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Humanness in their hearts
Where science and religion fuse

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> Theorizing about brain function is often considered slightly disreputable and anyhow a waste of time - perhaps even 'philosophical.'
> Patricia Churchland[1[1]]

> This is ... not the kind of area in which decisive arguments are available; rather it's the kind of area in which one has had a good day if one manages not to drown.
> Jerry Fodor[2[2]]

I. Intro

Attempts to relate science and faith have been of perennial interest to the Christian intellectual community. Given recent Western academic history, it is perhaps unsurprising that virtually all such attempts have been fundamentally propositionalistic. The problem has been seen as one of finding, stating and elucidating the right *principles* of integration, of discovering what *propositions* (and theories) of science should penetrate theology and religious beliefs, and of discovering what *propositions* of religious belief and what *doctrines* of theology should carry weight in the scientific context, of figuring out how *contradictions* or apparent *conflicts* between scientific and religious statements should be resolved, of working out how the *claims* of the two could be made *logically consistent*, of constructing *arguments* showing, e.g., how science could provide *rational support* for religious beliefs. What I wish to suggest in the following is that that may not be the most productive way to conceive of the problem.

That viable integration should not necessarily be fundamentally a matter of proposition dynamics is perhaps not really all that surprising. Our deepest springs are not (at least not all) propositional - much less propositionally articulable. That religion is not ultimately propositional has been and is a widely attractive view. And over the last two or three decades one influential conception of scientific theories is the semantic conception according to which theories are structures in an n-dimensional state spaces (or sets of models) rather than the traditional axiomatically structured collections of propositions.[3[3]] If the two relata of science/religion integration are not wholly propositional, then perhaps the conceptual resources for integration will not be confined to or even mainly those of relationships among propositions or propositional entities. They might, rather, partially reflect other aspects of the dynamics of human rational cognition. In what follows, I wish to do some initial exploration of one alternative possible approach oriented more in that direction. I am going to come at the issue from a philosophy of science angle - the angle I know best.

II. The Extra-empirical

The picture of a science grounded on a bedrock of pure empirical data, rigidly structured according to as logically rigorous a system of induction as constructable and shorn of all metaphysics,

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[1[1]] *Neurophilosophy* (Cambridge: MIT, 1986), p. 403
[2[2]] *In Critical Condition* (Cambridge: MIT, 1998), p. 63-4
[3[3]] See e.g. Frederick Suppe, *The Structure of Scientific Theories* (Urbana: Illinois, 1979), p. 221 ff, 710. Van Fraassen has also argued for this sort of view.

religion, and other perceived conceptual contaminants, reigned widely as an ideal beginning with its most influential early expositor, Bacon. That idea persisted in varying forms through the positivism of the early to mid twentieth century, and in popular circles continues to the present. A science consisting only of what reason could securely build upon a foundation of objective, utterly reliable observation (what could be 'rationally, scientifically proven') was attractive in promising a science having both epistemic security and conceptual purity - protected from all presuppositions, including especially the despised demands and influences of religious obscurantists.

But recent history has not been particularly kind to that view, and despite its still wielding significant inertial underground conceptual clout, the erosion of substantive parts of the view is very nearly complete (as is the collapse of positivism). The past century (especially the latter half) has seen a growing realization of how far humans and humanness penetrates/permeates/suffuses science. There are, naturally, those who have taken that theme to counterproductive extremes. But while rejecting those extremes, I want to suggest that recognition has perhaps not gone far enough in one orthogonal direction. Although this does not imply that all is human construct, etc., it does mean that if we are interested in truth – vs. advancing various philosophical agendas – we must revise some of our estimates and rein in some of our claims concerning science. After exploring some threads in that different direction, I will argue that science is in specified ways a profoundly theistic enterprise.

It is now no longer even controversial that things other than pure data and reason function within science (or that data themselves are not always quite so pure as once thought). Indeed, other factors - extra-empirical factors - *have* to function in science for science itself to function. How exactly does that come about?

A. Underdetermination

Empirical data underdetermine scientific theories in the sense that for any body of empirical data, no matter how large or complete, there are always in principle unlimitedly many theoretical interpretations consistent with those data. It follows that no body of empirical data (even if complete for the cosmos for all time) logically entails or conclusively confirms *the* relevant correct theory (or any contingent theory at all, for that matter).[4[4]] Empirical data by themselves can neither generate, identify, drive us to, nor conclusively confirm some single theory from among all possible competitors. Underdetermination, then, presents us with a forced choice between empirical purity (at a cost of the theoretical) and theoretical legitimacy (at the cost of empirical rigor). Thus, when we *do* single out a particular theory, whatever selection process we employ will of necessity involve 'extra-empirical' factors - factors beyond the purely empirical.[5[5]] A genuine realist science thus cannot survive on just empirical observation and logic, but requires richer conceptual resources and is of necessity integrally embedded in a deeper conceptual matrix from which, I shall argue, it cannot be cleanly detached intact. What are those resources?

B. First wave: fairly well-behaved basic presuppositions

Among the operative presuppositions upon which science unavoidably depends, many are conceptually unproblematic, and various of them are so familiar as to ordinarily escape special attention. The following list is not presented as exhaustive.

1. General metaphysics.

a. Intelligibility of nature. For any robust idea of science itself to make sense, the cosmos must be assumed to be to some degree understandable by the minds doing the science. Historically science has assumed that nature embodies an inherent intelligibility - that properly conceived, nature's mechanisms and structures make sense.

b. Basic character of nature. Relevant presuppositions concerning nature include e.g.: that there really is a real world, that it is largely 'out there', that it exists largely independent of us, that it persists, that

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[4[4]] One intuitive way to see that is as follows. Whereas it is widely accepted that genuine theories entail counterfactuals, empirical data in whatever quantity do not entail counterfactuals. Hence empirical data, no matter in what quantities, do not entail genuine theories.

[5[5]] This general idea has been recognized at least sporadically since about the 13th century, and is why Duhem says:

> [I]f the aim of physical theories is to explain experimental law, theoretical physics is not an autonomous science; it is subordinate to metaphysics.

Aim and Structure of Physical Theory p. 10 (cf also p. 19)

change is real, that events in that world have effects, etc. Although change is real, there are also stabilities and uniformities extending through time and space. There is a unity to reality - we live in a *cosmos*, rather than a random and arbitrary patchwork of different jurisdictions. And whatever their ultimate character, there are 'laws' of nature, that seem to inhabit a region somewhere between logical necessity and accidental generalization. The laws of nature, and nature itself, manifest a logical contingency, but an ordered - not a chaotic - contingency. There are other sorts of presuppositions as well, which I will not pursue here.[6[6]]

2. General anthropology

Science, on most accounts, purports to generate knowledge and understanding of nature, produced in interactions between human faculties - e.g., senses and reason - and reality. And that requires subsidiary presuppositions.

a. Human reason. Our grasping of nature's intelligibility (in any realist sense) requires a significant isomorphism between patterns defining the phenomena understood, and patterns in and of our cognitive structures. And where our science penetrates beneath the surface into theoretical domains, it must be assumed that our concepts (and cognitive structures) still have some traction.

b. Human senses. For our senses to be a means by which we acquire scientifically essential contingent data, those faculties must be in some general sense *reliable* re: aspects of the real world.

C. Second wave: axiology, and other not-so-well-behaved but partially voluntary matters

None of the above are perceived as seriously problematic, and even Baconians would, if pressed, be comfortable with most of them. As it turns out, however, the above collection is still profoundly inadequate. What else must factor in?

1. Goals, criteria. Science can be *pursued* only if it has some aim, some goal.[7[7]] All such are, of course, value-steeped - involving assumptions concerning the worth of such goals, the worth of pursuit of such goals, and criteria for making judgments of degrees of success/failure of achieving such goals. On most tellings, such goals and values are not forced upon us by reality, and in any case *pursuit* of such goals involves human decision. What *methods* are appropriate and productive is of course linked in part to what goals are being pursued, so even 'scientific method' itself may be partially shaped by such choices.

2. Methodological principles. Assumptions concerning what specific approaches to a nature (of the presumed sort) available to investigators (or our presumed sort) are likely to be successful will be inescapable as well. And exactly what is perceived as constituting - or even merely indicating - "success" in such will also be a crucial and historically defeasible matter.[8[8]]

3. Preferred descriptive/explanatory resources. Defining the very category of 'scientific' - let alone selecting specific theories within that category - has typically been taken to require restricting the explanatory and descriptive concepts legitimately deployable, the types of inferences permissible, and the obligatory structure of a 'good' explanation. For instance, it is now widely held that the natural sciences cannot employ
teleological concepts, and that scientific explanation must ultimately appeal only to purely material, natural matters. On an even more specific level, in the early modern period, theories whose dynamics were not mechanical, whose ontology was not corpuscular, whose forces were not contact, and whose structure did not meet other favored criteria of intelligibility were dissed and dismissed as beyond the proper scientific pale. The situation is complicated by the fact that such norms on nearly all levels have changed repeatedly

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[6[6]] Nearly every facet of science carries its own fund of presuppositions. It is assumed that experimental results are relevant to *natural* science, and that involves the presupposition that what nature does when constrained artificially (in test tubes, accelerators, cloud chambers and so forth) represents what she would do in other circumstances and/or if constrained non-artificially. Recourse to experiment presupposes that experimentation on nature is permissible (that, contrary to earlier views, nature is a *thing* rather than a being or a deity). Science often presupposes a principle of *analysis* (or *reduction*) according to which decomposing a system into its constituent subsystems, components and processes exhausts its identity and character. Science presupposes that truth and knowledge have genuine *worth*. Science assumes such *morals* as obligations of scientific honesty, for instance. And to the extent that science is a communal endeavor, scientists presuppose a wide variety of societal matters - including even such fundamentals as the possibility of interpersonal communication.

[7[7]] Such goals have varied widely historically - e.g., discovering truth, understanding nature, achieving empirical adequacy, predicting the future, controlling the physical realm, etc.

[8[8]] Politics has sometimes been described as "the art of the possible." That is true of science as well.

historically and have exhibited very different characteristics after Bacon, after Newton, after Darwin, after quantum mechanics, etc.

4. Epistemic values. Underdetermination in conjunction with science's penchant for trying to penetrate beyond the directly observable virtually forces science to employ non-empirical principles as (provisional) evaluative and selection criteria. Although historically unstable, the catalogue of such indicators typically includes empirical adequacy, accuracy, breadth, elegance, coherence, fruitfulness, predictiveness, simplicity, beauty, unifying or sytematizing power, inherent plausibility, explanatory power, interestingness and the like.

Such characteristics are not easily formally definable, come in a wide range of degrees, often come into conflict, can be given a variety of relative weights and rank orderings, admit of varying procedures for conflict resolution and so forth. Assessments of such characteristics are highly disputable, and are neither straightforwardly rigorously empirically driven, algorithmic, rule governed, nor neatly axiomatizable. They in fact operate as values in theory assessments, and application of such standards involve value judgments. Indeed, they are judgments of *relative* values, and human judgments of humanly chosen values at that. Such choice is not necessarily of an "anything goes" sort, but is choice nonetheless. And given that the very direction of science and that what is or is not eventually accepted as scientifically respectable sometimes tracks back to such choices and value decisions, they are far from inconsequential matters.

The underlying proximate justification for such values is that they are not just arbitrarily or subjectively chosen, but are norms of *good* theories - i.e., truth-relevant and intelligibility-relevant *epistemic* values. Therein lies their legitimacy in science - that theories exhibiting them are presumed alethically better off than those lacking them, despite the fact that they do not always behave according to notions of propositional good order. But human choices are part of the landscape nonetheless.

5. Concepts/ethos. The science that we do, the theories we employ, the picture of the world we piece together - human concepts are structural elements of all of them. In doing science we are inarguably limited to concepts for which our human cognitive faculties are competent. And some of those materials will have very human histories - histories with roots well beyond the domain of the laboratory.[9][9] After all, nature cannot simply dictate theoretical concepts or theories. Beyond that, at any given moment we are in practice limited to a perhaps fairly small subset of those humanly-graspable conceptual resources. We have not yet thought of everything humans can think of, and what we have thought of arises out of human-mediated resources. And human choices - religious, philosophical, and even political - have affected the scope and content of such resources.

We should thus not be particularly surprised when across cultures even as closely linked as English and French, we find different scientific assessment and reception of Newton and, later, of Darwin, or that some of the ethos of post WWI Germany (deep uncertainty and indeterminateness) might seep into the quantum mechanics born there or that field theory should arise during a time of Romantic insistence on the interconnectedness of all that is. Nor should the parallels between 17th century science and 17th century social theory, nor those between Victorian cultural themes and Darwinian evolution jolt us. Nor need it make us uneasy that some thrusts of the English Revolution were echoed in directions of newly emerging science or that Newton's very *definitions* of matter, space and time - the concepts around which he built his science - "were deeply indebted to the liberal Anglicanism of Restoration Cambridge." [10][10]

D. Third wave: humanness and deeper matters

But structures of our humanness factor in at even deeper levels - levels of which we are typically not even aware.

1. Perception. It has perhaps never been very controversial that interests, mindset, enthusiasms, expectations, and so forth might affect what was perceptually noticed, attended to, or singled out as

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[9][9] There is a small but fascinating bit of data in Anne Roe's *The Making of a Scientist* (NY: Dodd, Mead, 1952,1953) suggesting a correlation between the type of conceptualization a person uses and the scientific discipline that a person is attracted to. See her Ch. XI.

[10][10] Many of these stories are well-known. For others see e.g., Paul Forman, "Weimar Culture, causality and Quantum theory, 1918 - 1927", *Historical Studies in the Physical Sciences* 3:1-115, Margaret Jacob *The Cultural Meaning of the Scientific Revolution* (NY: Knopf, 1988) Ch. 3, and Jacob, "Christianity and the Newtonian Worldview", p. 240, in David Lindberg and Ronald Numbers, *God and Nature* (Berkeley: California, 1986). Margaret Jacob and Mary Jo Teeter Dobbs are both good on aspects of this topic.

significant. But at present many believe that some human factors are partially *constitutive* of the very experiences of perception themselves.

As presently conceived, perception involves more of the observer than merely mechanically operating sensory faculties, and some of that additional involvement is active. Such activity can grow out of anything from very specific theory-based expectations through broader conceptual commitments, or background mindsets, to full-blown worldviews. And it is not that such factors merely direct or filter perception, but that they partially shape the very content of some perceptual experiences. Thus, when veteran telescopic observers draw detailed diagrams of canals on Mars, when reputable professional physicists write technical papers reporting properties of the lines generated by their N-ray difractors, when professional followers of Darwin discuss observations of Bathybius haeckelii, or when early microscopists produce sketches of homunculi, we need not necessarily dismiss it all as just invention, self delusion or deceit. And when the two sides of 19th century disputes over heredity systematically report different observed behavior of chromosomes during meiosis, we need not necessarily attribute it either to incompetence or to desperate efforts to save face by the losing side. If perception is indeed an active process, it may well be that in all these sorts of cases, the scientists in question were perfectly *accurately* reporting the actual *contents* of their conscious observational experiences.[11][11] And if, as some argue (a la Kant), the constitutive activity of the subjective is preconscious, so that even our most basic perceptual experiences are simply presented to us already actively shaped and completed, then there is little prospect of self-correction.[12][12] Our awarenesses and experiences thus come to us in *some* degree shaped, screened, assessed – with a pre-interpretational cast to them. That is emphatically *not* to endorse the counsel of critical and epistemic unconditional surrender according to which cognition (or worse, reality or truth) is 'interpretation all the way down,' whatever that ultimately comes to. But it *is* to say that within our cognition some tinge of (pre)interpretation is never completely absent.

Where might such preconscious content come from? On modular theories, essential information-structures are built into the operation of the brain itself. For instance, Steven Pinker regarding vision:

> [O]ptics is easy, but inverse optics is impossible. Yet your brain does it every time you open the refrigerator and pull out a jar. How can this be?
>
> The answer is that *the brain supplies the missing information*, information about the world we evolved in and how it reflects light. [his emphasis][13][13]

Such built-in preconscious specialized information is essential for solving otherwise insoluable inverse problems in other areas as well (e.g., kinematics), and constitutes part of Pinker's case for modularity. This of course amounts to a neurophysiological solution to underdetermination.

2. Intelligibility

Among key tasks of the scientific enterprise, perhaps none is more fundamental than that of making parts of the world *understandable*, or *intelligible* to us. The concept *understanding* is extremely difficult to explicate. But the basic idea is straightforward: understanding something involves removal of at least some of its mystery.[14][14] The process of coming to understand something involves a transition from mystery to sense-making. What seems to make *sense* is, of course, tightly connected to such important epistemic factors as background beliefs, conceptual matrix, theory commitments, paradigms, and even worldviews. But what seems to make sense is also notoriously dependent upon psychological circumstances, mental condition, levels of various substances in the brain and so forth. Both batches of factors provide some potential for human intrusion into the process.

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[11][11] For an interesting theory of *why* this filling in of experiential content occurs, see Jeff Hawkins, *On Intelligence*, e.g., chapter 5, p. 117, and passim. Hawkins notes that there are up to 10 times as many paths leading *to* the senses as there are leading in the opposite direction. Although Hawking does not make the point, that would certainly seem to provide the means for incomplete, vague and fleeting perception to be completed with content not arising from the direct sensory experience itself.

[12][12]One person taking a position like this is Feyerabend, *Against Method*, 73, 78.

[13][13] *How the Mind Works*, (NY: Norton, 1997), p. 28. See also Ronald de Sousa, *The Rationality of Emotion* (Cambridge: MIT, 1987), p. 191, 194ff.

[14][14] Polanyi, in *the Structure of Consciousness* speaks of understanding as "relief from puzzlement by the spreading of coherence . . ."

But there is something even more fundamentally human at work here as well. Identification of sense-making, or intelligibility, presents itself to us experientially as a particular *feel*, a particular *seeming,* that defines our conviction that something makes sense, that we have gripped the correlation of reality to cognition. The presence of this experiential dimension may explain why our talk in this area is so often metaphorical - we 'see' it, the 'light dawns', we 'grasp' the matter, and so on.[15][15] And we cannot get behind or underneath this experience to examine its credentials. Any evaluation of its credentials would have to employ resources and procedures whose justification would ultimately track back at least in part to that experiential dimension itself - the support for those credentials would have to strike us as themselves making sense. As with our other faculties of cognition, at some point and in some circumstances it must simply become a human brute given of the process. This general point was behind the remark of the physicist Sir Denys Haigh Wilkinson that even on purely scientific questions, after having done all the science we can do, finally we "cannot do more than say 'this makes me feel good; this is how it has to be.' "[16][16] Others have made similar observations.[17][17] In fact, Paul Thagard even includes a "happiness node" in his computational scheme for justification of theories.[18][18] Of course, the opposite sorts of convictions operate in this region as well. A.G. Cairns-Smith mentions "a feeling of unease" which may be generated by a "false picture" even when that picture may still be successfully accommodating new evidence.[19][19]

It appears relatively clear that that experiential dimension can be triggered by any number of (suspect or completely unsuspected) human factors. Things that make *intense* sense in dreams, or to the intoxicated, or to the mad, are often utterly indescribable in ordinary discourse.[20][20] Not only is this 'sense' faculty thus not infallible, but there is apparently no non-circular procedure for justifying reliance upon it. Any such case, to have any chance of being convincing, would have to employ resources and procedures the justification for employment of which would ultimately track back at least in part to the faculty itself. There is thus apparently some internal faculty of human cognition upon which we cannot escape placing a crucial dependence, but into whose inner workings (and propriety) we cannot look.[21][21] And this faculty of course operates more deeply than formal principles of scientific methodology. [22][22] Some have argued that that situation is cognitively pervasive.[23][23]

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[15][15] Al Plantinga has discussed this matter in *Reason and Belief in God* (p. 57), although he has retracted some of what he said there (see *Warrant and Proper Function* p. 105-6, also p. 191 ff.)

[16][16] Wilkinson, *The Quarks and Captain Ahab or: the universe as artifact* p. 22. (Wilkinson taught at Cambridge and from 1962-76 was head of Oxford's Department of Nuclear Physics.) Subversive as Wilkinson's claim might sound to some, it is not that uncommon. For instance, John Tyler Bonner, in *The Evolution of Complexity by Means of Natural Selection* (Princeton: Princeton, 1988) says "As has so often been pointed out in the past, a good explanation is one that gives some inner satisfaction ..." [x], and notes that such satisfaction is provided by different types of things for different people. Peter Kosso remarks that "the accomplishment of explanation, after all, is a psychological accomplishment" *Appearance and Reality*, (Oxford: Oxford, 1998) p. 27-8 (see also 179). See also Polanyi *Science, Faith and Society*, p. 9 and Putnam *MFR*.

[17][17] E.g., Michael Polanyi:

> "[T]he ultimate justification of my scientific convictions lies always in myself. At some point I can only answer, 'For I believe so'." *Science, Faith and Society* p. 9.

[18][18] Thagard, *op. cit.*, p. 246-7.

[19][19] *Seven Clues to the Origin of Life* (Cambridge: Cambridge, 1985, 1993)

[20][20] We've all had dreams which made starkly clear sense at the time, but which were only fleetingly and sketchily even *thinkable* in ordinary waking states of consciousness - if at all.

[21][21] Indeed, we seem to be in exactly the same circumstance with respect to it as we are to not only our other cognitive faculties, but even to our perceptual senses.

[22][22] A nice illustration of the depths at which such factors operate was brought to my attention by David Van Baak. University of Maryland physicist Robert Park asserted that validating acupuncture would require "randomized, placebo-controlled, double-blind study with good statistics" and then remarked:

> But it wouldn't matter, I still wouldn't believe it. The trouble is it's silly.

(See his *What's New* website. This passage is widely quoted, but I haven't yet managed to locate it on Park's own website.) Thus, deep plausibility commitments can evidently trump even proper scientific method.

[23][23] For instance, Fauconnier and Turner (among many others) argue that

So the whole idea of understanding (scientific or otherwise) rests upon an involuntary endorsement of the objective legitimacy of specific *human inner phenomenal experiences* associated with particular things having a genuinely sense-making appearance. That we are not dealing here with some 'objective' human-free process seems amply clear.[24][24] Thus, one of the foundational aims of science and its key operative faculties may not even be *definable* in human-free terms. That is not to say that it does not work, is unreliable, should be ignored, is irrational to trust, or anything of the sort. I believe none of those to be true. But its workings seem to be largely involuntary, we have little clue as to how it works or why the things that trigger it do so, and it seems to be both profoundly human and inevitably (maybe even essentially) affected by a wide variety of human factors and foibles.[25][25]

3. Explanations are what supply the materials which allow that seeing.[26][26] And a good explanation must supply the sort of materials which, in the complicated human cognitive context in question, will trigger that shift from mystery to sense. Such shifts are mediated by a complicated, enmeshing system of outlooks, stances, theoretical commitments, expectations, sensitivities, psychologies, and the like.[27][27] Many of the relevant factors we can easily identify. But not all may be explicitly identifiable. And various of the crucial components do not seem to be propositional.

One hint of that indefinability, unidentifiability, or even non-propositionality is the fact that many explanations from past eras (in science and other areas) have such a peculiar *feel* to us, and we often cannot fully say what it is about those bits of past science that strikes us as so out of whack. That perception may stem from changes of scientific and theoretical *tastes* or *sensibilities* over time.[28][28] The indefinable out-of-whackness we sense often isn't just that we have better data in hand and can thus uncover empirical difficulties in earlier theories, but that there is just *something* ineffably *wrong* about the whole setup. Later, I will try to say a little about what that might be.

4. Reason. It is tempting to think that whatever other domains of human cognition may be human-colored, at least *reason* - especially such rigorously rational pursuits as mathematics, logic, and 'scientific reasoning' - will not be tainted. But that seems unlikely.

a. Human intuition. As paradoxical as it may sound, even our most rigorous reasoning rests at bottom upon human intuitions. Formal reasoning (mathematics, formal logic, etc.) cannot proceed without at least some basic axioms, derivation procedures, formation and transformation rules, and other inferential resources. Those in their turn can be justified only as basic givens which have the property of just seeming right (or necessarily true, self-evident, incorrigible, etc.), or which when employed in ways sanctioned by the system itself generate results which exhibit some required virtue (consistency, etc.). But either way, there will be an ultimate dependence upon some human capacity for registering or recognizing the special character involved. That capacity might be some judgment concerning consistency or coherence, or concerning the rational unacceptability of contradictions. Or it might be an unshakable sense that the foundational logic operations that *seem* absolutely right to us, really *are* absolutely right - that our inability to even imagine how denials of such intuitions could even be thinkable, testify to their absolute legitimacy.

"Nearly all important thinking takes place outside of consciousness and is not available to introspection." Gilles Fauconnier and Mark Turner, *The Way We Think*, (NY: Basic, 2002), p. 33. See also 18, 72 and *passim*.

[24][24]There are other related and essential judgments that are also not formally reducible -- e.g., *relevance*.

[25][25]There are those who deny that we ever even reach that point in some areas. See also Feynman, *The Character of Physical Law*, concerning quantum mechanics.

[26][26]This is close to Duhem *Aim* p. 7.

[27][27] According to some, the relation is stronger than just mediation. According to Weinberg, beauty is part of what it is to *be* an explanation. See Weinberg 149. See also 90, 131, 165.

[28][28] Here is a possible analogy. Think of fashions in clothing, hair styles, and the like. The styles of the 1970s and 80s now look to us silly, artificial, contrived, unflattering - or just plain repugnant. They now have that appearance even to those people who were their most enthusiastic followers at that time, and who at that time couldn't conceive of anything more glamorous than those fashions. Nothing has objectively changed, and propositional descriptions of the differences between earlier and current styles would not touch the core of the experienced repugnance. This alien feel occurs in the human sciences as well. It is really hard to sympathetically imagine competent scholars only a few decades back solemnly espousing the Freudian analysis of morning sickness as the mother's hatred of the unborn child triggering an act of symbolic abortion via vomiting.

Or it might be something else entirely.[29][29] Mathematician Keith Devlin notes (more or less apologetically) that:

> if you push me to say how I know [that Hilbert's proofs are correct], I will end up mumbling that his arguments convince me and have convinced all the other mathematicians I know.[30][30]

Here we find shared human *convictions* at the very heart of mathematics. And speaking of our "precision intelligence" Pinker says:

> No rational creature can consult rules all the way down; that way infinite regress lies. At some point, a thinker must *execute* a rule because he just can't help it; it's the human way, a matter of course, the only appropriate and natural thing to do - in short an instinct.[31][31]

So we deal here with not merely convictions, but *instinct*. Indeed, the credentials in question may not always even rise to the level of instinct. von Neumann is quoted as claiming that

> in mathematics you don't understand things, you just get used to them.[32][32]

But whatever starting point we pick will have a similar status - complete and unavoidable dependence ultimately upon some faculty or set of faculties, some intuition(s), that we human beings have. There simply is no other way to get any such project off the ground - or even onto the runway to begin with. That will hold true of any rational project - logic, mathematics, and scientific reason included.[33][33]

b. Emotion. Obviously, emotion could be involved in science in a variety of conceptually superficial (although perhaps practically consequential) matters - e.g., choice of research problems, and so forth.[34][34] But emotion may operate more substantively in certain types of rational decision-making.[35][35] A number of neurophysiologists (e.g., Antonio Damasio, Oliver Sacks) on the basis of both laboratory and

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[29][29] According to Richard Restak, there is some evidence that the brain does not always categorize things via the boundaries we would otherwise expect. I'm not sure what the consequences might be for our inbuilt categorical intuitions - including the underlying categorical logics, judgments of analyticity, etc. See Restak *The Modular Brain*, (NY: Simon and Schuster, 1994), p. 68ff. Emotion may also play a role in categorization. See Clore and Gasper, *op.cit.*, p. 28.

[30][30] *Discover* Jan 2004, p. 36 "2003: Mathematicians Face Uncertainty"

[31][31] Pinker, *op. cit.* p. 185. [emphasis his]

[32][32] Quoted in David Wells [1997] p. 259.

[33][33] Indeed, it is surprising how frequently one runs across claims that relying on "gut instinct" is often the rational alternative. For instance, Jeffrey Schwartz and Sharon Begley, *The Mind and the Brain* (NY: Regan, 2002), p. 66

[34][34] A number of other interesting roles have been ascribed to emotion. According to van Fraassen emotion provides an essential impetus in Kuhnian revolutions. This view is developed at length in *The Empirical Stance*, and van Fraassen summarizes it succinctly in an interview in *The Harvard Review of Philosophy*:

> [Consider a] scientist who is educated in certain older theories and is moreover committed to certain standards of explanation, of understanding, of intelligibility, and of good science, but who gets to the point where none of the options are good anymore. Then suppose someone ... suggests an option that simply violates all these criteria and values for scientific practice. If this older scientists stays in his own frame of mind, he can't go anywhere. Whatever it is that carries him across, if something does, can't be reasoning within his current frame of mind; it will involve the will and involve a change of will, in an emotional pattern.
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> [vol XIII no 2, 2005 "On Taking Stances" p. 86-102, p. 93

[35][35] Damasio also suggests that emotion can, in effect, properly substitute for reason in some circumstances (cf. *Looking for Spinoza*, p. 150; also 148), and suggests that emotions may attach to perception also (*The Feeling of What Happens*, p. 148). There is a significant literature arguing that emotions contain judgments or other cognitive components and can thus be in some sense rational - e.g., Robert Soloman, Bennett Helm, and others. Although that suggests that the traditional reason/emotion divide is illusory, it is not quite the issue I am pursuing here.

clinical studies have argued that people lacking appropriate emotional functioning can be incapable of full normal cognizing in some cases and in particular seem to be unable to make rational decisions in cases involving their own welfare. On the view advanced, what we typically take to be rational behavior especially in practical decision-making is an outcome of complex interactions among a number of systems of neural systems. Among the components involved are systems associated with emotion (e.g., the amygdala and other parts of the limbic system). What has recently apparently emerged is that certain sorts of rationality are compromised or absent in the absence of emotion - that when the 'emotion' systems are damaged or otherwise without effective function, the sort of rational decisions essential to normal social functioning and even to some types of personal welfare are not made. Without functioning emotion, the 'decision-making landscape' is flat, leaving the person involved with less than sufficient reason to pick any one goal or strategy over any other. Indeed, Damasio argues (in connection with his 'somatic marker hypothesis'[36[36]]) that were emotion not involved in such decisions, practical decisions in real time would generally be impossible.[37[37]] It was thus, he argues, a near evolutionary necessity that nature

> built the apparatus of rationality not just on top of the apparatus of biological regulation, but also *from* it and *with* it. [his emphasis][38[38]]

And various structures in the brain (e.g., tonically active neuron sites in the caudate) directly integrate reason inputs (from the prefrontal cortex) with emotion inputs (from the amygdala).[39[39]]

Emotion may be involved even more deeply in some cases.[40[40]] Ramachandran and Blakeslee discuss a variety of fascinating cases of neural impairment.[41[41]] Among the most fascinating are cases involving very specific failures of identification (connected to Capgras syndrome). For instance, one patient insisted that his parents were actually not his parents, but imposters or stand-ins who merely *looked* identical to his real parents. Oddly enough, although he denied their identity when they were visually present, he unhesitatingly accepted their identity (auditorally) as his parents when talking to them by phone. The explanation seems to be this. Image recognition (including faces) begins in the temporal cortex, the initial information then passes via the amygdala into the limbic system where the emotional significance of the given image is assessed. That pre-consciously associated emotional component is partially determinative of the consciously perceived *identity* of the person involved. In pathological cases of the present sort, the connection between initial visual image processing (which functions normally) and the amygdala is broken, and in the absence of the emotion component, the identification of the person as parent fails.[42[42]] (Ramachandran hypothesizes that auditory identification pathways had not been damaged, explaining why phone identification was thus unproblematic.)

So absolutely identical *sensory* images (the 'imposters' *look* identical to the real parents - indeed, in this case they were identical) generate convictions concerning identity which, so far as *we* can discern,

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[36[36]] This theory is developed in *DesCartes' Error*, and discussed also in *The Feeling of What Happens*, p. 41, and *Looking for Spinoza* p. 148. According to that theory, decisions of practical rationality are often "affected ... by signals hailing from the neural machinery that underlies emotion" and when communication from those architectures is disrupted, the person no longer makes 'rational' decision in relevant areas. "Well-targeted and well-deployed emotion seems to be a support system without which the edifice of reason cannot operate properly". Damasio takes the body's monitoring of its own internal states as "the backdrop for the mind", pain, pleasure and emotion being awarenesses of what were originally biological regulatory phenomena.

[37[37]] This result is no longer controversial, having been replicated by quite a number of researchers.

[38[38]] P. 128. emphasis his. (For a hint in a similar direction, see Jean-Pierre Changeux, *Neuronal Man*, (NY: Pantheon, 1985), p. 169.) Damasio also speaks of the "mind ... so closely shaped by the body" in *The Feeling of What Happens*, p. 143. According to Damasio in some organisms with nervous systems far too simple to have anything like feelings, one still finds emotion structures. *Feeling*, p. 70-71.

[39[39]] See e.g., Schwartz and Begley, *op. cit.*, p. 67ff., and Pinker, *op. cit.*, p. 371ff, for discussion. this is a common topic in the neuropsychology literature.

[40[40]] On some views, emotion structures are involved in consciousness itself. See, e.g., Dean Hamer, *The God Gene*, (NY: Doubleday, 2004), p. 100ff.

[41[41]] The case discussed here is the subject of chapter 8 in *Phantoms in the Brain*.

[42[42]] Ramachandran seems to believe that on some level there is awareness of the emotional marker, although it is not clear to me that the evidence given strongly supports that.

have no emotional *content* whatever - whether this is or is not one's parent is a straightforward matter of bare propositional fact. Yet, it is the presence or absence of an emotion processing input of which we are not even aware which determines whether the identification process yields 'parent' or 'not parent' - i.e., a non-conscious emotional factor determines the proposition accepted concerning those identities.

Emotion can even - properly, on some views - run deep in what are *de facto* more specifically science-relevant directions. Although Damasio does not argue explicitly for it, he suspects that other types of rationality beyond the practical (and he specifically includes scientific reasoning and mathematics) function essentially like the rationality of practical decision-making. (Of course, if one takes science to be a species of value-shaped practical reasoning, then possible implications of Damasio's views come very near the scientific surface already.) According to Ronald de Sousa

> Emotions are species of determinate patterns of salience among objects of attention, lines of inquiry, and inferential strategies.[43][43]

As such, they "set the problems" to which relevant beliefs (and desires) are the answers. They will thus constitute a profound shaper of the conceptual and inferential landscape upon which beliefs, inferences, cognitive strategies, and theories will have to rest.

There is even some evidence that evaluation of the logical validity of simple syllogisms involves different combinations of neural systems depending upon the emotional salience of the *topic* of the syllogism.[44][44] In any case, on a number of levels reason and emotion seem to function as a unit.[45][45]

Some interesting recent work has focused on the role of emotion specifically in science. Many of the cited instances have an 'external' feel about them, but others do not. For instance, Paul Thagard has recently argued that one important and legitimate factor in theory justification in science is whether or not acceptance of the theory maximizes coherence - including *emotional* coherence.[46][46] And Christopher Hookway has recently argued that emotion in some cases runs close to the cognitive heart of science. According to Hookway, felt emotional responses can be one way that intuitively applied but unarticulated *epistemic* evaluative criteria present themselves to us cognitively. If that is the case, then given that some individual criteria - not to mention the complete catalogue of criteria - may be not only unarticulated but propositionally unarticulatible, i.e., it may be that

> effective *epistemic* evaluation could turn out to be impossible without ... appropriate emotional responses. [my emphasis][47][47]

Further, in scientific investigations, *some* sort of stopping procedures are essential both because theories are in principle subject to massive underdetermination and because investigative, experimental and explanatory regresses threaten in the absence of applicable stopping points. Emotion constitutes a mechanism for stepping out of the regress:

> [T]he end of inquiry must be regulated by an emotional change.[48][48]

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[43][43] de Sousa, *op. cit.*, p. 196.

[44][44] "Reciprocal neural response within lateral and ventral medial prefrontal cortex during hot and cold reasoning", Vinod Goel and Raymond Dolan, *NeuroImage* 20 (2003) 2314-2321. For related discussion see Daniel Krawczyk, "Contributions of the prefrontal cortex to the neural basis of human decision making", *Neuroscience and Behavioral Reviews*, 26 (2002) 631-664.

[45][45]A bit more on this later.

[46][46] See for instance his "The Passionate Scientist: emotion in scientific cognition", p. 235-250 in Peter Carruthers, Stephen Stich and Michael Siegal, eds., *The Cognitive Basis of Science*, (Cambridge: Cambridge, 2002). See also Gerald Clore and Karen Gasper, "Feeling is believing: some affective influences on belief" p. 10-44, in Nico Frijda, Antony S.R. Manstead and Sacha Bem, *Emotions and Belief: How feeling influences thought* (Cambridge: Cambridge: 2000), especially p. 24ff, and Eddie Herman-Jones "A cognitive dissonance theory perspective on the role of emotion in the maintenance and change of belief and attitude", p. 185-211, in Frijda, Manstead and Bem, *op. cit*.

[47][47] "Emotions and Epistemic Evaluations", p. 251-262, in Carruthers *et. al., op. cit.* p. 257. A related position is taken in Clore and Gasper, *op. cit*.

[48][48] *Ibid*. p. 258

(That, of course, fits nicely with the earlier remarks of Wilkinson and others.) And given that relevant emotion may be how unarticulated epistemic criteria present, that need not undermine the rationality of such procedures. Emotion can not only stop the regress, but

> Emotional judgments ensure that our reflections stop at the right place.[49][49]

Various people (e.g., de Sousa) argue that

> [E]motions apprehend an axiological level of reality[50][50]

If that is true, and if we indeed live in a coherently integrated cosmos, then not only may human reason functionally depend in part on emotion, but science's capability of zeroing in on actual truth may thus depend upon emotion as well. In any case, to the extent that experiences of emotion tie into reality, or to the extent that they are essential even to scientific rationality, to that extent they cannot be dismissed as *mere* subjectivity, wholly irrelevant to truth.

But even if one finds some of that unconvincing, even the merely practical effects of emotions, moods, and general affective states can go in surprising directions. Although the interpretation of some of the data is controversial, Fiedler and Bless suggest that

> Positive emotional states facilitate active generation, whereas negative emotional states support the conservation of input data. In other words, positive moods should encourage the application of prior knowledge structures (schemas, stereotypes, scripts) to infer new information beyond the available data. In contrast, negative mood states should induce a conservative set to adhere to the input data as carefully as possible.[51][51]

(That might explain why one never hears of a jovial positivist.) In fact, judgments concerning whether or not one needs additional information to solve a problem can apparently be influenced by the character of one's occurrent affective feelings.[52][52]

It seems thus clear that Joseph Forgas is correct in his contention that:

> [I]n the last twenty years or so ... empirical research [has] established that affective states have a widespread, automatic and largely unnoticed influence on both the content, and the process of cognition.[53][53]

c. Somato-kinetics. In fact, Damasio believes that even the *body* gets involved in reason in ways so substantive that, he claims, the body

> contributes a *content* that is part and parcel of the workings of the normal mind. [his emphasis][54][54]

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[49][49] *Ibid*. p. 257.
[50][50] de Sousa, *op. cit.*,, p. 301.
[51][51] Klaus Fiedler and Herbert Bless, "The Formation of beliefs at the interface of affective and cognitive processes", p. 147, in Frijda, Manstead and Bem, *op. cit.* p. 144-170.
[52][52] Clore and Gasper, *op. cit.* p. 21.
[53][53] Forgas, "Feeling is believing? The role of processing strategies in mediating affective influences on beliefs", p. 108-143 in Frijda, Manstead and Bem *op. cit.*, p. 109. Forgas has also done some research suggesting that eyewitness observations are more accurate if one is in a bad mood. See http://www.medicalnewstoday.com/medicalnews.php?newsid=12396.
[54][54] p. 226. emphasis his. Some possible connections are nearly recursive. If the present suggestion is right, then the body does contribute to cognition - with which reason and emotion already interpenetrate. But beyond that, there can be neural *emulations* of (hypothetical) bodily emotional responses in the body maps within the somatic sensory regions - perhaps allowing the bodily content to be generated without the bodily behavior actually occurring, thus giving rise to the sense of 'muscular' input reported by e.g.,

That sounds extremely odd, but remarkably, in responding to a question concerning the "internal or mental images ... mathematicians make use of; whether they are motor, auditory, visual, or mixed," Einstein responded that

> the psychical entities which seem to serve as elements in thought ... are, in my case, of visual and some of muscular type.[55][55]

And as it turns out, Einstein was not alone here.[56][56] Of course to the extent that our concepts are shaped or determined by contingent human neurophysiological structures (rather than contingent human sociohistorical structures), which have (allegedly) resulted from contingent - even accidental - vicissitudes of our history, they may have tinges bearing no substantive relationship to anything whatever. It is not at all obvious that the substantive contents of various concepts generated by a physiology driven by biochemistry in turn driven by physical laws and randomness must be related either to each other or to relevant aspects of nature in any truth-preserving or truth-reflecting ways. And even if it *did* appear obvious, that appearance might itself be a mere epiphenomenon of neurophysiological quirks. In a related vein, the one-time Marxist J.B.S. Haldane remarked:

> [I]f my mental processes are determined wholly by the motions of atoms in my brain, I have no reason to suppose that my beliefs are true. They may be sound chemically, but that does not make them sound logically. And hence I have no reason for supposing my brain to be composed of atoms.[57][57]

(Nor any reason for supposing any of Dawkins's anti-religious memes to be true.)

Here then is another place for characteristically human but non-propositional input into science - one would anticipate that Alpha Centaurians (or even different human genders), with vastly different bodies presumably supplying a different *content*, would reason in different, or perhaps even incommensurable, ways.[58][58]

Tacit recognition of a role for the body within abstract cognition itself may underlie the conviction of Kuhn and others that hands-on training is an *essential* part of science education, that relevant aspects of

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Einstein. See Antonia Damasio, "William James and the Modern Neurobiology of Emotion" (p. 6-7), in *Emotion, Evolution and Rationality*, Dylan Evans and Pierre Cruse, eds. (Oxford: Oxford, 2004), p. 3-14.

[55][55] *An Essay on the Psychology of Invention in the Mathematical Field*, Jacques Hadamard, (NY: Dover, 1945), Appendix II, p. 142-3. Hadamard was an important mathematician in his own right during the first half of the 20th century.

[56][56] In her *The Making of a Scientist*, p. 145-7. Anne Roe reports that 19% of the social scientists in her study reported "kinaesthetic elements, that is, feelings of muscular tension" involved in their thinking, while - oddly - none of the physical scientists did so. The late physicist David Bohm, however, in his *Thought as a System* speaks in terms related to those of Einstein. In fact, in the forward to Bohm's book, Lee Nichol speaks of "Bohm's concept of thought" in terms of "the proposal that body, emotion, intellect, reflex and artifact ... [constitute] *one unbroken field of mutually informing thought*." [p. xi, his emphasis

Ronald Giere also notes that some spatio-geometric abilities are

> located in the preverbal parts of the brain, closely connected with the motor control system.

Giere, *Explaining Science* (Chicago: Chicago, 1988) p. 136.

[57][57] Haldane, "When I am Dead", p. 220, *Possible Worlds* (NY: Harper & Brothers, 1928). In a similar vein in "I Repent an Error" Haldane said:

> I am not myself a materialist, because, if materialism is true, it seems to me that we cannot know that it is true. If my opinions are the result of chemical processes going on in my brain, they are determined by the laws of chemistry, not those of logic.

Literary Guide April 1954. This argument has taken on a life of its own. See Victor Reppert, *C.S.Lewis's Dangerous Idea*.

[58][58] And for that matter, the hope that semi-abstract two-dimensional, static, visual representations (our vision, our wavelengths) of such unobservable theoretical matters as the microstructure of hydrogen atoms engraved on plaques carried by human space probes will be readily identified by any aliens encountering those probes may be breathtakingly provincial

scientific pursuits may not even be expressible - much less reducible to propositions - but may be part of a very literal somatic 'feel' that guides a significant part of scientific activity (what Karin Knorr-Cetina calls an 'action/cognition mesh).[59[59]] (And of course, many religions take *acts* of worship to be essential to the grasping of the very *content* of religious faith itself.)

d. Gedanken models. Some have argued that reasoning (of at least some types) is not propositional, but involves direct mental manipulation of mental models. For instance, Nancy Nersession argues that key types of reasoning

> "developed as a means of simulating possible ways of manoeuvering within the physical environment".[60[60]]

Such reasoning processes are, she claims,

> modal in format and employ perceptual and possibly motor mechanisms in processing.[61[61]]

On this view

> The reasoning process is through model manipulations and involves processing mechanisms used in perceptual-motor activity.

Such reasoning would again introduce an implicit physical and non-propositional motif into the operation of reason itself.[62[62]]

e. Other. Various people have argued for the involvement of other factors and faculties as well. For instance, it has recently been argued by Fauconnier and Turner that many of our deepest cognitive processes rest ultimately on our faculty of *imagination*.[63[63]] And, of course, the roles of culture, social structures, and the like are frequently cited in this context. Much of that is familiar to many, and I will not pursue such additional suggestions here, except to note one intriguing hint that so far as I know has not gotten much attention. The societal connections are not necessarily as straightforward as one might suppose. Beliefs generated by emotions are often temporary - not outliving the emotion in question - but sometimes such beliefs do become 'fixed' and it has been argued that this fixing occurs more readily to people in collectivist cultures than in more individualistic societies.[64[64]] Thus more enduring affective states - moods or 'sentiments' - may not only contribute to the persistence of belief (perhaps partially accounting for the frequently remarked and scientifically indispensable *tenacity* scientific belief and commitment), but different sorts of societies may contribute that in varying degrees.

E. One more wave: personhood and individuality

All of the above factors have potential consequences for human cognition - from perception to common sense to the most delicate tweaks of our theorizing.[65[65]] What might be the consequences of all

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[59[59]] Knorr-Cetina p 4. Positions like this have been strongly advocated by Polanyi (e.g., *TD*).

[60[60]] *Ibid. 140*.

[61[61]] "The cognitive basis of model-based reasoning in science", p. 133-153, in Carruthers *et. al., op. cit.*, p. 152 and 146.

[62[62]] This has possible connections to Pinker's speculations concerning the origin of some of our inferential "scaffolding" (Pinker, *op. cit.* p. 335). Perhaps along a similar line, Freud once suggested that

> Thinking is an experimental dealing with small quantities of energy, just as a general moves miniature figures over a map before setting his troops in action.

See *New Introductory Lectures on Psychoanalysis*.

[63[63]] See Fauconnier and Turner *op. cit.*, p. 6, 8, 89, 95, 115, and *passim*.

[64[64]] See Nico Frijda and Batja Mesquita, "Beliefs through Emotion", p. 45-77, in Frijda, Manstead and Bem, *op. cit*., p. 60ff.

[65[65]] Some argue that we have innate conceptual modules (e.g., "folk physics") which even "provide us with deep theories [which may] involve[] a commitment to a number of unobservable forces or principles. ...

this humanness here? Looking at nature through night-vision goggles, everything is tinged green. Looking at reality through human-cognitive goggles, everything is tinged - what? We can abstract away the greenness, being able to isolate it by contrast with other experiences as an artifact of the system. In the human-cognitive case, we apparently have no abstraction-permitting contrast - *all* our experiences are human-mediated. And this humanness cannot be purged from science.

Science-relevant factors get even more specific. Individual perceptions of color and the like may be absolutely unique - we don't seem to have any definitive way of telling - but nonetheless seem to be generally isomorphic for most of the human species. But other individually varying things may be less well-behaved. As one example, consider elegance, beauty and other such aesthetic matters. Many major physicists both past and present have been struck by an aesthetic dimension in nature. Nature's laws have often been cited for their symmetry, their elegance, their order, their unity, their exquisite meshing, and for the harmonies sung by their mathematical structure. All of those have been taken as constituting part of their *beauty*.[66[66]] This aesthetic dimension is perceived as so fundamentally infused into the structure of law that many physicists take beauty to be a pointer toward truth.[67[67]] Aesthetic properties seem to be dimensions of the deep match between cognition and the cosmos and are part of the intuitive intelligibility of the cosmos. Some scientists have made even stronger claims. Thus Polanyi:

> No one who is unresponsive to such beauty can hope to make an important discovery in mathematical physics, *or even to gain a proper understanding of its existing theories*. [my emphasis] [68[68]]

Polanyi is here claiming in effect that beauty is *part of the content* of the theories of mathematical physics. And Weinberg suggests that beauty is part of what it is to *be* an explanation.[69[69]] Polkinghorne makes the issue ontological:

> Beauty is not just a sort of froth on the surface of things.[70[70]]

But surely if *anything* is deeply rooted in our individual humanness it is our appreciation of what is and is not beautiful or elegant.[71[71]] If our sense of the beautiful serves among the indispensable evaluative procedures within science, then deep human factors figure into selection of descriptive and explanatory content within those areas. [72[72]]

These modules might therefore be thought to provide us with a set of initial theoretical contents ..." (Carruthers, *op. cit.*, p. 89). If that is correct, our terrain may thus already have an inbuilt theoretical slant.

[66[66]]For instance, Feynman defines beauty in terms of simplicity (*Character of Physical Law*, 173), Weinberg variously in terms of symmetry and simplicity (*Dreams of a Final Theory* p. 135 ff, , 148 ff), and Herman Weyl, *Symmetry*, (Princeton: Princeton, 1952, 1980) p. 3, in terms of symmetry . Similar identifications can be found historically - e.g., Whewell speaks of the "beautiful symmetry of relation" to be found in natural laws (p. 381). Haldane characterizes simplicity as beauty: "[Simplicity] is really an aesthetic canon such as we find implicit in our criticisms of poetry or painting" p. 239 "Science and Theology as Art Forms", *Possible Worlds*.

[67[67]] That is widespread and well known. As one example, John Polkinghorne, in *The Quantum World* (p. 57-8) says:

> There is a deep feeling among those who practice fundamental science - a feeling that has so far proved reliable - that the way to true understanding is the one that satisfies the canons of economy and elegance; the way which, in a word, is mathematically beautiful.

[68[68]] *The Study of Man* (Chicago: Chicago, 1959) p. 38.

[69[69]] Weinberg, *Dreams of a Final Theory*, p. 149. See also 90. 131, 165.

[70[70]] *Serious Talk* ((Harrisburg: Trinity, 1995) p. 8.

[71[71]] And of course, some argue that aesthetic appreciation contains an ineliminable emotional component.

[72[72]] Although many advocates of what Glymour calls the "new fuzziness" in philosophy of science may take things far too far, they do ask some crucial questions. For instance, Rorty:

> Why should we think that the tools which make possible the attainment of these particular human purposes [scientific prediction and control] are less 'merely' human than those which make possible the attainment of beauty or justice? What is the relation between facilitating prediction and control and being 'non-perspectival' or 'mind-independent'? *ORT* p. 58.

Even such seemingly tractable, no-nonsense values as "empirical adequacy" have their murkier side. In practice, adequacy often operates among a cluster of such ill-definable principles as that of 'enoughness' - convictions concerning whether the data are precise enough, numerous enough, close enough to predicted values, whether a theory is accurate enough, simple enough, powerful enough, better enough than alternatives, supported by data strongly enough, whether essential concepts are clear enough, non-metaphysical enough, whether the picture generated fits well enough with other conceptual commitments, and so forth. On none of those fronts are there definitive cut-off points or rigorous - or even statable - algorithms for resolution.[73][73] Thus, here in what was once supposed to be the heart of scientific empiricist rigor one finds individual human inklings, urges, intuitions and inclinations - and indefinable and contentious ones at that.[74][74]

Even personal psychologies function here. Nearly every theory lives in tension with some bits of awkward data, and in some instances, a scientist's degree of tolerance for tension or dissonance becomes important. Sometimes, a scientist may be inclined to brush off some tension or troublesome inconsistency, but at other times might be less willing to do that. The evidential, logical situation is the same, but the scientist's threshhold level of sensitivity - or cognitive irritability - is altered (often due to factors concerning which the scientist is unaware), and the force of the problem is now allowed to operate as a live candidate for potential falsifier.[75][75] More generally, the kind of science we get is partially dependent upon the kind of scientists we get, and a variety of personal, genetic, psychological, social and environmental factors play roles in that context.[76][76]

According to Damasio, the participation of the person is even deeper, with one's very "*sense of self* ... influenc[ing] the processing of whatever gets to be known".[77][77] That accords with some further remarks from Wilkinson:

> How do we then choose between alternative scientific hypotheses when we have used up all our scientific criteria? We are, of course, left face to face with ourselves. The only remaining criterion is what seems right to us ... in the deepest seat of human feeling ...
>
> [I]n science, we sift and exhaust the evidence and then choose because we feel. Man's essential humanity must become, at this stage, not integrated with, but a replacement for, science until new data come along to permit the taking up again of the scientific method...[78][78]

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[73][73] In this general connection, Giere takes acceptance/rejection of theories to involve judgments concerning *satisficing* - a process which is not completely propositional. And that means, as he points out, that

> "the necessity for dealing with values or interests is explicit from the start."

Giere, *op. cit.* p. 161. Some work of van Huyssteen is relevant on this point as well. See, e.g., his *Shaping of Rationality*, in which he argues that one core component of any sort of rationality is "responsible judgment" which in turn ultimately rests upon "pre-theoretical reasonableness."

[74][74] Polkinghorne speaks specifically of judgments and assessments which rest on "experience and intuition, and ... can never be reduced to the following of a set of rules" *Serious Talk*, p. 36

[75][75] It is quite common historically for the seriousness of some difficulty facing a theory to be denied until a viable alternative theory becomes available, at which point the previous problem becomes the standard textbook disconfirmation.

[76][76] There are some fascinating data and speculations concerning the personal psychologies of those choosing a scientific career in Liam Hudson, *Contrary Imaginations* (Baltimore: Penguin, 1966), especially Ch. 7, and in "On the Psychodynamics of Creative Physical Scientists", D.D.McClelland, in H.E. Gruber, *et al*, *contemporary Approaches to Creative Thinking*, (NY: Atherton, 1962). See also Roe, *op. cit.*, Ch XVI. Roe even suggests that certain sorts of emotional problems may play a role in specific career choices in the social sciences (p. 237). See also Liam Hudson (e.g., p. 175).

[77][77] [my emphasis]. *The Feeling of What Happens*, chapter 1 and *passim*. See also van Huyssteen, *op. cit.*, Ch.3, e.g. p. 174, 176, and Ch. 4.

[78][78] Wilkinson, *The Quarks and Captain Ahab*, Schiff Memorial Lecture, Stanford, 1977. Keep in mind that we are always in a situation of having less than complete data.

It thus looks as though some deeply intertwined - even unitarily melded - features of our humanness and even individual personhood lie deep in the heart of science. As Polanyi once remarked, the personal dimension is "no mere imperfection but a *vital component* of knowledge." [79][79]

III. Cognitive terrain

How exactly ought we to think about this? I don't know how we should think about all this *exactly*, but I want to develop an analogical way of thinking *approximately* about the above factors and their implications for various aspects of cognition. Indeed, it is not clear how other than analogically (including narratively) one *can* approach non-propositional matters in cognitive contexts.[80][80] In fact, some have held that there are truths which can be expressed in no other way than analogically or narratively.[81][81] And however such truths might be expressed, some (Dennett, for instance) claim that narrative - stories - carry more effective convincing power than does e.g., argumentation.[82][82]

Think of the underlying structure of one's cognition as a *terrain* with a variety of hills, peaks, valleys and other contours.[83][83] Just as water flows preferentially in some directions and resists others on a physical terrain, inferences, intuitions and convictions might tend to flow in some directions rather than others on a cognitive terrain. Or just as strange attractors may make arrival at a specified region nearly inevitable on a mathematical terrain, a cognitive terrain might contain some conceptual depression (a "blik" perhaps) into which every interpretation of every experience or bit of data eventually slid. (Think of conspiracy theories, paranoia, or deep philosophical commitments.) And just as some physical landscapes cannot support some buildings, some types of theories might not sit stably upon some types of cognitive terrain.[84][84]

One consequence of all this is that there will be various inbuilt undertows in our cognition. Sometimes those undertows can even carry our thinking and inferences in directions which we wouldn't consciously and intentionally approve. Numerous studies have showed that the ordinary logical,

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[79][79] [my emphasis]. *Personal Knowledge*, preface.

[80][80] One intriguing variation is suggested by an incident involving Leo Tolstoy. When asked what *Anna Karinina* was *about*, Tolstoy reportedly replied that to answer that question he would have to recite the entire novel. That suggests that there might be some broadly cognitive matters not expressible in any simply and direct linguistic propositional form. But it might turn out that this variant mode of expression is analogical also. The deep truths expressed in *Anna Karinina* are not about the specific characters, places, and events of the novel, but arise out of and are isomorphic to structures embedded in those specifics - a structural relationship very like analogy. And it is also worth noting that expression of those truths is - if Tolstoy is right - essentially via a story.

[81][81] I think that Iris Murdoch held something like this - see *The Sovereignty of Good* (New York: Schocken, 1971, c1970), p. 34. Some postmodernists can be read in this direction - e.g., Van Huyssteen cites Lyotard as holding that narratives can provide types of knowledge unavailable in any other way. And if I read parts of Donna Harraway's *Primate Visions* correctly, she is suggesting that this is the way scientific theories sometimes carry their content. Newberg and D'Aquili note (in connection with their 'cognitive imperative') that

> we cannot help but to organize the world and our experience of the world by creating stories and ultimately myths to help perform this function.

Why God Won't Go Away, p. 191 note 8.

[82][82] *Darwin's Dangerous Idea* (Simon and Schuster, 1995) p. 12.

[83][83] Others have arrived at similar pictures, and speak of conceptual topologies, conceptual landscapes, etc. Such pictures may be especially appropriate, given that some research suggests that "the brain works more on geometric than on algebraic principles", Giere, *op. cit.* p. 135.

[84][84] I'm not sure exactly what all the connections are, but there may be some deeper issues here involving even the very nature of intelligence. Hawkins *op. cit.* has argued that intelligence itself is the ability to predict (generally unconsciously) from memories stored in some invariant and thus widely applicable form. (E.g., we make implicit predictions - unconscious tacit expectations almost continually, and typically do not even notice that fact unless the prediction goes awry - for instance, when the implicit expectation is not experientially fulfilled. A cognitive terrain would underly such unconscious prediction - it would be a (relatively) stable structure which would automatically shape cognition and expectation appropriately according to 'where' (cognitively) the terrain was 'viewed' from.

mathematical, probabilistic, and physical reasoning even of those trained in relevant fields does not conform to the formal rules they (and we) rationally endorse. We are often, of course, left to try in various ways to pick up the pieces. And as Thomas Huxley once remarked:

> What we call rational grounds for our beliefs are often extremely irrational attempts to justify our instincts.[85][85]

In some sense reality, via those of our contacts with it to which we causally respond, projects onto our cognitive terrain, and the picture modeled there will depend both upon the character of the projection and upon the shape of the terrain. Of some of those projections we are aware – those would constitute a subset of our experience, sensory and/or otherwise. There will be many projectings of which we are unaware and no doubt many such of which we cannot even in principle be aware, even though they may affect features of that terrain. Obviously, not merely the character of the resultant picture, but whether or not the resultant picture reflects, is in some sense isomorphic to, or in some sense mirrors reality depends upon the character of the projection, the terrain, and the projection/terrain outcome. (It is, of course, possible that reality is such that no projection upon any possible terrain could mirror that reality, in which case the character of *truth* in any sense available to us becomes problematic if not inscrutable. That may be one way to read Kant. See Appendix I.)

Principles governing interactions between our cognitive structures and (contacts with) the reality outside of us, as well as principles governing the internal dynamics of our reactions to and processings of such contacts, and principles dictating the effects of such contacts, reactings, and processings upon our cognitive terrains are, of course, themselves parts of the standing order of the reality independent of us.[86][86] (It may, perhaps, be possible for our cognitions – or other effects – to affect the given structures and processes of reality, but even if so, the principles according to which such changes occur would themselves belong to the reality beyond our reach. Some might claim that we can arbitrarily, freely, and outside all constraints effect such alterations, but aside from galloping hubris I know of no reason to accept that view, and the doctrine of creation would seem to militate pretty decisively against it.)

One implication of the above is that depending upon exactly what the relevant governing principles are and upon exactly how fine-grained the effects they dictate, it may be that no two human beings have *exactly* the same cognitive terrain, or that no one person has *exactly* the same cognitive terrain for any time longer than the minimum stimulus processing time.[87][87] The picture of reality any individual has will depend upon interactions between the factors which define one's individual personhood and the

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[85][85] Quoted in Ramachandran, V.S. and Blakeslee, Sandra, in *Phantoms of the Brain*, p. 152. Or as William James put it in Lecture III, *The Varieties of Religious Experience*: "The unreasoned and immediate assurance is the deep thing in us, the reasoned argument is but a surface exhibition. Instinct leads, intelligence does but follow."

[86][86] I do not necessarily mean for this picture to rule out any sort of free will (or even necessarily to preclude some sort of dualism). We may well be genuinely free with respect to some range of our actions and behavior. But I do not believe that we have much latitude when it comes to what we do or do not believe, to what we think is or is not plausible, to what we accept as following or not following from given evidences, and so forth. There are, obviously, differences between individual people, and differences over time with any given individual, but that, of course, shows nothing to the point concerning the degree to which our beliefs and various other cognitive stances are or are not within our immediate control. But even if it is contended that there are some degrees of freedom here, and even if it is claimed that such degrees contain the possibility of freely chosen cognitive stances altering specific features of the underlying cognitive terrain itself, it seems to me that (a) such effects would be relatively modest, and (b) that the extent and character of such effects would themselves be among the things lying outside our control – i.e., would themselves be part of the reality independent of our choosing and doing.

[87][87] That would not, of course, imply some sort of coherentism, since there is no reason to think that every effect changes the underlying cognitive terrain rather than merely changing some detail of some structure constructed upon that terrain, and no reason to think that even *if* every such change had implications filtering down to terrain level that every part of a terrain was altered by every such change. However, if conditional implications of specific possible inputs were seen as constituent components of terrains, then every change on any level would result in terrain change, much as change of one member of a set yields a different set. I do not believe that anything much hinges upon which way one goes here.

reality which impinges upon that personhood. The resultant combined package may be individually unique. Certainly, the package of experiences, the precise corner of reality, etc. will be unique, and if each such feature/factor has the requisite sort of effect, then unless some details get swamped or unless the causal correlates follow some many-one mapping, the resultant terrains will be individually unique. But depending upon the relevant degree of finegrainedness, there may be overlaps in terrain – we may all experience the moon in roughly identical, similar or equivalent ways, for instance. But even so, there may be individual differences, there might be cross cultural differences, and there would almost certainly be species differences.

I take any individual's cognitive terrain to be (ideally) a single, unified entity comprised of the relevant melded ingredients. Not only do cognitive scientists tend to talk that way in related areas,[88[88]] but the unity and comprehensive character of individual terrains is at least suggested by a variety of correlations between apparently disparate parts of the thinking of a wide range of scientists.[89[89]] The integrated character of cognitive terrains would further suggest that wider social and historical matters - and religion - would have their effects on not only directions and reception, but on the contents of science as well. I take that to be right, although claims in this area are routinely overblown and undersupported. But while recognizing the existence of such phenomena (and some of the cases mentioned in passing above fall into this category) I shall explore a different direction.

IV. Cognitive terrains and science

As mentioned above, some current research indicates that a flat emotional terrain leaves one rudderless and incapable of *practical* rational decisions. Similarly, a flat extra-empirical conceptual terrain leaves one theoretically rudderless and incapable of *theoretical* rational decisions. (And, some philosophers of science take scientific reasoning to be more closely akin to decision making than to inference.[90[90]]) But more fundamentally, scientific content is compromised on a metaphysically flat conceptual terrain as well. Of course, epistemic values and various other of the presupposed principles glossed early on (largely propositional - at least, versions of most of them are at least partially statable) provide some of the required relief features for a science-permitting conceptual terrain, but they are not sufficient - the non-propositional factors catalogued above have a role as well. Thus:

1. a 'non-flat' conceptual terrain is essential to science
2. the terrain in question is human-shaped

Those I take to be pretty much beyond dispute. The first represents in part the demise of Baconianism and Positivism, the second some of the insights (often overblown) of the post-Kuhn era. It will be crucial to recognize also that:

3. there may be only a very small part of the possible terrain state-space which can display (or model) truth/nature

Think of a flat grid with a number of separate irregular closed loops of varying size irregularly placed. It might very well be impossible to assign any rhyme, reason, rhythm, pattern or meaning to those

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[88[88]] For instance, Faconnier and Turner, *op.cit*., p. 394.

[89[89]] Not only are there the early cases explored by Merton and the mid-20th century cases studied by Anne Roe, but there are some striking contemporary cases as well. For instance, Calne reports that:

> At a recent meeting of the American Association of Physical Anthropologists, those present were polled on the vexed question of whether early hominids were initially hunters or gatherers. After voting, the same members were asked if they voted Republican or Democratic in the last presidential election. The answers were analyzed, and a high correlation was found between Republican voters and the hunter hypothesis; to the same extent, Democratic voters favored the gatherer hypothesis.

Donald B. Calne, *Within Reason: Rationality and Human Behavior*, (NY: Vintage, 1999), p. 288. Here political leaning is correlated with theoretical interpretive tendencies. And recall the sorts of instances mentioned above in II.C.3

[90[90]] For instance, see Giere, *op. cit.* p. xvi.

loops. But suppose that the grid was 3-dimensional, with a projection rising through each loop, contoured in such a way that every segment of every loop was at a uniform height, precisely at the same level as every other loop. Significations now begin to virtually leap out of the grid - e.g., a contour map of an erosional field cutting through a specific geological horizon which has left a number of peaks projecting above that horizon - a reading that the most complete two-dimensional description and equations would never have hinted at. (In fact, what might appear to be closed loops on a flat grid would actually be just the irregular edges of buried lithic planes.) And that significance would have been masked - indeed non-existent - over the vast majority of possible grid terrains. Only a very particular *sort* of terrain would display the right revealing picture. In the case of a conceptual terrain, the flat case would be something like a situation of underdetermination, that situation being remedied by the collection of extra-empirical factors from earlier discussion constituting an elevation dimension.

Of course, physical structures cannot just hover detachedly and independently above the underlying terrain - and scientific theories (given underdetermination and all the rest) cannot just hover detachedly and independently above the underlying cognitive terrain. Theory stability requires that theories *fit* the relevant terrain. (And that *fit*. I shall claim, is the core of rationality itself.)

If genuine scientific understanding involves (or just is) an isomorphism between our cognitive structures and reality, then not just any old cognitive terrain will permit intelligibility.[91][91] Think of it this way: nature in some sense projects onto our cognitive terrain, and only if we have cognitive contours upon which nature's loops can be properly signifyingly projected will we get any purchase upon truth.[92][92] And contours and tilts built into or developed within that terrain will have significant effects for what theories are even thought of (e.g., the traditional context of discovery), thought to be worth exploring (e.g., Laudan's context of pursuit), thought to make *prima facie* sense (e.g., Berger's plausibility structures), thought to be likely (e.g., Bayesian prior probabilities), thought to be supported (e.g., the traditional context of justification), and a variety of other scientifically consequential matters.

In addition, light might be shed on another cluster of puzzles. Understanding nature is not the only scientific project depending upon cognitive fine tuning. Peirce wondered why and how the mind, looking for scientific hypotheses could so quickly zero in on a truly vanishing fraction of all possible hypotheses which yet - if science indeed moves toward truth - contained theories which were on the right general track. Mind, Peirce said, somehow has a "natural adaptation to imagining correct theories," a "power of guessing right" after a mere few trials, while "leaving the vast majority of possible hypotheses unexamined."[93][93] Induction, chance, standard inferences, and other formalisms do not provide any answers here.

This problem is, in effect, what de Sousa refers to as the "philosopher's frame problem." But the right sort of cognitive terrain would automatically exclude the vast bulk of misdirected hypotheses, and might even provide a tilt at least isomorphic to the right sort of hypothesis. Hookway argues specifically that emotion can help with the necessary pruning function, that

> some emotions facilitate cognition by creating this precondition for effective cognitive management. [94][94]

de Sousa also argues that emotion constitutes a partial solution. Indeed, he says, emotions are "indispensable" to that solution, and thus "their existence grounds the very possibility of rationality at [the] more conventional levels [of e.g., lines of inquiry, and preferred inference patterns]"[95][95]

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[91][91] C. S. Peirce, for instance, spoke of the necessity for a

> "sufficient affinity between the reasoner's mind and nature's"

Essays in the Philosophy of Science, (ed. Vincent Tomas), (Indianapolis: Bobbs-Merrill, 1957), p. 228.

[92][92] That 'projection' will, of course, itself be mediated by our own sensory/cognitive systems - themselves affected by that terrain.

[93][93] Peirce, *op. cit.*, p. 238 ff. Aristotle, Galileo, and others have held versions of this sort of view. This is reminiscent of the ability of human chess grand masters to beat computers such as Deep Blue which have the capacity to analyze 100 million chess positions per second - i.e., to single out better moves without (it seems to me) processing anywhere remotely near that number of alternatives.

[94][94] *op. cit.* p. 261. (One version of this solution casts emotion as involving state-space search procedures. See Dylan Evans, "The Search Hypothesis of Emotion" in Evans and Cruse *op. cit.*, p. 179-191.)

[95][95] de Sousa, *op. cit.*, p. 192ff, p. 203.

As noted, many of the extra-empirical matters are not only non-cognitive and non-propositional, but are involuntary as well. We do not control the structure of our intuitions, the basic character of our emotions, our neurophysiology, our biochemistry, the innate principles of terrain modification, and so forth. (And if it is ultimately only stories - narratives - that convince, then even scientific explanations will be subject to the sort of non-formal constraints which satisfactoriness of narrative imposes. The shape of such satisfaction requirements are, of course, part of the underlying terrain.) So if we have any hope of getting our science right, that will rest in part on the hope that the deep, involuntary, non-cognitive matters that shape our cognitive terrain have done so in appropriate ways. Science depends upon cognitive fine-tuning just as our existence depends upon cosmic fine-tuning.[96][96]

And the fact that that underlying cognitive fine-tuning is (partially) non-propositional may be one reason why earlier attempts to axiomatize science (or parts of it) were so sterile. (Of course, such attempts themselves sat upon a deeper human cognitive terrain.[97][97]) It also ties in with Kuhn's contention that some crucial scientific sensitivities cannot be learned except by doing - important parts of the terrain are carved and absorbed only somatically, kinesthetically, tactilely.[98][98] (Thagard says that factors in emotional assessment may in part be acquired in one's scientific training through "a kind of contagion of taste and enthusiasm."[99][99]) That general process is familiar from ordinary experiences such as learning to ride a bicycle, or to fly by the seat of one's pants. (That latter is not an empty metaphor - anaesthetize the buttocks, and one literally cannot fly the same way.[100][100]) We think of those as skills involving the often-ignored "knowing how" district of epistemology, but science is - inescapably - part skill.

The fact that the initial creative invention of, the value-shaped assessment of, and the selection and acceptance of scientific theories simply cannot be done in any completely formalizable way demonstrates that science requires *humans* (or relevantly similar creatures). And the fact that humans can do it suggests remarkable human abilities and cognitive resources. Those abilities and resources are, of course, constituted in the cognitive terrain of the scientist.

Terrain changes at least partially involve processes of which we are not in direct conscious control and of which we are probably not fully aware,[101][101] since the terrain itself is not an object in normal investigation, but is rather a lens through which investigation takes place - a lens which when functioning properly is transparent to us. Alterations over time of a worldview, an ethos, feedback effects of specific practices - all such things can gradually resculpt the terrain to the point that theories and beliefs that used to fit snugly now raise conceptual blisters.[102][102] That, I think, is one reason why when one reads older science one sometimes senses that the whole thing is just ineffably wrong - the old structure simply no longer sits stably on our current terrain. The structure was constructed for a different terrain - one that we

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[96][96] Somewhat reminiscent of this picture is Wolfgang Pauli's remark (as phrased by Stuart Kauffman) that "the deepest pleasure in science comes from finding ... a home for some deeply felt, deeply held image." Kauffman, *The Origins of Order* p. vii. Polanyi also speaks of "enjoying [the structure of mathematics] as a dwelling place for our understanding" (*Study of Man*) p. 38.

[97][97] According to Polanyi the attempt is worse than merely sterile: "the process of formalizing all knowledge to the exclusion of any tacit knowing is self-defeating ... [and] self-contradictory and logically unsound." *Tacit Dimension* p. 20-21.

[98][98] Coming from a different angle, Robert Solomon, in *Not Passion's Slave* argues that emotion has propositional content - even using the phrase "kinesthetic judgments" (p. 187).

[99][99] "The Passionate Scientist: emotion in scientific cognition", p. 235-250 in Peter Carruthers, Stephen Stich and Michael Siegal, eds., *The Cognitive Basis of Science*, (Cambridge: Cambridge, 2002).

[100][100] This delightful bit of information comes via David Van Baak. For a nice informal discussion of the role of the buttocks in flying, see Budd Davisson, at: http://www.airbum.com/articles/ArticleUsingButt.html.

[101][101] Some (e.g., Allison Gopnik) argue that structures governing processes of theory alteration may themselves be both unchanging and inborn. Others - from Quine to Chomsky to current nativists - see a variety of capacities as inborn.

[102][102] To the extent that terrain is a function of neural structure, backwash can have effects even to that level. Schwartz and Begley cite some evidence that certain sorts of cognition can even alter neurological structures:

> [M]ental effort and acts of will [have] the power to regate the circuitry of [the] brain.

Schwartz and Begley, *op. cit.* p. 93. And according to Carl Zimmer, the placebo effect - which presumably is fundamentally cognitive - can have the same neural effect as some psychotropic drugs. See *Soul Made Flesh* (NY: Free Press, 2004), p. 296.

do not resonate to.[103][103] And we often cannot put a finger on exactly what the problem is, for the simple reason that part of the old terrain is in places we no longer *have* fingers for. We thus experience the epistemological equivalent of phantom itches.[104][104]

That sort of experience is not, however, without significance. I take the rationality of a theory to consist in its having the appropriate fit to the underlying terrain. It is that *fit* to terrain that generates the right 'feel' of a theory - recall Wilkinson - and it is the theory/terrain misfit that generates the 'feeling of unease' noted by Cairns-Smith. Thus, that phenomenal *experience* becomes the (or at least *our*) bottom-line marker for rationality itself.

But science-permitting terrains may have an even more intriguing feature. Seeing that, however, requires a preliminary detour.

V. Cognitive fine-tuning: origin?

If the terrain in question must be so exquisitely fine-tuned, exactly how does that fine-tuning arise?

A. Natural selection as sculptor?

It is widely assumed that evolution sculpted our human cognitive terrain in ways appropriate to the material reality around us, that being why science is reliable, tracks truth, and so forth. Were the relevant evolutionary processes *guided*, that might very well be the case. But that purely unguided processes would be capable (let alone likely) to do the job is less obvious.[105][105] As has been previously argued by others, even if one could provide a naturalistic evolutionary justification for the reliability of common sense perceptions and conceptions, that would not automatically translate into reasons for trusting the *theoretical* deliverances of human epistemological projects - such as science. For instance, Noam Chomsky:

> The experiences that shaped the course of evolution offers no hint of the problems to be faced in the sciences, and the ability to solve these problems could hardly have been a factor in evolution. [106][106]

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[103][103] I do not think that the issue simply reduces to differences in presuppositions - or to any fully propositional matter. It goes deeper than that. At least if it is purely propositional, that cannot be readily demonstrated, since so far as I know no attempt to completely catalogue the relevant presuppositions underlying any single scientific theory has ever been successful.

[104][104] There might be connections to Kuhnian incommensurability here. And science's own involvement in sculpting cognitive terrains may partially explain an otherwise curious sociological fact. Science advocates routinely behave almost as if not being up on the science of one's day is a character defect. The unenlightened of the past are systematically invidiously compared to the scientists of the past, but the superiority of those scientists cannot rest upon their being in possession of truth or upon their methods being correct, given that the science of whatever their day has been superceded in all such respects - repeatedly. (Conversely, Christians in the past are given no extra credit for being right - well ahead of science - about the cosmos having a beginning. On the contrary, they are pilloried for rejecting the (in fact incorrect) science of their day for allegedly disreputable (religious) reasons.) Perhaps part of the scientists' perceived superiority lies in the deeper changes their science effected in the character of their cognitive terrain. Why otherwise should there be some presumptive obligation to learn or to have learned things which are destined to be demonstrated to be false? (More later.)

[105][105] It is worth keeping in mind that evolutionary theories of mind are not at the moment what one would call exact science. As David Sloan Wilson remarks:

> [The] diversity of ideas ... about the evolution of human mentality ... probably exceeds the diversity of phenomena to be explained and yet show no signs of reducing itself.

"Species of Thought: A commentary on evolutionary epistemology" p. 39, in *Biology and Philosophy*, 5, 1990, p. 37-62.

[106][106] Chomsky, *Language and the Problem of Knowledge* p. 158. I have argued this elsewhere, as have Alvin Plantinga, Marjorie Grene, Thomas Nagel and others. Nagel, for instance, in *The View From Nowhere* (Oxford: Oxford, 1986) says:

> In fact if, per impossible, we came to believe that our capacity for objective theory were the product of natural selection, that would warrant serious skepticism about its results beyond a

In short, a purely naturalistic evolutionary history would provide almost no grounds for suspecting that a resultant human cognitive terrain would underpin the cognitive fine-tuning necessary for theoretical accuracy. In the cosmic fine-tuning case, attempts to sidestep conclusions of cosmic guidance typically involve multiplying varying universes - overwhelming the odds. It is far from obvious that such a strategy works even in the cosmic case[107][107] but that it would work in the present case is even less likely. The evolutionary production of vastly many cognitive variants would not materially raise the probabilities of the right sort of *theoretical* terrain emerging triumphant for the simple reason that there seems to be essentially nothing there for selection to get a grip *on*. An ability to romp through Fourier series did not, so far as anyone knows, have any bearing whatever upon differential reproductive success in the Pleistocene.[108][108] Indeed, it could even have eroded fitness. Scott Atran:

> [I]t may be more important that our ordinary [biological] concepts be adaptive than true. The ontological shift required by science may be so counter-intuitive and irrelevant to everyday life as to render inappropriate and maladaptive uses of scientific knowledge in dealing with ordinary concerns.[109][109]

Science-essential sculpting might be an evolutionary spandrel[110][110] - but to take it as such is to put the human ability to do theoretical science into the same category as some contemporary evolutionists (the early Rodney Stark, for instance) put religious belief, which might for some people raise serious questions about the rational uprightness of science itself. In fact, if science is (or arises out of) an evolutionary spandrel, and if religion is, as some other scientists (e.g., David Sloan Wilson) currently allege, a fitness-enhancing product of group selection, then evidently religion is (or has been) evolutionarily more important to human flourishing than is science, which on the spandrel view is at most a byproduct of other

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> very limited and familiar range. An evolutionary explanation of our theorizing faculty would provide absolutely no confirmation of its capacity to get at the truth.

Nagel's discussion over the following few pages is extremely insightful.

[107][107] See my "Saturation, World Ensembles, and Design" [forthcoming]

[108][108] Plantinga, Polkinghorne, Peirce, *op. cit.*, p. 120, Pinker, *op. cit.*. p. 306, Wilson, *op. cit.*, and many others have also made this point. And mathematician R.W. Hamming has said that "it does not seem to me that evolution can explain more than a small part of the unreasonable effectiveness of mathematics" p. 89, "The Unreasonable Effectiveness of Mathematics" p. 81-90. While the 'unreasonable effectiveness of mathematics' has been widely remarked, the present point involves the unreasonable effectiveness of humans to do mathematics.

[109][109] "Modular and Cultural Factors in Biological Understanding" (in Carruthers, *op. cit.*).

[110][110] One current spandrel-type account involves a variety of markedly subtle observational, inferential, creative, imaginative, and theorizing skills required for tracking quarry in even primitive hunter/gatherer contexts:

> [I]t may then be that the cognitive adaptations necessary to support scientific thinking and reasoning were selected for precisely because of their important role in hunting. But it might also be that these abilities were selected for on other grounds, and later finding application in tracking and hunting. [p. 90]

(Peter Carruthers, "The Roots of Scientific Reasoning: infancy, modularity and the art of tracking", p. 73-95 in Peter Carruthers *et al.*, *op. cit.*

Others have suggested that humans have a theory-formation system" and that innately constructed 'folk' theories have an

> abstract, coherent, causal, counterfactual-suggesting character [as well as an] ability to provide predictions, interpretations and explanations [and may undergo] changes in the light of new evidence.

(Alison Gopnik and Clark Glymour, "Causal maps and Bayes nets: a cognitive and computational account of theory-formation", p. 117, in Carruthers *et. al.*, *op. cit.* On that latter view, the capacities underlying science might be not merely an evolutionary spandrel, but a spandrel of a spandrel. And if Carruthers is right, the spandrel in question is riding on *sexual* selection at that - a process not notoriously 'rational'.

capacities evolution chose for other reasons entirely.[111][111] That will be true *even if* - serendipitously - our *theoretical* science (including evolutionary theory) has some connection to truth.[112][112] And it should be noted that some of the capacities selected by evolution and upon which contemporary science in part inescapably rests consist of emotion, feels, intuitions, etc. which are traditionally associated with religious belief and which were selected by evolution not as mere spandrels, but for their own fitness-conferring characteristics.[113][113] If *feels* or *intuitions* or the like really do constitute one bedrock of science itself, then that same faculty can hardly be rejected in other realms and applications on mere grounds that it does not come up to some 'scientific' evidential snuff, since it partially defines scientific evidential snuff. But surely it is *precisely* this sort of faculty - perhaps even the identical one - which operates within areas of faith and religious belief, and which has in fact been routinely cited by critics of religious belief as a prime justification for repudiating the legitimacy of such belief. Along that same line, van Huyssteen suggests that *if* our religious sentiments are as much an evolutionary product as are our sensory and more general cognitive convictions, and *if* - as naturalists are typically committed to - those latter two have some reliable and selected link to truth, then refusing that same epistemic status to the former looks purely arbitrary, or at the least philosophically driven.[114][114]

Michael Ruse and E.O.Wilson have argued that a (false) belief in the objectivity of morality fosters fitness and has been favored by evolution.[115][115] David Sloan Wilson has argued that a (false) belief in religion fosters group fitness and has been favored by evolution.[116][116] According to Scott Atran,

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[111][111] In e.g., *Darwin's Cathedral*, Wilson argues that the intra-group cooperation religion fosters had fitness consequences favoring religious groups. Wilson does not, however, think that religious beliefs are true, however much fitness they might confer on groups holding them.

[112][112] It is interesting that evolutionary explanations of science typically take science's adaptiveness as linked to *truth* whereas religion's adaptiveness (when accepted) is typically glossed in terms of *behavior*. One reason for that is that evolutionary explanations of science and of religion frequently start from the bald assumption that theism is false. For instance, in his "Religious Costs as Adaptations that Signal Altruistic Intentions" (*Evolution and Cognition*, vol 10 #1, 2004, p. 19-42), Joseph Bulbulia defines religious belief as "ontological commitment to the existence of x where x is a supernatural entity or force" (p. 39 note 1), then near the beginning of the article says that

> The main problem facing any adaptionist theory is how to account for religions [sic] reproductive cost. The most immediate expense of religious belief is a distortion of reality. [p. 19]

i.e.,

> One such cost is the mistaken supernatural belief itself.

His concluding paragraph begins:

> Religious cognition is based on a strategic distortion of reality as god infested. [p. 38]

Other distortions in the neighborhood include e.g.

> magical substances like sin and grace

and

> belief in supernatural punishments and rewards.

Why does that latter represents a distortion?

Because the gods do not exist, they are unable to deliver the relevant rewards and punishments. Bulbulia does on occasion simply pronounce that there is "zero evidence for the gods", but aside from asking in passing "Why do bad things happen to good people?" does not bother to try to provide support for those substantial and offhand allegations, or for any of the other similar allegations with which the article is laced.

[113][113] Ironically, Scott Atran, in *In Gods We Trust* says:

> Religious beliefs and experiences cannot be validated by social consensus either through deductive inference or consistently reliable induction from observation and experience. Validation occurs only by satisfying the very emotions that motivate religious beliefs and experiences. [p. 149]

Very similar things could be said about science.

[114][114] J. Wentzel van Huyssteen, *Duet or Duel?*, (Harrisburg: Trinity, 1998), p. 154. 155/

[115][115] "Ethics ... is an illusion fobbed off on us by our genes to get us to cooperate ... Our biology enforces its ends by making us think that there is an objective higher code, to which we are all subject" "The Evolution of Ethics", in J. E. Huchingson, ed. *Religion and the Natural Sciences*, HBJ, 1993)

[116][116] This is the thrust of *Darwin's Cathedral* (Chicago: Chicago, 2002). For instance:

evolution has apparently favored a (false) belief very nearly in its own denial.[117][117] Non-theistic evolution apparently does not merely lack an interest in truth - truth taking the hindmost, as Patricia Churchland puts it [118][118] - but in important instances seems to have a vested interest in falsehood. There is a deep irony in the neighborhood. Nietzsche (often credited with turning evolutionism into a form attractive to Hitler) is read by some Nietzsche scholars as attributing the rise of science to Christianity's unqualified commitment to truth.[119][119] We have here an odd near-reversal of the secularly assigned roles for science and religion.

In any case, attempts such as the foregoing to justify the essential presuppositions and related resources of science via science itself will, of course, be problematic. Versions of such materials being *pre*-requisite for generating any scientific results to begin with, those materials can hardly themselves be straightforward scientific *results*. Thus, science cannot straightforwardly provide the rational justification for its own foundations.[120][120] And if science cannot be justified unless the foundations upon which it rests are, then science itself is not rationally justified unless there is some *other* - non-science – source of rational justification. Thus, rational justification even of science must ultimately spring from some deeper level.[121][121]

> Religion returns to center stage, not as a theological explanation of purpose and order, but as itself a product of evolution that enables groups to function as adaptive units - at least to a degree. (p. 6).

[117][117] Atran cites empirical evidence that

> One characteristic of an evolved cognitive disposition is evident difficulty in inhibiting its operation.

Atran also cites evidence suggesting that a strong, universal tendency to believe in specifically biological essences emerges spontaneously early in childhood. The indirect result of this evolutionarily generated tendency?

> The essentialist bias to understand variation in terms of deviance is undoubtedly a hindrance to evolutionary thinking. even for "students and philosophers of biology."

Scott Atran, "Modular and cultural factors in biological understanding: an experimental approach to the cognitive basis of science" p. 41-72 in Carruthers *et. al.*, *op. cit.*

[118][118] Patricia Churchland, "Epistemology in the Age of Neuroscience" p. 544-553, *Journal of Philosophy*, 84/10 (Oct. 1987), p. 553. Jerry Fodor notes that while it is important to appreciate truth, it is more important not to be eaten. On a related front, in *Beyond Good and Evil* §4, Nietzsche says:

> The falseness of a judgment is not necessarily an objection to [it]. The question is to what extent it is life promoting ... life preserving.

Anthropologist Scott Atran, in *In Gods We Trust* subjectivises logic itself:

> Logic itself is merely a tool for shifting one's intuitive feelings of confidence about premises to the conclusions that the rules of logic generate. [p. 156]

More generally, evolutionary views such as astrophysicist Jim Peebles's conception of humans as "flotsam and jetsam" don't inspire great confidence. (Quoted in Weinberg, *Dreams of a Final Theory*, p. 255-6.)

[119][119] That attribution generally rests on Book 5 § 344, *The Gay Science*:

> But you will have gathered what I am driving at, namely that it is still a *metaphysical faith* upon which our faith in science rests - that even we seekers after knowledge today, we godless anti-metaphysicians still take our fire, too, from the flame lit by a faith that is thousands of years old, that Christian faith which was also the faith of Plato, that God is the truth, that truth is divine.

At least some Nietzsche scholars explicitly associate this with Christ's statement concerning truth:

> The really corrosive effects of doubt, Nietzsche notes, began with Christianity's faith that "the truth shall make you free." It was Christianity's uncompromising critique of pagan superstition and its quest for truth that began to shatter older, taken-for-granted ways of thinking. This method of doubt was later intensified by the emergence of science and scientific procedure in the modern age ....." p. 93.

Charles Guignon and Derk Pereboom *Existentialism: Basic Writings*

[120][120] I have discussed this elsewhere - e.g. *Science and Its Limits* (Downers Grove: InterVarsity, 2000), p. 92-3. The same general point applies to mathematics – that being, I take it, one implication of Gödel.

[121][121] I have argued this elsewhere, e.g., *Science and its Limits* (Downers Grove: InterVarsity, 2000), p. 93.

B. Atheism doesn't have much promise here either

The prospects for any sort of philosophical naturalism - and specifically a materialism - providing the requisite resources here are questionable as well.[122][122] Although I will not pursue the issue here, Alvin Plantinga has recently argued that there may be inescapable self-generated defeaters for any such naturalism in this context, and there are other significant questions which arise straightforwardly.[123][123] If Plantinga is right, the prospects here are none to minus slim. Dennett lauds Darwinian evolution as a "universal acid",[124][124] but the acid may be more universal than Dennett suggests - dissolving even its own case for itself.

What would a non-theistic science look like - a science that was truly non-theistic and not one which merely appropriated theistic-shaped science while gluing on a thin veneer of non-belief? An exercise in (hypothetical) comparative science may be revealing here. Stalinist principled denials of "idealist" Mendelian genetics, Nazi principled denials of "Jewish" physics, Maoist principled denials of religion-friendly "bourgeois idealist" Big Bang cosmology (and of the "bourgeois" Copenhagen interpretation), Marxist principled preference for Newtonian absolute space and time over "anti-materialist" relativity theory[125][125] (and rejection of "anti-Marxist" conceptions of the universe as finite but unbounded, or, in some cases principled objections to 'capitalistic' Newtonian physics), and postmodern principled denials of various "essentialist" theories might give one pause. But although I will not go into all of them here, I think that problems might run much deeper than rejection of specific theories and might involve inadequate metaphysical foundations, inadequate epistemological foundations, rational adequacy concerns, conceptual adequacy concerns, and others. The upshot for science could be grim indeed. The Stalinist theorist Nickolai Bukharin once claimed that pure science was a morbid symptom of class society. [126][126] And we all - including the later-executed Bukharin - know the standard Stalinist response to things and people perceived as 'morbid symptoms of class society.'

VI. Enter religion

I wish to suggest a fourth principle concerning cognitive terrains:

4. the 'fine-tuned' cognitive terrain required by science is religion-shaped

There are several considerations that offer at least some support for that. The first involves the early rise and history of science. Following is a brief examination of that history.

A. Science's theological history

As a historical matter of fact, modern science arose only once, and that took place within the Western European context of Judeo-Christian theology and praxis - not in Egypt, India, the Middle East, or China, all of which had earlier and longer cultural and technological traditions than had Western Europe.[127][127] Although there are disputes over degrees, virtually every serious historian of science recognizes that that was not mere coincidence - that some specific Christian theological doctrines (most

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[122][122] *Methodological naturalism* is, of course, simply the stipulation that *naturalism* must be employed as an extra-empirical factor within science regardless of whether or not it is true, believed, employed beyond science, etc.

[123][123] See his "Evolutionary Argument Against Naturalism" in *Naturalism Defeated?* ed. James Beilby (Ithaca: 2002, Cornell) p. 1-12. The argument appeared earlier in *Warrant and Proper Function*. Being committed to a view which generates its own undefeatable defeaters puts one in a position for which Plantinga proposed the technical term of being *epistemically screwed*.

[124][124] *Darwin's Dangerous Idea*, *passim*.

[125][125] The Chinese Communist government did not drop opposition to relativity until 1985. Earlier China is interesting in this connection as well. During some dynasties, learning mathematics without permission was a capital offense, and in the 17th century, five astronomers were executed in connection with attempts to reform the calendar.

[126][126] Polanyi reports this from a personal conversation with Bukharin (*Tacit Dimension* p. 3).

[127][127] Since modern science only began once, all subsequent science has descended from that origin in 'meme'-transmission fashion, science thus being a Dawkinsian mind-virus.

notably creation and divine voluntarism) played key roles in the origin and rise of modern science.[128][128] (Indeed, the condemnation of 1277 which emphasized divine voluntarism explicitly against a necessitarian Aristotelianism has been cited by a few historians as the initiating spark for what became modern science.[129][129])

I will not pursue the details of the historical dynamics, and I do not claim that a Christian intellectual/practical context *caused* the rise of science, or that nothing like modern science could have arisen without such a context. But key figures in the emergence and growth of what we think of as modern science deliberately and explicitly claimed to find the grounding and intellectual justification for not only the formative presuppositions of science, but even for the legitimacy of the scientific project itself, in the content and implications of the doctrine of creation and other components of basic Christian theology. Perhaps they were confused, self-deluded, or their claims on this point are otherwise untrustworthy. But given the identities involved - some of the most noted minds of the last several centuries - such easy dismissals are not prima facie compelling.

Very briefly, the strongest version of the doctrine of creation says that the cosmos and everything that exists in it was *created* by a transcendent, rational God. That implies that the cosmos had a *beginning* - it has not existed always and is not eternal. The only thing eternal, according to this doctrine, is God. All else is created. This doctrine also says that the things which God created were created *out of nothing* - that God brought the cosmos itself into existence by His decree and command, and did not merely fashion the cosmos out of some pre-existing (possibly recalcitrant) materials or matter. Further, according to this doctrine, since only God is eternal, there were no substantive pre-existing rules or principles or boundaries that He had to work within. He was not subject to any substantive constraints in choosing what to create, so all else - being made by Him - was utterly subject to His will and free decisions.[130][130]

Again very briefly, that theological position was explicitly taken to imply that the cosmos (being structured around God's wisdom) was rational and intelligible, that we (being created in God's image) could in principle comprehend that creation, that our senses and cognitive faculties (being designed for knowing) were basically reliable, that we (being finite) could not just deduce *a priori* what and how God would have created, and consequently that since God had created not only rationally but *freely* in a way not evident to us *a priori* that we *had* to actually look if we wanted to know what God had done - i.e., that our investigation of nature had to be fundamentally empirical. (For additional specifics on this general theme, see Appendix II.)

B. The alleged separability possibility - backwash[131][131]

Of course, it might well be that even if religion was instrumental in getting science up and running, that science has long since left any such connection behind. But despite widespread assertions that science and its theistic heritage are separable, it is not at all clear that this separability thesis is true. It may be that the overtones of the theological conceptual context of science are not only essential, but have filtered deep into the very bones of science, and that science cannot be theologically filleted. Let me suggest some considerations which make that position at least plausible.

The phrase 'scientific inference' is often taken to suggest that there is some single style of reasoning which is definitively and uniquely scientific. Such is not, of course, the case. A number of types of reasoning are essential to various facets of science. Prediction, for instance, may involve straightforward implication, but currents often run in the opposite direction in confirmation - from confirming data back up

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[128][128] Interestingly enough, a corresponding point was recently made by the world class Chinese cosmologist Fang Lizhi (who is also China's most prominent political dissident of the past two decades, and who is currently at the University of Arizona). In an essay in *Bringing Down the Great Wall* (NY: Knopf, 1990), Fang attributes China's failure to independently generate modern science to the absence of three key principles characteristic of Western religion - the cosmos being intelligible and nature's laws exhibiting uniformity and universality (p. 33-36).

[129][129] This view has been attributed to Duhem by Weisheipl (62) and Crombie (Vol I, 64). Crombie seems to concur.

[130][130] There have been disputes historically within the Christian community over whether or not the basic laws of logic constituted boundaries within which God had to work. We need not settle that question for present purposes.

[131][131] Much of this section derives from my "Natural Theology, Methodological Naturalism, and 'Turtles all the way down'" *Faith and Philosophy* Vol 21 # 4, Oct. 2004, p. 436-455.

to confirmed theory. There is here a backwash - an inferential ebb tide - with the empirical success of a theory anchoring its epistemic warrant. In some cases, even in the absence of strict inference in any direction a substantive intermeshing - the smooth embeddability of a theory into an accepted wider conceptual matrix - is taken as constituting support for the embedded theory.[132][132] Other currents are both more complicated and even less directional. For instance, the familiar claims that data are theory-laden, or that observation is partly constituted by paradigms, have led some to see epistemic feedback loops within science.[133][133] And depending upon where the boundaries for scientifically acceptable explanations are set, 'inference to best explanation' presents an extremely wide scope for scientific validation.

Epistemic legitimation can thus move in a variety of directions within science. Given that cognitive procedures within science are basically honed versions of common sense procedures, it is possible that processes generating epistemic legitimation within science may do so beyond science as well. For instance, just as empirical success provides backwash confirmation to relevant theory, the broader success of science itself might provide some level of genuine confirmation to the larger philosophical matrix within which that science is embedded.[134][134] It is well worth noting that anyone claiming that science undermines religion – i.e., that science confirms some sort of metaphysical naturalism – is thereby committed to this general possibility of science confirming metaphysical principles.

As noted above, that matrix owes a considerable conceptual and practical debt to the Christian intellectual context. Science works only in a very particular sort of reality and only with a very particular sort of conception of reality. The requisite picture - of a comprehendable, intelligible, uniform, predictable, even beautiful, cosmos which can in principle make sense to finite minds like ours when observed via perceptual faculties like ours - is a picture of a cosmos structured in fundamental ways like a mind would do it. It is a picture of a cosmos structured like a *creation*.

As also noted above, smooth interlockings of that sort *within* science are typically taken to have confirmatory force. By parity of reasoning, an epistemic backwash to the philosophical presuppositions of science *and* on back to the theological principles which historically provided their foundations and within which they smoothly embed, would seem both in principle unproblematic and productive of epistemic significance.

Even deeper potential arises in other ways. First, the possibility of theory-ladeness of data suggests that currents may sometimes even carry substance as well.[135][135] If so, then *content* may migrate among fundamental presupposition, theory, and observational data. Historically, varying conceptions of reality, of the proper aims of science, of the proper conceptual resources available (or not) to science, of the relative importance of competing epistemic values within science, and so forth have both affected and been affected by developments within science, within philosophy, and within theology (not to mention the broader social context in general). Just as observational data may be theory-laden, theories in this circumstance may be metaphysics- or even theology-laden.

Second, it is sometimes argued that conceptual structure and content are not cleanly separable - that at least in (subtle) part structure is content.[136][136] That, if true, has significant implications. If science

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[132][132] As Owen Gingrich says,

> Science is primarily looking for a self-consistent description of nature that hangs together in a convincing way ... Science works by coherence, not by proof.

"How Galileo Changed the Rules of Science." p. 32-36, *Sky and Telescope* Vol. 85#3, 1993, p. 36.

[133][133] Data are the repository of choice for all sorts of things. Not only are they alleged to be theory-laden, and/or partially constituted by paradigms, but they (or their 'fabrication') are sometimes described as "decision-laden" (Karin Knorr-Cetina, *The Manufacture of Knowledge*, p. 5-6 (NY: Pergamon, 1981)) or as "inference-laden" (Naomi Oreskes, Kristin Shrader-Frechette, and Kenneth Belitz, "Verification, Validation and Confirmation of Numerical Models in the Earth Sciences" p. 642, *Science* Feb. 4, 1994, vol 263 #5147, p. 641-646).

[134][134] I have argued for this sort of view elsewhere (Ratzsch, e.g., *ibid.*). This picture also emerges from work by Stephen Wykstra and also in some really nice work a half century ago by J.W.N. Watkins, e.g., "Confirmable and Influential Metaphysics", *Mind* vol 67, no 267, Jul. 1958, p. 344-365.

[135][135] Of course, coherentism or any other sort of view entailing that forward inferences and backwash are not cleanly separable would have this same consequence. And if the observation/theory line is as blurred as often claimed, similar consequences ensue.

[136][136] This idea has some currency in literary circles - that e.g., part of what is conveyed by a literary work depends upon (or is carried by) the structure, genre, etc. of the work, and cannot be adequately expressed

has co-opted some of its conceptual structure from theology, filtering out every even distant echo of theological content seems unlikely.

Third, it is widely recognized that metaphor plays an indispensable role in theoretical understandings. That would carry the potential - indeed the inevitability - of structure and content flowing into even the most arcane and abstruse scientific levels. Dirac once remarked:

> Nature's fundamental laws . . . control a substratum of which we cannot form a mental picture without introducing irrelevancies[137][137]

That seems right - those alleged irrelevancies including the metaphoric overtones of the human concepts formed elsewhere and imported into the theoretical context.[138][138] And metaphors with ultimately theological tints - for instance, biological 'design', cosmic fine-tuning, or even *law* - would suffuse that tint wherever applied. (And recall that some science-essential presuppositions - e.g., *intelligibility* - may be agent-freighted as well.) This observed pervasiveness of teleological talk may have deep roots. Mary Midgley argues that it is unlikely that even our (scientifically crucial) imagination can work without notions of teleology. She goes on to say that

> These words are indeed metaphors. But they are not optional, disposable metaphors. They cannot be replaced at will by literal and 'objective' language. Like many metaphors, these *form part of the thought*. [my emphasis][139][139]

So science cannot escape teleological metaphors, those metaphors are essentially agent-flavored, and that agent undertone becomes an indispensable and inescapable part of scientific thought itself.[140][140] Any science denying on principle the existence of the relevant agency will, of course, encounter some awkwardness here.

In any case, if out of conceptual embedding and interactions any theistic *substance* flows, at least some whiff of that will nearly inevitably make its way into science 'proper.' And as noted earlier, one does indeed find hints of such in the writings of some scientists.[141][141]

But if anything like a tint-suffusing backwash really functions within science, why is separability so widely and confidently held? That may stem from the tints and overtones having become so familiar that we no longer recognize them for what they are. Einstein once asked: what does a fish know of the water in which it swims all its life? Perhaps in similar fashion, science is so thoroughly infused with core theological conceptual structures - in which it has swum all its life - that we no longer recognize them for what they are. Paul Davies has remarked that:

> Science began as an outgrowth of theology, and all scientists, whether atheists or theists ... accept an essentially theological worldview.[142][142]

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via significantly varying forms. The idea is also, I suspect, deeply implicit in Wittgenstein's "the meaning is the use" and in David Lewis's treatment of propositions as sets of worlds. (Don't ask me to defend that suspicion.)

[137][137] Quoted in Polanyi, *Science, Faith and Society* p. 88.

[138][138] The same general point applies to models as well.

[139][139] *Science as Salvation* p. 10. Others - e.g., Michael Ruse - sometimes talk in this direction.

[140][140] If arguments by Alvin Plantinga are correct, the biologically crucial concept of *proper function* may be unavailable within any purely naturalistic system. See his *Warrant and Proper Function* (NY: Oxford, 1993), p. 199 ff. Even something as important as the Principle of Sufficient Reason is seen by Steve Fuller as just a disguised contemporary version of the core of the traditional design idea.

[141][141] E.g., Planck on action principles.

[142][142] Davies, *Are We Alone?* (NY: Basic, 1995), p. 138. Kant, of course, argued that science could not operate *except* under design as a regulative principle - meaning that the structure Davies refers to is not mere historical accident. In this vein recall again Neitzsche, *Gay Science* § 344:

> even ... we godless anti-metaphysicians still take our fire, too, from the flame lit by a faith that is thousands of years old, that Christian faith which is also the faith of Plato, that God is the truth, that truth is divine.

Much both of the cognitive and of the non-cognitive underpinnings of science is starkly appropriate to the domain of artifacts, personhood and agency - e.g., intelligibility, values, the relevance and basic reliability of tacit feels and emotions, the inescapability of teleology in some guise or other, the significance of beauty.[143][143] That appropriateness is so stark that even Dennett notes that

> Nowhere are Mother Nature's hidden constraints *written down* in a way that can be read without the help of the interpretive rules of artifact hermeneutics. [his emphasis][144][144]

And the fact that a science which functions via such deeply person-appropriate cognitive resources *works*, whereas systems explicitly and intentionally contradictory to such resources routinely fail, is surely not just arbitrarily dismissible.[145][145] At the very least, the naturalist claim to ownership of science is not merely intellectual imperialism[146][146] - it is the intellectual equivalent of Moby Dick trying to collect royalties as the inventor and first practitioner of the bicycle. In any case, if Davies is correct (and I think that he is) then science seems to (still) exhibit a deep theological shape - a theological Cheshire cat's skeleton.[147][147]

If nature is not only a creation but an *integrated* cosmos genuine understanding of which must lock into relevant religious truths (or at least their structure), and if part of learning to do good science is via praxis osmosis, and if science is striving for intelligibility (i.e., for a projection/terrain fit), and if science involves an immersion into nature and nature's projections onto our cognitive terrain which can in some way alter that terrain, then the very practice of science may ineluctably shape one's terrain in religion-friendly directions. After all, intelligibility *is* an agent-laden concept, and if nature is supposed to shape our scientific cognition (and that is the core of science's 'self-correctiveness'), and if nature as a creation is agent-reflective, then our science - including our terrain - must be sculpted (or polished) to accommodate that agency.

Furthermore, *if* the cosmos is constructed with a purpose or meaning, one would *expect* that whatever that meaning was would have ramifications for the structure and governance of the cosmos. If a human architect claimed that she was going to construct a building for a particular purpose, but insisted that that purpose would have absolutely no bearing upon the structure of that building, we would find that puzzling, if not downright unintelligible. Attempts to understand the cosmos while insisting on ignoring even the possibility of such meaning would be similarly intellectually risky in the extreme. It might be asserted that one does not *need* to take account of any such meaning (if any), but it cannot be easily claimed that science

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[143][143] I have argued this point from a slightly different angle in *Nature, Design, and Science*, and Mary Midgley, in *Science as Salvation*, p. 12, says:

> [T]his category of the intelligible necessarily counts as akin to mind, because the order we detect in it is of the kind our minds acknowledge.

[144][144] *Darwin's Dangerous Idea* p. 259. That sort of view is echoed in Dawkins's definition of biology:

> Biology is the study of complicated things that give the appearance of having been designed for a purpose.

Blind Watchmaker (NY: Norton, 1987), p. 1.

[145][145] For example, with respect to specifically Maoist views, Fang Lizhi claims that:

> The fact is that every single 'philosophical' [Maoist] intrusion in the natural sciences since the founding of the People's Republic has been a huge mistake.

Fang, *op. cit.* p. 25.

[146][146] I love William James's reference to

> the strange arrogance with which the wildest materialist speculations persist in calling themselves 'science'.

Principles of Psychology, Ch. 11.

[147][147] As one example, Michael Ruse says that

> [A]t its heart, Darwinian evolutionary biology is riddled through and through - in language and in attitude - with a mode of thought which, when it entered biology, was highly value-impregnated. And that in itself is no small thing to note.
>
> Moreover, I'm far from convinced that all the values have gone from the adaptationist way of thinking.

"Biology and Values: a fresh look" p. 455, *Logic, Methodology and the Philosophy of Science VII* ed. Ruth Marcus et al, Elsevier, 1986. p. 453-466.

confirms that fact. Science requires the presence of intelligible pattern in the cosmos, and the presence of such pattern is hardly promising grounds for assertions of an absence of purpose or meaning.

VII. Religion, terrains and science

If science fits firmly (only?) on a theistic-shaped terrain, and if science's foundational structure is forced by its search for coherence to conform to the underlying terrain, then any fully satisfactory science may *de facto* have a theistic foundation and shape. This is *not* to say that only believers will get science ultimately right - only that any ultimately successful science will involve an *implicit* practicing conceptual theism.[148][148] Science depends upon a fund of absolutely indispensable presuppositions which not only grew out of a theistic context, but still look awfully like the weight-bearing members of a creation - intelligibility, coherence, reliability, beauty, and the rest of the familiar list. And as just seen, there is some reason for suspecting that science cannot be hermetically insulated from the harmonics which that structure might generate while still reaping the payoffs of exactly that structure.

There is a potentially significant - and intriguing - reported result from studies of scientists. Hudson summarizes results of one study as follows:

> Scientists and non-scientists differ significantly in their reactions to descriptions of nature. Compared with non-scientists, scientists show a marked preference for metaphors of nature which are anthropomorphic - with certain significant exceptions. They *reject* anthropomorphic metaphors if these suggest nature as threatening or anarchic.[149][149]

Note that this 'marked preference' is a preference for the conceptual structure reflecting a benevolent (at least not threatening), faithful (not anarchic), person. That predilection could explain an otherwise surprising observation by astronomer Fred Hoyle:

> I have always thought it curious that, while most scientists claim to eschew religion, it actually dominates their thoughts more than it does the clergy.[150][150]

It might also explain why some unbelieving scientists protest vastly too much - e.g., Richard Dawkins, Daniel Dennett, Francis Crick, E.O. Wilson, Peter Atkins, Michael Shermer, George Williams, William Provine, etc.[151][151] One sometimes wonders just who they are trying so shrilly to convince.

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[148][148] In fact, deliberate attempts to alter one's cognitive terrain to conform to some conscious but incorrect theology may itself have unfortunate scientific effects. Galileo lauded Copernicus for letting his reason 'ravish' his senses, but letting one's own preferred sectarian theology ravish one's created cognitive terrain may have rather less happy results.

[149][149] Hudson, *op cit*., p. 148. This is Hudson's gloss of results of a study by David McClelland's student Ellen Greenberger. See McClelland, "On the Psychodynamics of Creative Physical Scientists", p. 141-174, in *Contemporary Approaches to Creative Thinking*, eds., Howard Gruber, Glenn Terrell, and Michael Wertheimer, (NY: Atherton, 1962). According to McClelland,

> First, scientists prefer metaphors describing nature in idealized human (male or female) terms. ... Secondly, scientists reject images of nature as threatening.

McClelland, p. 161. I do not know if there have been attempts to replicate those results.

[150][150] Quoted in Davies *The Mind of God* p. 223.

[151][151] There are some fascinating themes buried here. Several of those just listed had religious childhoods but then, obviously, rejected their earlier belief. That may be part of a broader pattern. Not only are there suggestions of that in Roe, but second on McClelland's catalogue of traits characterizing physical scientists, is the following:

> 2. Experimental physical scientists come from a background of radical Protestantism more often than would be expected by chance, but are not themselves religious.

See McClelland, *op cit.,* p. 144. Although this study is several decades old, I have been unable to find similar systematic but more recent work. (And perhaps characteristic of the times, this 1962 study deals with the usual Freudian twaddle far too respectfully.)

(Dawkins's anti-religious emotionalism has gotten so over the top that he is now suggesting that sexually abusing a child may do less lasting harm than raising that child Catholic.[152][152])

It should again be noted that beyond the metaphoric preferences just mentioned, that some of the more basic human cognitive structures which are irremovably and properly infused into science are among those stereotypically associated with religious belief - emotion, feels, intuitions, faith, deep cognitively-formative stances and ethoi, values, goals, commitments to principles and praxes beyond the empirically determinable.[153][153] As Larry Laudan has argued,

> [T]he presence of [philosophical, religious and moral issues in science] may be entirely rational; [indeed] the suppression of such elements may itself be irrational and prejudicial.[154][154]

It is again now clear that one cannot demonstrate any substandard rationality of religious belief merely by citing emotion, subjective experience, interpretation, etc., as constituting components of religious belief – unless one is willing to see scientific rationality sink alongside it. (Such factors may play different roles exhibiting different degrees of prominence or involvement in the different domains, but that is quite different from being absent.) In any case, if human understanding and rationality *does* have a constitutive terrain fused out of religion-shaped components then having the *right* such components may have a scientific importance of the same general type as does having the right traditional components - presuppositions, epistemic values, and so forth. (Although I won't pursue it here, some work has been done on the question of why even among theistic cultures (Islamic, Jewish), science arose only out of the specifically Christian intellectual background.)[155][155] Effects would not, of course, be transparent, on the surface, or subject to anything like a straightforward falsification - and in those respects would be exactly like some of the more familiar extra-empirical factors. Attempts both to clearly separate science and religion, and to assign science and religion vastly different levels of rational warrant will at the least be complicated.[156][156] Every terrain is - at least in detail - personal and individual. In each such individual case the personal - including factors typically associated with religion - and the scientific are not only at bottom not completely separable, but some of the same exact terrain is partially constitutive of each. There is of necessity no clear science/religion divide in the individual case, and that would raise some question for their separability in the abstract as well.[157][157]

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[152][152] In *Free Inquiry*, Fall 2002, Vol 22 #4, p. 9, Dawkins said:

> Odious as the physical abuse of children by priests undoubtedly is, I suspect that it may do them less lasting damage than the mental abuse of having been brought up Catholic in the first place.

[153][153] A good example is Dean Hamer, who in his (widely criticized) *The God Gene* says:

> [F]eelings of spirituality are a matter of emotion rather than intellect. ... We do not know God; we feel him. [p. 139]

I am certainly not endorsing the view that religion resides in the realm of emotion, etc. Something along the above lines could be said concerning science also.

[154][154] *Progress and Its Problems* (Berkeley: California, 1977), p. 132.

[155][155] Islam, on some views, stressed God's will too strongly over God's reason, and Jewish (and some Islamic) thought, on some views (e.g., Rodney Stark), focused upon exactly what God *said*, rather than developing a theoretical theology of what God *meant*.

[156][156] On a related matter, Faconnier and Turner argue that the capacity for what they call "double scope conceptual integration" acquired roughly 30,000 years ago, was the common trigger for the human capacities for science, art, language, and religion. *Op. cit.*, p. 186.

[157][157] One might read Polanyi as holding that this meld characterizing the personal level characterizes other levels as well. And if the foregoing is right, then the Duhemian project, however laudable, will ultimately fail. (In fact, even ignoring different subtle contours of allegedly shared terrain, there is no good *a priori* reason for thinking that a genuinely Duhemian science actually built only on foundations shared by believers and non-believers would constitute a subset of the full science of either group. A theory conforming in the requisite way to a larger subset of one's foundations might not accommodate a theory conforming in a permissible way to some smaller subset of one's foundations, even if that smaller subset were a subset of the initial larger subset.) Even if some truncated foundation for science *could* be cleanly extracted from the larger embedding conceptual matrix, the resultant science might still be problematic. If reality is truly integrated across all levels (a *cosmos*), then intellectual projects required to refuse to

The constitutive integration of such religious-shaped entities into science not only opens some deep possibilities for religion/science interactions, but may make such interactions inevitable. Indeed 'interaction' may be too separationist a term. In discussing their theory of conceptual blending, Fauconnier and Turner say:

> A mental space consists of elements and relations activated simultaneously as a single, integrated unit.[158][158]

In a similar way, just as some tendencies of thought, inference and reason are simply presented to consciousness as *faits accompli*, preshaped by deeper, unrecognized cognitive structures, so, I'm claiming, a deep mutually constitutive interweaving of human science and underlying conceptual structures - including religious structures - is also a cognitive *fait accompli* by the time the tip of the content and direction of science surfaces to formal scrutiny.

And if the cosmos *is* a creation, then unless that creation differs from all other known (or conceivable?) artifacts in lacking an inbuilt intelligibility keyed to the mind and purposes of the artificer, then in our attempts to understand the structure of the cosmos either we and our science are unteachable (i.e., science is not self-corrective) or else, to adapt a phrase from John Polkinghorne, our science itself will be laced with subtle "rumors of divinity." An inescapably unified science/religion picture will arise out of the unity of the traditionally disparate aspects of human personhood itself, the unity of the multi-hued ingredients of rationality itself, and the unity of scientific and religious truth within the cosmos itself.[159][159] Given that a single, unitary cognitive terrain underlies all our cognitive procedures - including both science and religion - the same fundamental structures and processes of rationality are of necessity imposed on, or better, partially constitutive of, both science and religion. As Faconnier and Turner put it in a related context:

> Our mental world is not an amorphous collection of relations and formal structures. Rather, it is inherently shaped by the rich topology of conceptual integration networks and mental spaces, including vital relations and their compressions. This landscape of conceptual integration networks is not something that gets superimposed onto [our] apprehension of basic meaning and form. It is the very way in which meaning and form, and hence the mental world itself, are constructed.[160][160]

And the embodied structures of rationality are neither axiomatizable, formalizable, rule-reducible, nor even fully propositional. Conceptual decisions - including theory evaluation and choice - are indeed decisions, but reason-conducive decisions channeled by non-statable terrain-determinates of rationality.

The question then becomes not whether science and religion should be integrated, but which deeply pre-integrated terrain package best nourishes a flourishing - and truth-tracking - science. And religion certainly has the resources to make a serious case here.

VIII. Some assembly required

Suppose that something like the preceding is right. That still leaves the rather large questions of how any relation between science and religious belief is to be pictured and of how the broader constraints constituted by the various factors catalogued above will be expressed within the global epistemic structure - even granted that science and religion share a strongly overlapping undergirding cognitive terrain. Much of the foregoing is blatantly metaphorical, and in briefly exploring the present questions, I am going to compound the original offense by sketching an analogy on top of the metaphor, constructing something like what Patricia Churchland once referred to as "metaphors in search of a genuine theoretical

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acknowledge either the existence or possible effects of stipulated aspects of that reality are at deep risk of producing skewed pictures.

[158][158] *op. cit.* p. 104.

[159][159] In his *Mysterious Universe*, Sir James Jeans observes that "the universe begins to look more like a great thought than like a great machine."

[160][160] *Op. cit.,* p, 394

articulation"[161[161]]. Actually, I'm not all that apologetic about this. If, as suggested earlier, there are types of content that can only be expressed narratively or metaphorically, there may be no alternative to such an approach.

To begin, think of binocular vision, a 3-D movie, a stereopticon, or etc. - for example the following (Figure 1) in which the two components A and B represent slightly different views of a single reality.

A **B**

Viewing the above with the eyes appropriately (un)focused, a three dimensional blended image appears. On considering this phenomenon, a number of points emerge.

a. Duality. It is only with both eyes fully engaged in their own specific - but coordinate - tasks that the full picture pops out. Close either eye, and the 3 dimensionality vanishes. One can, of course, insist that the relevant reality is 2-dimensional, and insist on restricting one's visual experience to reflect that 2-dimensionality. But suppressing the emergence of the additional experienced dimensionality will require systematically refusing to countenance the relevant experience of at least one of the coordinate figures - a sort of methodological monocularism.

b. Coordinateness. It is only because the relevant components (A and B) are coordinate - that each of the components is highly constrained by the structure of the other - that the third dimension leaps into view. Alter either of the above figures, and things begin to unravel. Rotate either, and a disorienting chaos (or at least Escher) ensues.

c. Distinctness. Although coordination is tight, differences are essential as well. In the visual case, the two eyes do indeed report objectively different things - they *have* to for the 3-D experience to occur. Look again at Figure 1 above. The left side of the 'cube' has a different orientation in the two sketches, the diamond inscribed in it displays different literal distances between the left and right vertices, etc. Thus, distances between those vertices are objectively different in the reporting of one's two eyes. In some sense, those differences represent genuine inconsistencies - one eye claiming that some distance is α, the other that it is $\alpha + \delta$. There is indeed a contradiction if one insists on taking each picture (and the report of each eye) as separate and discoordinate, and in 2-D literality refusing to allow the brain to do its own characteristic synthetic work with the two monocular views. But insisting on that conflict-generating interpretation guarantees flat and/or chaotic visual experiences.

[161[161]] *op. cit.* p. 407.

I want to apply this analogy - and the three above characteristics - to the larger science/religion issue.

First, it is only with all the resources of one's cognition fully engaged - reason, emotion, etc., each fully engaged in its own specific but *coordinate* task - that a depth-displaying picture of reality emerges (regardless of what might be gained initially by focusing on only one plane or on each individually). More specifically, it is in acknowledging - indeed insisting on - the religious dimension that science can begin to see things in the round. It is in acknowledging - indeed insisting on - the scientific dimension that theology can begin to see things in the round.

As the *duality* point above would suggest, only with both eyes on the cosmos, only in seeing its contours in their full scientific *and* religious conformations can we fully *experience* why it is that structures built upon the underlying cognitive terrain have the characteristic architectures they do - in part because we can see the terrain *as* terrain only in the combined light of both.

Some aspects of a religious dimension are imperfectly visible even to a monocular science. The *coordinateness* point would suggest that important facets of science and religion can indeed be discerned via the other dimension alone. Natural theology involves seeing a flat partial projection of the religious in the scientific dimension - a projection the possibility of which perhaps cannot be eliminated from science without destroying science.[162[162]] And (as noted earlier) the theological doctrine of creation embodies implications for the intelligibility, values, contingency, etc. of the cosmos, with the corresponding implications for science and scientific method itself - a flat partial projection of the scientific in the religious dimension, a projection the possibility of which cannot be eliminated from religion without destroying essential components of the doctrine of God, of creation, etc.

But despite such tight interweavings, despite each being required to blend into the other to allow full comprehension, science and religion each retains its own identity and character. Depending upon the angle/perspective, etc., there may be things in the visual field of one eye which simply do not appear in the field of the other. (For instance, the left side of an object may be just visible to the left eye, but not at all to the right eye.) That does not constitute a defect in one and a superiority of the other - but is the sort of *distinctness* and independence upon which depth experience depends. Similarly, science and religion are not simply differently-resourced versions of each other, differently conceptually situated perspectives of each other, redescriptions in characteristically different terms of each other, or anything of the sort. They do see some of the same things, but they are distinct enterprises, and each can see some things out of sight of the other. Thus, neither can - even in principle - engulf the other. Each has proprietary material, characteristic concerns, a unique pattern of foci, and so forth. If that were not true, no new dimensionality would ever leap out at us.

The natural question at this point is: should any of this make any difference *to science itself, to science qua science*? That question may be equivalent to asking whether it would make any difference to 3-dimensional visual experience were one to close one eye. In both cases, depth is lost, and science remains unaffected only if science properly and *de facto* has no such depth - only if, as Carnap, Neurath and Han are often quoted on a slightly different topic:

> In science there are no 'depths': there is surface everywhere.

But once one has seen the 3-dimensionality in Figure 1, then one knows that there is more information buried in each component than can be extracted from that component alone - even scrutinizing it with both eyes. Look at the left hand component. You now *know* that it in some sense hides 3-dimensional information, but *you cannot experience it*. (And if science is built upon experience, science may be unable even to notice it.) You know that there is more there than *can* meet one eye. Some lines which on the paper surface are just on a diagonal are in some sense *really* horizontal lines extending out of the surface in question. That is in some sense the *reality* - a reality not merely not reported, not merely out of the scope of, but in fact *denied* by methodological monocularism.

Important information about the 3-dimensional reality can, of course, be acquired with one eye only focusing on only one component (e.g., various general features, and perhaps even what sort of figure the experienced 3-D image would be). Indeed, one eye focusing on both of the two components, or alternate eyes focusing on alternative figures might yield significant *propositional* information regarding

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[162[162]] See my "Natural Theology, Methodological Naturalism, and 'Turtles all the way down'", *Faith and Philosophy*, Vol 21 # 4, October 2004, p. 436-455.

the third dimension. But that would still not produce any *experience* of dimensionality. And in that experience, one comes to know something that one did not know before, although that knowledge is not reducible to any set of propositions, any more than are the earlier discussed 'feels' that characterize scientific sensitivities.[163][163] There is a sort of mutuality of transformation. Thus, there is little virtue to be gained by holding out for mono-vision past some point - regardless of what might be gained along one dimension initially.

Given melded/common terrain *plus* backwash infusion, there can and will be blended themes in any structure constructed *on* that terrain as well (theories, etc.). The depth dimension is not just some additional factor in the picture. It partially constitutes the structure even of the other 2-D picture. Recall that factors often taken as definitive of religion are also essentially constitutive of science as well. So the relationship is more pervasive and structuring than merely a shared deep foundation, or shared resources of rationality.[164][164]

Pinpointing the effects of that additional dimensionality in specific cases is difficult. But think of the different flavors of mechanical as opposed to least action theories.[165][165] Despite the fact that the two are predictively equivalent, despite the fact that some argue that some problems virtually intractable on mechanistic approaches are solvable on least action theories,[166][166] least action exists in a bit of a scientific shadow. But if there are no "scientific" liabilities, why the shadow? It seems to have the wrong depth-structure. Planck famously noted that:

> [W]hat we must regard as the greatest wonder of all, is the fact that the most adequate formulation of this law [least action] creates the impression in every unbiased mind that nature is ruled by a rational, purposive will.[167][167]

It is that impression, that flavor, which has generated some unease historically with such theories. But, obviously, it is something deeper than the 'science' that is at issue here, and that something is neither removable from the theory nor does it interfere with the theory's scientific effectiveness and real credentials.

As another example, think of the different character of a design theory according to which the cosmos we live in is an artifact rather than an accident. The two views could be *predictively equivalent*, exactly equally falsifiable (or not), yet the former raises hackles to the point of eliciting character assassinations. Call them what you will, but there are tendrils that go deeper than "science" but are inarguably in the science, and the mind has to use different grips in the two cases.

One could claim that methodological monocularism does not *deny* the 3rd dimension, it just doesn't report it - its reports being merely incomplete in that sense. But if the two dimensional representation of a three dimensional reality is (of necessity) not an accurate representation, incompleteness is not mere incompleteness. I shall address this point shortly.

One would not necessarily achieve the quasi-positivist hope of *complete* science/religion detachment even if science were only surface. Even pre-perspective artists knew that somehow some things - even in two dimensions - stood differently with respect to the third dimension, that even if the artists didn't know how to do it, they somehow needed to try to indicate that some things were *closer* than other things despite the canvas being flat - i.e., being "surface everywhere." Of course, all this is analogy and analogies are fraught with peril. Indeed, Figure 1 could be classified as a 3-D *illusion* - the bald *truth* being that there are really only two dimensions there. The monocular view *is* the truth in that respect. But given that in science we are dealing with a creation, the Reformed position, it seems to me, is that monocular views of reality frequently are not the truth.

Is there any hope of getting at the larger truth? Our human limitations entail that our representations of reality are ultimately only that - representations - and ultimately that they will no more

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[163][163] This parallels the point made by Frank Jackson re: perceptions of redness, in "What Mary Didn't Know", *Journal of Philosophy,* Vol. 83, 5, May 1986, 291-5.

[164][164] This latter is what I take van Huyssteen's view to be.

[165][165] The ramifications of this specific case I first heard explored by David Van Baak.

[166][166] See John Barrow and Frank Tipler, *The Anthropic Cosmological Principle*, (New York: Oxford, 1986), p. 150.

[167][167] Max Planck, "Religion and Natural Science" p. 177 in *Scientific Autobiography and Other Papers* (London: Williams and Norgate, 1950), 151-187.

fully reflect reality than will two dimensional oil paintings fully reflect the 3-dimensional world in which the artist lives. Still, *some* new dimension of representational *truth* was introduced into painting with the discovery of perspective and its attempts to reveal in two dimensions the reality of a third. One cannot reasonably claim that perspective represented no gain on grounds that canvases themselves both before and after the discovery were still exactly two dimensional.

Once we abandon insistence upon two-dimensionality, shortcomings of some categories of the usual science/religion typologies can at least be suggested in terms of the above analogy.

Complementarity. The view that science and religion operate in separate, disjoint domains, each discipline being complete within its own domain but both being required for a complete account of the larger reality, has been popular to the point of *de facto* orthodoxy in recent decades. If we seek a coherent, global worldview picture (and the coherence and unity of a *cosmos* is not only a presupposition of science but one underwritten historically by the doctrine of creation) then the disparate truths generated via any epistemic project will have to lock integrally into the overall structure somewhere, and its integration will impose at least conditional constraints on the larger whole. Complementarity views do acknowledge *something* like this, but they do not, it seems to me, adequately take account of the demands that science and religion impose on each other (coordinateness), nor do they accommodate the idea that the two are mutually transforming, with something contained in neither emerging (as 3-dimensionality emerges from the two 2-dimensional structures in Figure 1).

Conflict. The conflict model is already fashionably out of fashion (except with various evangelical atheists), but the present analogy provides further reason for suspicion. In the 3-D case, the two eyes do indeed report objectively different things - indeed, as the *distinctness* idea implies, they *have* to for the 3-D experience to occur. But insisting on a conflict-generating interpretation, i.e., insisting that only one eye can be right and that (reports of) the other had best be jettisoned - guarantees flat and chaotic visual experiences. Similarly, if one insists on refusing to allow cognition to see a reality emerging in the round from science and religion, insisting instead on seeing only contradiction - then similarly crabbed worldview cognition may be expected as well.

Autonomy. As noted above, science and religion are distinct enterprises, each can see some things out of sight of the other, each has proprietary resources, and neither can - even in principle - engulf the other. But that distinctness is not a complete lack of relevance. Science and religion impose substantive constraints on each other (coordinateness), and denying those constraints - as autonomy claims do - introduces an incoherence in any attempt to see reality whole, just as arbitrarily changing lines in either of the sketches in Figure 1 warps the 3-D perception. In any case, walling each off from the other, allowing neither to give substance to the special dimension of the other means in effect that not only are both science and religion "surface everywhere" but that that is an irremediable situation.

Along this line, complementarists also frequently claim that science and religion are each 'complete' in their own domain, or on their own level. I'm not entirely sure what that means, but given coordinateness, I suspect that it is incoherent. Einstein famously remarked that science without religion is lame, and that religion without science is blind. I think that he was right. If either lameness or blindness constitutes completeness, it is a completeness of a particularly incomplete sort. But in fact, it is worse than mere incompleteness. What does it mean to say that, say, the left hand component in Figure 1 is *complete* in its 2-dimensional perspective? It means that every x-axis component of every line in the relevant 3-dimensional space is represented by a line of exactly appropriate displayed length on the xy plane. But in the 3-dimensional reality, *there is no line of that length*. Except for lines which happen in fact to have no z-axis component, no single line in either picture in Figure 1 has the true length of the line it is a representation of. This alleged 'completeness' is not only woefully incomplete, but systematically false as well *unless interpreted in terms of the other - absent - axis*.

A Merkator projection map is not merely incomplete in its representation of the length of the coastline of Antarctica – in flattening a spherical surface it portrays wild falsehoods. Similarly, to admit that reality has a scientifically relevant religious dimension - that it is a cohesive cosmos - while holding that science presents only two-dimensionally flattened models of that reality, is to pose grave difficulties for a general scientific realism.

Of course, our cognitions may irreparably have distinguished scientific and religious poles simply because we lack the cognitive capacities necessary to epistemically embrace reality whole. Consider a race of humans living on a spherical earth but having only flat cognitive abilities. They might map their world Merkator fashion - getting the equatorial regions close to right, but making a total pigs breakfast of the poles. Or they could center their projections on the poles, getting them roughly right, while making a hash

of at least some equatorial regions. The would, however, utterly lack the capacity to get the whole right. (And note that in their inevitable disputes, neither the Tropians nor the Polians can legitimately claim superiority here, even though both could be absolutely correct in pointing to mistakes in their opponents's views.) That may be us with respect to science and religion in the round.

Dialogue. Perhaps mutual constraints and mutual transformations can be construed as dialogue, but some care is required. One's two eyes are not in *dialogue* in the sense of trying to convince the other of something, trying to induce the other to alter its vision, etc. It is only *if* each sticks non-negotiably to its own particular guns that any 3-D vision *can* happen. But each eye must - on pain of destroying depth perception - admit that its picture is not complete, and even that its picture conjoined with the flat projections of the other dimension does not constitute the complete picture. One eye - no matter how acute, comprehensive, etc. - simply cannot produce a perception of depth.

But can we do any better than sheer metaphor here? I do not know how to work this out in any very substantive way, but in one area it might go something like this. The uniformity concept which science inescapably deploys has a dimension of brute rigidity to it, a *necessity* which nonetheless (somewhat awkwardly) embodies a contingency as well - a *nomological necessity* as it is often termed. Religion, addressing the same reality, must also acknowledge both that contingency and that uniformity, but here the concept has a depth dimension of *agency* - a character of deliberate, voluntarist free choice (the contingency) of faithfulness (the uniformity). The *necessity* vector reveals to us the firmness of God's commitment to faithfulness - a commitment that goes nearly beyond our agency-based conceptions of freedom. The *voluntarist* vector reveals to us the utter inadequacy of formal characterisings of the rigidity of laws - an inadequacy which strenuous Positivists efforts to the contrary failed miserably and predictably to overcome.

It is only in taking cognizance of the agency dimension that we may be able to get a really viable analysis of the logical character of natural law, as I have argued elsewhere.[168[168]] And it may be only through a science that came into its own only upon adopting the rigor of mathematics as its very language that we can begin to see what divine faithfulness really amounts to. The connection is quite direct in Jeremiah 33:20-21, 25-26:

> ... if you can break My covenant for the day, and my covenant for the night, so that day and night will not be at their appointed time, then My covenant may also be broken with David My servant ...
> ... If My covenant for day and night stand not, and the statutes of heaven and earth I have not established, then I would reject the descendants of Jacob and David My servant ...

The uniformity with the sharp mathematical edge which we find in nature is the faithfulness in the living face turned toward us as human persons.

Of course, there may be no universal integration procedure. In theory construction, theory competition, and theory adjudication the scientific community is forced to proceed by unstated - and perhaps unstatable non-propositional - means of resolution. We play science by ear, but it is not an uneducated, nature-deaf ear. There may be loose patterns, but in the down and dirty trenches resolution of scientific conflict and progress are case by case affairs. They are nearly unavoidably so, since if in specific instances there were settled, governing principles, conflict and even genuine competition generally would not have arisen in the first place. Precisely the same may apply in resolving science/religion issues as well.

IX. Conclusion

Definitive and constitutive features of our humanness not only lie at but comprise part of the very core of both science and religion (or at least the core of our cognitive faculties underpinning both). In fact, some of exactly the *same* human factors are constitutive in both cases. And some of those factors are not religiously peripheral, but are *precisely* among those traditionally taken to be definitive (often pejoratively so) of specifically religious belief and commitment. Scientific thought rests on an agent-shaped foundational terrain which constitutes part of the structure of scientific thought, and that structure (and

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[168[168]] I have explored this issue in depth in "Nomo(theo)logical Necessity", *Faith and Philosophy*, 1987. 4:383-402. Reprinted in *Christian Theism and the Problems of Philosophy* ed. Michael Beaty, Notre Dame, 1990. p. 184-207.

whatever content it drives) partially configures scientific theories. And the reality mapped (or 'mirrored') can only be cognized via subtly agent-based, teleological, even theological, metaphors - despite ongoing insistent attempts to strip them from science. And if Midgley is right concerning metaphor and content, then that implicit theism will constitute part of the very content of scientific thought - content which, given backwash, cannot simply be quarantined within some confined region - e.g., a context of discovery.

All of that suggests that cases for

a. science systematically undercutting religion
b. science and religion being hermetically quarantined from each other
c. science automatically taking precedence over religion

and d. science being conceptually and intellectually autonomous

are all deeply misguided. Furthermore, once we fully commit to (at least a Reformed view of) the doctrine of creation - that an integrated cosmos, to be seen aright for any distance along any of its dimensions must ultimately be seen whole - it becomes plausible that complementarity, dialogue, autonomy, and other such traditional models are far too impoverished and timid. If the cosmos is a deliberate creation - and surely that is a *factual* question and not one to be simply *a priori* decreed by late-arriving humans in a small corner of the cosmos, or to be decided by stipulated methods unequal to the task - then science may inescapably bear the implicit but nonetheless consequential imprint of that fact, regardless of whether it is overtly recognized and acknowledged as such or not. Indeed, it may be that although we can think in superficially atheistic ways, really *thinking* about the *cosmos* may be an irreducibly theistic undertaking.

That idea fits nicely with an intriguing remark made by physicist Edwin Chargaff:

> If [a scientist] has not experienced, at least a few times in his life, this cold shudder down his spine, this confrontation with an immense, invisible face whose breath moves him to tears, he is not a scientist.[169[169]]

Not only can one glimpse that orthogonal reality from within science, but, says Chargaff, one is not yet even a scientist if one does not.

Augustine in the *Confessions* famously said that the heart is restless until it finds its rest in God. Perhaps something very similar is true of human natural science as well.[170[170]]

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[169[169]] Quoted by Newberg and D'Aquilli, *op. cit.* p. ---------

[170[170]] I am grateful to Alvin Plantinga, Jeff Schloss, Jitse Vandermeer, Joe LaPorte, Stephen Matheson and Luke Maring for discussion and comments.

Appendix II

Reference was made earlier to the formative role of Judeo-Christian beliefs in the emergence of science - in particular via the doctrine of creation (and divine voluntarism). But how could that theological doctrine have any relevance to the character and shape of modern science - and specifically to the justification of science's essential extra-empirical foundations? Following are a dozen or so brief sketches of connections - all of which were specifically made by various early scientists.

(1) Contingency and empirical investigation. Since God created the cosmos out of nothing, and since in creating it He was not constrained by prior principles or inherent properties of pre-existing matter, the structure and character of the cosmos were not dictated by any pre-existing necessities. That meant that the principles and structure of the cosmos were contingent, and thus could not be deduced just from *a priori* principles of reason, logic, or mathematics. In creating, God had been *free*, and consequently in order to discover what God had done, we had to actually *look*. It followed that science must have part of its foundation in *observation*.

Various scientists (e.g., Boyle and Cotes) specifically endorsed that consideration.[171][171]

(2) Intelligibility/coherence of creation. God is a rational being. Since the things which a rational being does reflect the being's nature, the cosmos God constructed would be constructed according to principles and laws He chose in his wisdom (as Scripture explicitly indicates). There would thus be reason to nature's structures. So in a basic sense, nature would be *coherent* and *intelligible* - a principle which is indispensable to any substantive science, and a precondition to any rational understanding of nature. The cosmos actually being a creation, it could be expected to embody patterns reflective of and resonating with a *mind* - e.g., simplicity, elegance, and other such properties.

But would there be any realistic hope that *we* - finite, limited beings - could ever actually understand it? Here again, Christian doctrine suggested that the answer was "yes."

(3) Understandability of creation. Since God had also created human beings and human intellect, and since according to Christian doctrine God had created humans *in his own image*, there was hope for understanding nature and its governing principles, since the intellect with which we tried to understand the cosmos reflected in some degree the intellect which had planned and created the cosmos, and whose principles were structured into the cosmos. That connection is explicitly stated by a number of the early founders of modern science - e.g., Kepler and Galileo.[172][172]

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[171][171] In *Reason and Religion*, Robert Boyle, reasonably considered to be the founder of modern chemistry, says:

> God [is] the author of the universe, and the free establisher of the laws of motion ...[These laws] depend perfectly upon his will...

and in his *The Christian Virtuoso* again notes:

> The laws of nature ... were at first arbitrarily instituted by God

This basic idea can be found earlier, of course - e.g. Ockham, Nehemiah Grew (discoverer of the fact that plants reproduced sexually), and others. Roger Cotes in the Preface of Isaac Newton's major work, *The Principia Mathematica* makes the explicit inference:

> Without all doubt this world, so diversified with that variety of forms and motions we find in it, could arise from nothing but the perfect free will of God directing and presiding over all.
>
> From this fountain it is that those laws, which we call the laws of Nature, have flowed, in which there appear many traces of the most wise contrivance but not the least shadow of necessity. These *therefore* we must not seek from uncertain conjectures, but *learn them from observations and experiments*. [my emphasis]

There are at least suggestions in early literature that our empirical faculties might have been intended precisely for that purpose. For instance, Bacon in *Refutation of Philosophies*:

> [God] did not give you reliable and trustworthy senses in order that you might study the writings of a few men. Study the Heaven and the Earth, the works of God Himself, and so while celebrating His praises and singing hymns to your Creator.

[172][172] Kepler (in a 1599 letter to Johannes Georg Herwart von Hohenburg):

But although we *could* understand nature, our limitations as compared to God (emphasized by Galileo) meant that we needed all the empirical help we could get.[173][173] Empirical data were not just the launch pad for speculation - science had to be unremittingly data-driven, as e.g. Bacon noted.[174][174]

Such points alone were not, however, yet enough. Older systems pictured the cosmos in terms appropriate to *organisms* or even as being very like an active, living being - perhaps even a god. That general metaphor for conceptualizing the world was not ultimately fruitful, and Christian theology provided part of the foundation for the necessary change.

(4) Nature's dependence. According to the Christian doctrine of creation, nature was completely dependent upon and subject to God's actions and commands. The cosmos was consequently seen as not only *distinct* from God, but as being of a fundamentally different kind than God. Thus, Bacon and Boyle both saw nature not as a *being* but as an *artifact*.[175][175] The earlier organism metaphor was superceded by a picture more suited to a dependent object, an artifact, obeying laws decreed for it: a *machine* metaphor - nature as purely physical and operating according to mechanical principles.[176][176]

> Those [laws] are within the grasp of the human mind. God wanted us to recognize them by creating us after his own image so that we could share in his own thoughts ... and, if piety allows us to say so, our understanding is in this respect of the same kind as the divine, at least as far as we are able to grasp something of it in our mortal life.

Kepler (in a 1597 letter to Maestlin):

> [In publishing the *Mysterium Cosmographicum*] the effect which I strove to obtain [was] that the belief in the creation of the world be fortified through this external support, that thought of the creator be recognized in its nature ... Then man will at least measure the power of his mind on the true scale, and will realize that God, who founded everything in the world according to the norm of quantity, also has endowed man with a mind which can comprehend these norms.

Galileo, in the *Dialogues Concerning the Two Chief World Systems* makes a similar connection:

> I say that as to the truth of the knowledge which is given by mathematical proofs, this is the same that Divine wisdom recognizes, [although] our understanding ... is infinitely surpassed by the Divine. [Yet] when I consider what marvelous things and how many of them men have understood, inquired into, and contrived, I recognize and understand only too clearly that the human mind is a work of God's, and one of the most excellent.

On the general idea of linking the image of God in humans to an ability to understand, Aquinas (*Summa Theologica* Ia Q93 A6) says:

> Only in rational creatures is there found a likeness of God which counts as an image ... As far as a likeness of the divine nature is concerned, rational creatures seem somehow to attain a representation of [that] type in virtue of imitating God not only in this, that he is and lives, but especially in this, that he understands.

[173][173] And Roger Cotes again:

> He who is presumptuous enough to think that he can find the true principles of physics and the laws of natural things by the force alone of his own mind, and the internal light of his reason, must either suppose that the world exists by necessity, and by the same necessity follows the laws proposed; or if the order of nature was established by the will of God, that himself, a miserable reptile, can tell what was fittest to be done.

[174][174] Francis Bacon in *The Great Instauration of Learning* says:

> All depends on keeping the eye steadily fixed upon the facts of nature and so receiving their images simply as they are. [Only by so doing can we hope to discover] a true vision of the footsteps of the Creator imprinted on his creation.

[175][175] Bacon in *The Advancement of Learning*:

> [Non-Christians] suppose the world to be the image of God ... But the Scriptures never vouchsafe to attribute to the world that honor, as to be the image of God, but only the work of his hands.

Boyle in his *Notion of Nature*:

> [N]ature is not to be looked on, as a distinct or separate *agent*, but as a rule, or rather a system of rules, according to which these agents and the bodies they work on, are, by the great Author of things, determined to act and suffer. [my emphasis]

[176][176] Boyle, again, in his *Notion of Nature* says that nature is

That switch proved to be enormously fruitful - indeed, modern science probably could not have begun without it.[177][177] This idea of the world as an artifact also had a further crucial consequence, involving the status of experiments.

*(5) Experiment significance***.** If nature is an artifact, and if we as image bearers of God are similar in activities, concepts, and so on, then our art (artificially manipulating nature) is on the same continuum as nature.[178][178] That idea is explicit in Descartes's *Principles of Philosophy*.[179][179] That idea was crucial because it suggested that the artificial experimentation of human scientists was not distortion of nature as many Greeks had held. That meant that experimentation could be an important source of the reliable information about nature which our efforts depended upon.

There was one other important implication of the doctrine of creation as it related to experimentation.

(6) Experiment permissibility. The cosmos being a creation, an artifact, a thing, and especially not a deity, it did not have to be approached with fear or worship - it was neither inappropriate nor impious nor dangerous to try to understand it, to manipulate it, to pry into it experimentally.

The Christian doctrine of creation also provided justification for a variety of other essential - but perhaps less unique - principles and components of science and scientific method. Following are a few of those.

(7) Laws of nature. The change from the metaphor of organism to that of machine was not merely a small change in the mental picture of nature, but had deeper consequences. Organisms act from their own *inner* principles, whereas machines simply *obey* the laws that govern them, or are even *imposed* on them. The shift in metaphor from organism to machine was thus associated with the idea of things in nature being wholly subject to laws. The character of law as in some sense normative (*nomologically* necessary) and the foundation of law were also located in their arising from God's sovereign decrees.[180][180]

(8) Uniformity of natural law. Given God's faithfulness and unchanging reliability, one would expect that in a cosmos created by God there would be pattern, consistency, *uniformity*.[181][181] The

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> like a rare clock ... where all things are so skilfully contrived, that the engine being once set a-moving, all things proceed, according to the artificer's first design ... by whose laws the grand agents in the universe were empowered and determined to act, according to the respective natures he had given them ... [T]his, I say, I think to be a notion more respectful of divine providence than to imagine ... that God has appointed an intelligent and powerful being, called nature, to be ... his vice regent ...

[177][177] The doctrine of God's creation and direct control of the cosmos, on the one hand, and the mechanistic conception of nature on the other, is explicit in Boyle's *The Excellency and Grounds of the Mechanical Hypothesis*:

> Thus the universe being once framed by God and the laws of motion settled and all upheld by his perpetual concourse and general providence; *the same philosophy* teaches, that the phenomena of the world are physically produced by the mechanical properties of the parts of matter, and that they operate upon one another according to mechanical laws. [my emphasis]

[178][178] See e.g., Hooykaas, *Religion and the rise of modern science*.

[179][179] Descartes's *Principles of Philosophy*:

> I know of no distinction between those things [human artifacts] and natural bodies except that the operations of things made by skill are, for the most part, performed by apparatus large enough to be easily perceived by the senses.

[180][180] This sort of "legal" terminology was already being used by late Medieval times, in e.g. Buridan and Ockham. Specifically on the connections of the concept to theism, Boyle in his *Notion of Nature*:

> The nature of this or that body is but the law of God prescribed to it [and] to speak properly, a law [is] but a notional rule of acting according to the declared will of a superior.

while the laws as God's ongoing activity governing the cosmos is expressed by, for example, Charles Kingsley

> there are no laws of Nature, but only customs of God

[181][181] Samuel Clarke linked that uniformity explicitly to God:

> ...what men commonly call the course of nature ... is nothing else but the will of God producing certain effects in a continued, constant, and uniform manner

Robert Holcot (c.1290-1349), *Super Libros Sapientiae*, explicitly linked uniformity to God's *covenant*:

principle of the uniformity of nature is, of course, absolutely essential to science, to inductive inference, and so forth.

(9) Universality of natural law. Science requires the principle that the laws of nature hold universally, and Newton claimed in his *Opticks* to find the justification for that principle in theistic terms.[182[182]]

(10) The creation as good. Since God had declared the creation to be *good,* examining and exploring the physical realm would not degrade one, as some Greeks (and others) had believed. The doctrine of the goodness of the creation removed one previous barrier to doing empirical science. Of course, the cosmos belonging to God, we had to approach it with an attitude of respect - and even with an anticipation of delight.

(11) The creation as worth studying. Since the cosmos was a creation of God, and represented God's own work, it was *worth* studying. In fact, some Christians saw investigation of the creation as itself having *religious* significance. Furthermore, many believed that study of God's creation - the cosmic artifact - could even teach us about God himself. That intuition underlay the 'natural theology' movement and had provided important motivation for some earlier scientific efforts as well.

(12) Science as 'good work' Religious belief provided not only a legitimation (a sanction) but a motivation for some scientific efforts, construing them as good works and as obedience to various divine mandates - and perhaps even as evidences of salvation.[183[183]]

> [God rules nature with] an unfailing [conditional] necessity ... appropriate to God ... because of his promise, that is, his covenant, or established law.

This instance is particularly interesting, since it is less plausible to claim that this is merely an after-the-fact co-opting of theology as a rationalization for something already scientifically entrenched. And, of course, the Condemnation of 1277 can hardly be viewed as craven accommodation to modern science, given that (a) it long predated modern science, and (b) it was in flat defiance of the reigning Aristotelian science of the time, thus not being in deference to anything in the region.

The same connection was made in William Ames's 1623 work, *The Marrow of Theology,* where he speaks of

> the establishment of law and order, which is to be observed perpetually in the thing to which ordaining power applies. The constancy of God shines forth in that he would have all creatures observe their order, not for days or years but to the end of the world. [p. 104]

Ames was not a scientist, but *Marrow* was extremely influential (it went through about 17 editions in several languages, and was for a time required reading for divinity students at such schools as Leiden, Harvard and Yale.

[182[182]] Newton said:

> If there be an universal life and all space be the sensorium of a thinking being [God] who by immediate presence perceives all things in it [then] the laws of motion arising from life or will may be of universal extent.

[183[183]] For example, in a 1692 letter to Richard Bentley, Newton claimed an evangelical purpose for the *Principia*:

> When I wrote my Treatise about our system [the *Principia*] I had an eye upon such principles as might work with considering men, for the belief of a deity, and nothing can rejoice me more than to find it useful for that purpose.

And Kepler, in *Mysterium Cosmographicum* says:

> And there were three things above all for which I sought the cause as to why it was this way and not another - the number, the dimensions, and the motions of the orbs. I have dared to carry out this search because of the beautiful correspondence of the immobile Sun, fixed stars, and the intermediate space with God the Father, the Son, and the Holy Spirit.