functor mapping onto the codomain of the other. The details of adjointness are expanded on later.

Robert Rosen seems to be one of the early few to appreciate adjointness as fundamental to the Universe and even life itself. Figure 1 is a modern version of his original diagram of the adjointness between a natural system and its formal representation. Figure 2 provides a more general version of adjointness with process represented by the arrow of Category Theory. It is only since the arrival of Category Theory⁴¹ that it has been possible to explore systematically and scientifically the logic of adjointness. It applies intuitionistic logic to Process in metaphysics. The value of Whitehead's shift to metaphysics is that it is not a model nor reductionist and needs no assumptions. It can also replace negation with contravariancy although that was never appreciated by Whitehead.

41 Eilenberg, Samuel, and MacLane, Saunders, General Theory of Natural Equivalences, Trans Amer Math Soc 58 231-294 (1945).

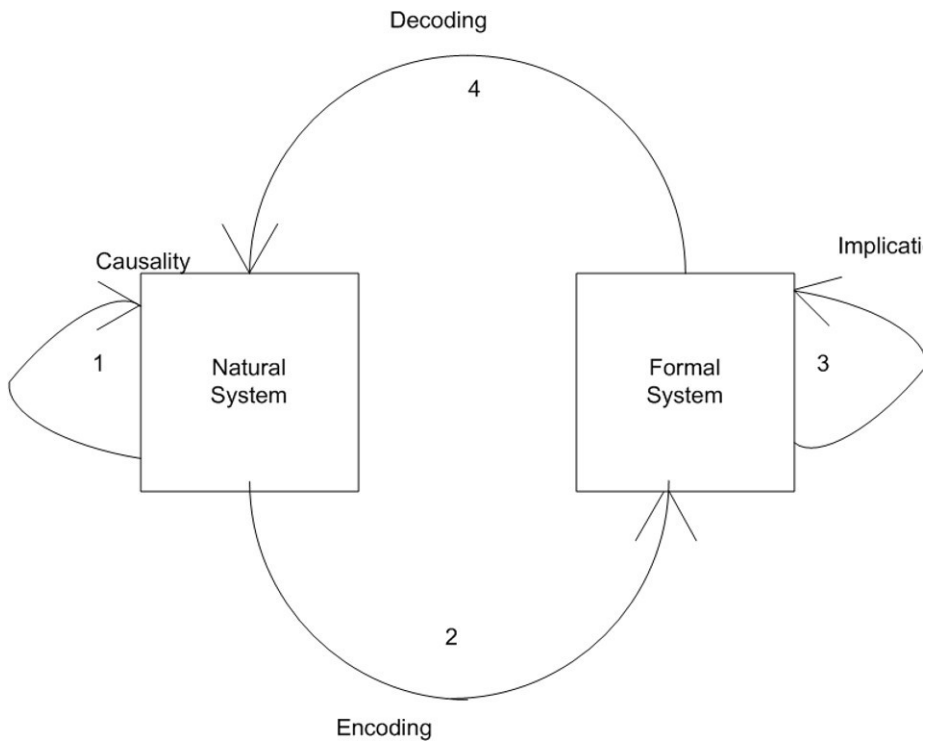


Figure 1 Adjointness between a natural System and its formal representation (after Rosen)

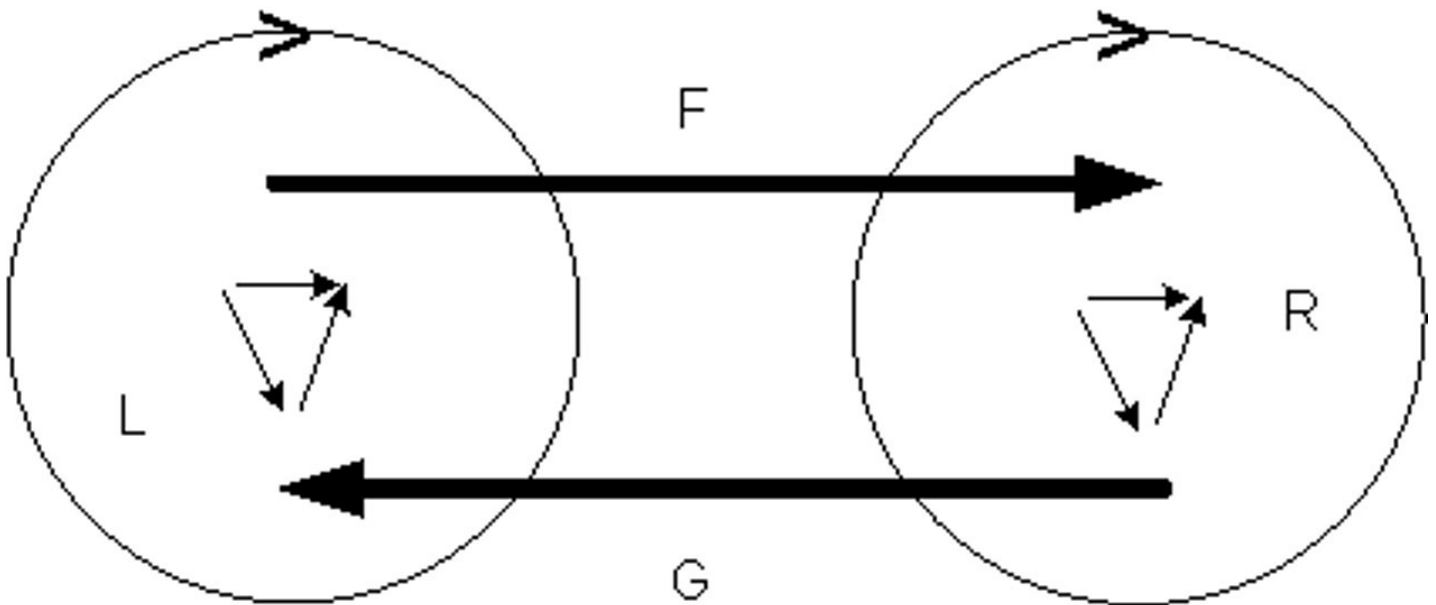


Figure 2 Universal Adjointness

Adjointness in Category Theory between any pair of events or any pair of entities in the world are represented in Figure 2 by a pair of contravariant functors $F \dashv G$ between a pair of categories as identity functors consisting of objects as identity arrows. In the physical World neither objects nor arrows as morphisms can stand alone but exist in their most simplest form in triangles the most fundamental structure according to Plato. The triangles are general in the sense that they represent all triangular relationships throughout the Universe. They each have objects head and tail not drawn in the diagram. Functors map objects to objects and arrows to arrows. F is the free functor that maps the right exact triangles of the left hand category to the left exact triangles of the right hand category. G the underlying functor maps the other way but not in general back to the same triangles. The fresh triple is second order compared to the initial triangle. There will be a third order triad of arrows at the level of a natural transformation between the initial and final triangles. Given any two of a left hand category, right hand category, free functor and underlying functor the other two are unique. This is a matter of logic and how the Universe hangs together in an exponential structure. It is the principle known as Cartesian Closure but which is not well understood nor named and even misleading if it wrongly connotes that we live in a Euclidean space. Furthermore Whitehead speaks both of Descartes' error of dualism and not recognising too Kant's world of phenomenalism⁴².

The logic of the topos suggests that adjointness is the logic of the Universe and unique. This means that it is the metaphysical origin of all the laws of physics. This has yet to be demonstrated for each law but there are no alternative sources offered to explain the source of physical laws. Mainstream Big Science does not recognise the uniqueness of the logic to be found in Category Theory. Modern multiverse theories allow different universes to have different logics.

Mereology as a Family of Adjuncts

Certainly a whole family of quite varied relationships may now be seen as adjunctions. Of these mereology is only one example although there is quite an extensive literature on the subject and one claimed by some to originate from Whitehead. The 'whole and its parts' is a pervasive theme in both HL1 & HL2. It seems that the unnecessary complexity it attracts is because the nature of adjointness is not fully understood as shown from its treatment by Whitehead outlined above. However Category Theory shows that the many versions of 'what is a part?' are all examples of adjointness. These are the same functor pair by different names:

Limits \longleftrightarrow Colimits

Covariancy \longleftrightarrow Contravariancy

Conjunction \longleftrightarrow Disjunction

Synthesis \longleftrightarrow Analysis

Truth \longleftrightarrow Falsehood

Category \longleftrightarrow Subcategory

Class \longleftrightarrow Subclass

Whole \longleftrightarrow Part

Intension \longleftrightarrow Extension

Subject \longleftrightarrow Predicate

Action \longleftrightarrow Reaction

Open \longleftrightarrow Close

Complement \longleftrightarrow Negate

Category Theory follows post-modern features of process relating to truth and facts with neither number nor Closed World Assumption.

1. Truth and falsity only apply to actual world HL2 165
2. Process is an empirical view of the Universe requiring no assumptions
3. Negation is only derived from some Closed World Assumption
4. Number is based only on assumptions (eg Peano's)
5. There are no facts in the past because history is a matter of interpretation. Two individuals at the same event will give different accounts of it. If their two accounts are identical that is evidence of concoction.
6. There are no facts in the future. Even an omniscient god cannot know the future because the future does not exist.
7. The only facts are in the ever present and continually pass.
8. Mainstream Big Science rests on paradox and is to be avoided (HL2 367-8) as derived from error in antecedent reasoning.

There is extensive treatment in both HL1 & HL2 of the nature of 'fact' although it is not systematic nor integrated with any theory of time. In HL2 Whitehead refers at several places to the example of when Caesar crossed the Rubicon which is a fairly simple Boolean fact although not completely simple for as Whitehead pointed out it was a fact to him but not for Alexander the Great (HL2 235).

Space & Matter

The great conundrum of any cosmology is the origin of space and matter.

Whitehead would have us believe that space arises from the extension of substance and therefore as a consequence of the logic of adjunction. 'The theory of extensions' is themes⁴³. Space does not have positions for that would be the 'receptacle view of space' (HL2 375). The properties of the *topos* are not that of a Euclidean container.

Mainstream Big History would have us believe in the Big Bang as an 'exploding nothing' but Process adheres to the principle of Leibniz *ex nihil nil fit*, 'nothing comes from nothing', one of the anomalies of mainstream Big Science and in reality a paradox which Whitehead once claimed indicated an error in antecedent reasoning.

43 The relationship of the physical World to Space is dealt with in P&R part IV particularly at pp.288-289

Conclusions

The 'symbiosis' of mathematics and science, where one feeds on the other and progress comes from climbing up on the other's back, has been of profound benefit to the development of human thought. Category Theory has so far proved an exception with little or no development driven by science. Likewise any contribution category theory has so far made to the advancement of science seems limited to the category of sets and amounts therefore to little more than categorification with any advantage limited to format of expression without the power to exploit the distinctive new notions that Category Theory has revealed to the World. We can see here how Category Theory is needed to represent the advances brought about by the switch to Process in Metaphysics that Whitehead ably described informally in his lectures but which he could not formally explain as he could previously with his work with set theory. That great advance in science and technology brought about by Sir Isaac Newton and his contemporaries when they were able to present theories like gravitation formally but now insufficient for the higher complexity of globalisation and the modern World urgently calls for the application of Category Theory where it is probably true to say that anything less than Category Theory will not do.