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OCKHAM'S RAZOR: A HISTORICAL AND PHILOSOPHICAL
ANALYSIS OF OCKHAM'S PRINCIPLE OF PARSIMONY

BY

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THESIS

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CHAPTER I
OCKHAM'S PRINCIPLES OF PARSIMONY

1. Ockham's razor has long been a topic of philosophical discussion. It has been a topic which philosophy students have tended to acquaint themselves early in their educational career. In that encounter it might have been referred to as Ockham's razor, the nominalists' razor, the law of parsimony, or "novaculum nominalium," titles which refer to the dictum "entia non sunt multiplicanda praeter necessitatem." This dictum was supposed to have been first uttered by William of Ockham, the fourteenth century English philosopher. Apart from the abundance of ways to refer to it, Ockham's razor has had many formulations. It has been formulated and reformulated. "Entities must not be multiplied without necessity," the translation of entia non sunt . . . is the common formulation, but two other reformulations have had their champions. Some philosophers, theologians and linguists have used Ockham's razor to refer to Sir William Hamilton's reformulation "neither more nor more onerous causes are to be assumed than are necessary to account for the phenomena;"¹ and some philosophers have used it to refer to Bertrand Russell's reformulation "Whenever possible, logical constructions are to be

¹Sir William Hamilton, Discussions on Philosophy and Literature Education and University Reform, Longman, Brown, Green and Longmans (London, 1853) p. 626f.

substituted for inferred entities."² Since these reformulations are prima facie radical departures from the supposed Ockham dictum, it is not surprising to find that there are many different interpretations of Ockham's razor. Ockham's razor has been characterized as "a judicious maxim of logic,"³ "a sound maxim of scientific procedure,"⁴ and "the supreme maxim of scientific philosophizing."⁵ It has been interpreted as a metaphysical doctrine about the simplicity of the world. It has been connected with the aesthetics of minimality of certain axiomatic systems and it has also been connected with the topic of scientific simplicity, that one ought to opt for the simpler hypothesis or simpler theory when either hypothesis or theory explained the facts equally well. Ockham's razor has also been interpreted as a linguistic rule about the meaning of signs: "If a sign is useless it is meaningless, that is the point of Ockham's razor."⁶ Along similar lines, it has been thought to be a methodological

²Bertrand Russell, "Relation of Sense-data to Physics," Mysticism and Logic, Doubleday (New York, 1957) p. 150.

³Charles Sanders Peirce, "Logic and Mathematics," Collected Papers of Charles Sanders Peirce, Vol. IV, Harvard (1960) p. 25.

⁴Charles Sanders Peirce, "Lectures on Pragmatism," Collected Papers of Charles Sanders Peirce, Vol. V, Harvard (1965) p. 41.

⁵Bertrand Russell, Mysticism and Logic, p. 150.

⁶Ludwig Wittenstein, Tractatus Logico-Philosophicus, Routledge & Kegan Paul, (London, 1961) p. 31.

rule of concept formation and a pragmatic rule about the redundancy of some explanations. Ockham's razor has been thought a tool of the nominalists, especially by those who are also reductionists; but it has been accepted by realists as well:

Dr. Carus professes himself a realist and yet accuses me of inconsistency in admitting Ockham's razor although I am a realist, thus, implying that he himself does not accept it. But this brocard Entia non sunt multiplicanda praeter necessitatem that is, a hypothesis ought not to introduce complications not requisite to explain the facts, this is not distinctly nominalistic.⁷

That Ockham's razor can be accepted as a tool of the realists is displayed in the philosophical pun "Ockham's razor is a double edged sword." There are other puns about Ockham's razor; the nominalist's version is "Ockham's razor shaved Plato's beard." The preponderance of jokes about Ockham's razor suggests that the principle is capable of different interpretations. It may be that the name, Ockham's razor, lends itself to puns; there is even a mathematician who proposed a counterpart to Ockham's razor: Menger's comb and someone once suggested that it is a "safety razor." Of course the dictum does lend itself to the writer's fancy. "Entities must not be multiplied without necessity" sounds more like a slogan for planned parenthood than a principle of philosophy.

It is not likely that Ockham's razor can be all these things; it is impossible for all the different interpretations to cohere.

⁷Charles Sanders Peirce, Collected Papers, Vol. IV, p. 4.

Further, not all these different interpretations are apt to be coherent in themselves. The problem, then, is to sort out and criticize these different views. The difficulty is that Ockham's razor has been much overused; the different interpretations have been confused. An example of typical thinking about the razor can be demonstrated by the following passage from a modern "history of philosophy" text:

This maxim, which became known as "Ockham's razor," is a most important methodological principle: "Do not multiply entities beyond necessity"--that is, avoid postulating entities to account for what can be explained without them. Or, alternatively, when presented with two hypotheses, both of which account for a given fact, give preference to the simpler. This is the rule that has guided, and is still guiding the development of modern scientific thought. The reason, for instance, that Copernicus and everyone since his day has preferred the heliocentric to the geocentric hypothesis is not that the latter breaks down (for it is quite possible to work out a consistent description of the movements of the planets on the hypothesis that the earth is stationary and at the center of the system), but that the former is much simpler.⁸

A simple analysis of this brief passage would lead one to believe that the author has too readily gone from a supposedly methodological principle about "entities" to a simplicity rule (about hypotheses) which is intended to guide scientific thought. Aside from the more obvious historical deficiencies of the acceptance of the Copernican hypothesis, there are philosophical difficulties as well. It is not at all clear why the principle about entities ought to be thought as a methodological principle. The question

⁸W. T. Jones, The Medieval Mind: A History of Western Philosophy, Harcourt, Brace and World, Inc., (New York, 1952) p. 322.

one ought to ask is whether it has been thought as a methodological principle by Ockham and whether, if it came to Ockham from another source, it was originally thought as a methodological principle. Further, one may wonder whether the rule about preferring simpler hypotheses is the same as Ockham's razor; one can ask whether the justification for preferring the simpler hypothesis is the same as the justification for Ockham's razor. And in a more practical vein, one can ask whether the simpler hypothesis is the one with fewest entities.

To add another difficulty, there is a historical problem about the authorship of the razor. This is not unusual in philosophy. Even a nodding acquaintance with the history of philosophy would engender a healthy skepticism as to the veracity of most claims of authorship; in this case it is the claim that Ockham was the author of Ockham's razor or that Ockham first coined entia non sunt multiplicanda praeter necessitatem. Ockham never said "entia non sunt multiplicanda praeter necessitatem" and the Medievals whose well known propensity to coin nicknames and give honorific titles never dubbed the maxim "Ockham's razor," "the nominalists' razor," or "Novaculum Nominalium." The history of philosophy as it is often taught is replete with minor misinformations; in the case of Ockham's razor the fiction is more often repeated than the truth. Much has been said and written about the razor; references to the razor are plentiful in many literatures, such as philosophy, history of science, linguistics, religion, mathematics, and others, but few articles have been bona fide articles dealing primarily with Ockham's razor.

2. In the philosophical literature the consensus seems to have been that Ockham, the nominalist and forerunner of such great modern nominalists such as Locke and Hume, held a principle of parsimony by which he was able to reject the realist metaphysics of Duns Scotus, especially the formal distinction and the reality of relations and motion. It is interesting that Ockham's arguments about these crucial matters hardly ever brought in parsimonial principles, but just the opposite; in these arguments Ockham made extensive use of his principle of absolute divine omnipotence.

There is a temptation on the part of some historians of philosophy to identify Ockham's principle of absolute divine omnipotence with Ockham's razor. But that is just a confusion. Ockham's principle of divine omnipotence is a principle of possible plenitude; therefore it can easily be distinguished from any principle of parsimony that Ockham might have held. In itself the principle of absolute divine omnipotence has nothing to do with paring down entities. It states that "all things are possible for God save such as involve a contradiction."⁹

⁹"Aliquando accipitur posse pro posse omne illud quod, non includit contradictionem fieri, sive Deus ordinavit se hoc facturum sive non, quia multa potest Deus facere quae non vult facere." William of Ockham, *Quodlibeta Septem* (Strasbourg, 1491) Fac. Edition de la Biblioteque (Louvain, 1962) VI, q. 1. Trans. Boehner in William of Ockham, *Philosophical Writings, A Selection*, Ed. & Trans. Philotheus Boehner, Bobbs Merrill (N. Y., 1964) P. XIX. In fact, Boehner, who thinks that this principle is a guiding principle throughout Ockham's works, points out that there are two variants to this principle: (1) Whatever God produces by means of secondary (i.e. created) causes, God can produce and conserve immediately and without their aid--*Quod. Vi, q.6.* (2) God can cause, produce and conserve every reality, be it substance or accident, apart from any other reality--*Reportatio II qu. 19F.*

Ockham inherited his principle of absolute divine omnipotence from the condemnation of 1277 which implied that God is absolutely omnipotent in His antecedent will. The basic problem of medieval philosophy had been that of finding a means of accommodating the Aristotelian system within the dogmas of the Christian church. Philosophers attempted this enterprise in different ways. Scotus, like Avicenna and others, emphasized the Neoplatonic or realistic elements of Aristotle's system. They eliminated the contradictions between Aristotle's system and the Church's dogmas by reinterpreting some of Aristotle's assumptions and arguments. Aquinas had sought to achieve an external accord between philosophy and theology such as would leave Aristotle's system internally intact. Averroes was seen as propounding a philosophy of double truths because of his dual role as chief Aristotelian commentator and his advocacy of doctrines contradictory to principles of the Christian faith: the eternity of the world, the impossibility of individual immortality, and the radical non-contingency of existence. In this light it was not surprising that Averroes' non-Christian doctrines were forbidden to be read at the University of Paris in 1210, 1215, and 1231, and that they were condemned in 1270 and 1277. Likewise it is also not surprising that Aquinas' doctrines seemed also to be condemned in 1277. The 1277 condemnation rejected Averroes' supposed doctrine of double truth. In particular the church denied the non-contingency of existence by affirming God's absolute freedom: the world is not a necessary emanation of God's nature and He does not need the world to

complete His nature; He could have done otherwise. God has absolute omnipotence and absolute freedom. Ockham seemed never to have lost sight of these two basic Christian doctrines. It is the latter doctrine which supplies Ockham with his principle of absolute divine omnipotence, the powerful tool which he actually used to reject the realist metaphysics of Duns Scotus.

The formal distinction of Scotus was Scotus' answer to the problem of universals and individuation. For Scotus there are only individuals; yet some individuals are in some way exactly like another so that we can classify them into species. This is due to their common nature which can be in several numerically distinct things. In order for the common nature to be the nature of a particular individual, some individuating feature must be added (the haecceity); this is so because individuation cannot be accomplished by accidents. Accidents presuppose substance and cannot individuate it. And, if accidents individuate, the removal of accidents would destroy the substance. Matter cannot be the principle of individuation either. A change in matter, like a change in accidents, does not mean a change in the individuality of a thing. The haecceity is formally distinct from the common nature of the individual: the distinction is formal in that it is not real; we cannot discern it and for us it is only an indispensable requirement of the theory. Scotus states that we cannot perceive the haecceity by means of our senses.¹⁰ The

¹⁰ John Duns Scotus, Reportata Parisiensia, Opera Omnia, Vol. 24, (1894) II d. 12 q. 8 no. 10, & II d. 3 q. 3 no. 15.

common nature and the haecceity are realities but the common nature exists before the operation of the intellect.¹¹ Further, the haecceity does not add anything to the qualitative determinations of the individual.¹² Scotus also states that the common nature cannot be separated from the haecceity, and the common nature and haecceity are formally distinct because the two cannot be included in the same concept even though they are inseparable.¹³

Ockham, of course, rejected Scotus' view. But Ockham's rejection was not based on any argument that Scotus' ontology was too rich nor that Scotus multiplied entities; rather, Ockham felt that if we can assert something about the common nature that we can deny of the haecceity, then the common nature and the haecceity are really different. Therefore they are implicitly separable by the absolute divine omnipotence.

Therefore it must be said that in creatures there is no such formal distinction, but whatever constitutes a distinct thing, if each of the two things distinguished is truly a thing. Just as in creatures we must never deny the validity of such modes of arguing as "This is A, this is B, consequently a B is A," or "This is not A, this is B, consequently a B is not an A," so also as regards creatures whenever contradictory predicates are true of certain things, we must not deny that the things are distinct; unless of course some determination or some syncategorematic term should be

¹¹John Duns Scotus, Ordinatio, Opera Omnia, Vol. VII, Vatican City Press (1973) II d. 3 q. 1.

¹²Scotus, Reportata Parisiensia, II d. 12 q. 5 no. 12.

¹³John Duns Scotus, Questiones Subtilissimae Super Libros Metaphysicorum Aristotelis, Opera Omnia Vol. VII (1893) I d. 35 q. unica.
Also John Duns Scotus, Ordinatio, Opera Omnia, Vol. VI Vatican City Press, (1963) VII q. 13 n 15.

what causes this to be true, as should not be assumed in our present case.¹⁴

Naturally, Scotus' view would collapse if it were possible to separate the elements of the formal distinction; it would reduce to a kind of Platonism or a kind of middle medieval view (Avicenna) that the universal was the common nature existing in many singular things. Ockham also argued against the latter view by means of his principle of absolute divine omnipotence: if the universal were one thing existing in many singular things, the universal or the singular thing could, by the absolute power of God exist without the other. This is absurd because the universal is supposed to be the essence of the singulars in which it exists. "Furthermore, if a universal were one substance existing in singular things and distinct from them it would follow that it could exist apart from them; for every thing naturally prior to another thing can exist apart from it by the power of God. But

¹⁴"Dicendum est ergo, quod in creaturis nulla est talis distinctio formalis, sed quaecumque in creaturis sunt distincta, realiter sunt distincta et sunt res distinctae si utrumque illorum sit vera res. Unde sicut in creaturis tales modi arguendi numquam negari debent: 'Hoc est A, hoc est B, ergo B est A,' nec tales: 'Hoc non est A, hoc est B, ergo B non est A,' ita numquam debet negari in creaturis, quin quandocumque contradictoria verificantur de aliquibus, illa sunt distincta, nisi aliqua determinatio vel aliquod syncategorema sit causa talis verificationis, quod in proposito poni non debet."

William of Ockham, Summa Logicae, Opera Philosophica Et Theologica Vol I, Ed. P. Boehner, The Franciscan Institute (St. Bonaventure, N.Y. 1974) I c. 16, p. 56. Trans. by P. Boehner in Ockham, Philosophical Writings, p. 43.

this consequence is absurd."¹⁵

Ockham made use of his principle of absolute divine omnipotence in other crucial metaphysical arguments, namely, the denials of the reality of relations. Ockham maintained that if relations were real things existing distinct from their terms, God could create a relation without creating the terms of the relation. Since this seemed absurd, Ockham suggested that relations are not real things apart from their terms: if relations were distinct things that are fundamentally real God could create in an agent a relation of causality without this agent having done anything. God could make it be that a man be father to a son that he has not engendered, or that another man be the son of a man that is younger than himself.¹⁶ Furthermore, if relations were real entities, they could be known independently from the entities in which they subside. Inversely, if relations were a real thing, since God can always create two beings independent from each other without creating a third, He could make two white walls that would not resemble each other.¹⁷ For Ockham "relation" denotes only two entities and connotes that one of these is being compared with the other.

¹⁵"Item, si aliquod universale esset substantia una existens in substantiis singularibus ab eis distincta, sequeretur, quod posset esse sine eis, quia omnis res prior naturaliter alia potest per divinam potentiam esse sine ea; sed consequens est absurdum." William of Ockham, *Summa Logicae* I c. 15., p. 56. Trans. by Fr. Boehner in Ockham, *Philosophical Writings*, p. 39.

¹⁶William of Ockham, *Super 4 Libros Sententiarum* (1494) Fac. Greg Press Ltd. (London, 1962) I d. 31.

¹⁷Ockham, *Quodlibet* 6 q. 8.

Motion is treated similarly. If motion were an absolute thing, God could create and conserve it without creating and conserving anything else, which is absurd.¹⁸ The last absurdity might bring to mind our modern conceptions of waves with nothing waving or smiles with nothing smiling.

A few words must be said about the statement that Ockham makes at the end of his divine omnipotence arguments; "but this is absurd." It may be thought that this statement reintroduces parsimonious considerations. This thesis would be correct if the absurdity were the absurdity of multiplying entities. But that is not the case. The absurdity Ockham has in mind is normally the absurdity of God doing something which involves a contradiction as in making it be that a man be a father to a son that he has not engendered. Sometimes it is the absurdity of holding contradictory positions, as in holding that the universal and singular could exist without each other and holding that the universal is the essence of the singular. And sometimes it is an epistemic

¹⁸Julius R. Weinberg, A Short History of Medieval Philosophy Princeton University Press (Princeton, 1964) p. 254. This point is also made as a general point about motion by Léon Baudry in Léon Baudry, Lexique Philosophique de Guillaume D'Ockham, Publications de la Recherche Scientifique (Paris, 1958) p. 157: "Il ne fallait pas être grand clerc pour apercevoir la difficulté que soulevait cette doctrine de Duns Scotus, qui faisait du mouvement une réalité fluente comme une forme purement absolue, Dieu est tout puissant, il peut faire tout ce qui peut être fait sans contradiction; il peut donc produire à part n'importe quel absolu. Si donc on fait du mouvement une "forme purement absolue," on se trouve contraint d'admettre que Dieu peut créer le mouvement sans un corps qui se meuve. . .Telle est la raison qui conduisit Guillaume à refuser au mouvement toute réalité propre."

absurdity--motion without a moving thing. Without getting too deep in Ockham's epistemology this epistemic absurdity ought also be discussed further. Ockham's statement that if relations were real entities they could be known independently from the entities in which they subsist indicates that independence is the key epistemic notion which if violated engenders the absurdity. From the existence of a real thing we cannot know the existence of another. The existence of motion is known by the existence of moving things; were motion a real thing we would know it independently from moving things.

It is seen then that in some crucial metaphysical arguments Ockham did not rely on principles of parsimony but rather on principles of possible plenitude; God can do anything including the multiplication of entities. At first glance this appears to be an odd principle for a nominalist to hold along with Ockham's razor, and it gives impetus to the study of Ockham's views on principles of parsimony. Having already stated that Ockham was not the author of Ockham's razor, it may be necessary to back-track somewhat.

3. It is slightly misleading to state without qualifications that Ockham was not the author of Ockham's razor. It is misleading to do so for two reasons. First, Ockham scholarship is not complete and it is possible, though unlikely, that somewhere in some unedited Ockham manuscript one can find the words entia non sunt multiplicanda praeter necessitatem. Second, Ockham

did hold a principle of parsimony similar to Ockham's razor, though sufficiently unlike it in many important respects. It is this fact that casts doubts on whether Ockham ever said "entia non sunt. . ."

In a note in Mind 1915,¹⁹ W. M. Thorburn asked whether any reader of Mind can give an exact reference for entia non sunt He had stated earlier in the note that he could not find these words in Ockham. The earliest use of the phrase that Mr. Thorburn had lighted upon occurred in an inaugural dissertation by Leibniz in 1670, De Stylo Philosophico Marii Nizolli; further, Leibniz's reference proved to be a blind alley. Eliciting no response by 1918, Mr. Thorburn then wrote a lengthy note entitled "The Myth of Occam's Razor."²⁰ In the 1918 note Mr. Thorburn, having researched the matter further, stated as provisional conclusions that entia non sunt . . . was invented in 1639 by the Scotist commentator John Ponce of Cork, and that its Latin title Novaculum Nominalium was the translation of the French title, Rasoir des Nominaux, which was bestowed upon the maxim by Condillac in 1746.

The scholarly problem to which Mr. Thorburn was addressing himself is a formidable one; it is difficult enough to prove that Ockham never said "entia non sunt. . ." but it seems almost impossible to maintain the thesis that it was invented by John Ponce of Cork. In order to maintain this thesis one would have to

¹⁹W. M. Thorburn, "Occam's Razor," Mind, (1915) pp. 287-288.

²⁰W. M. Thorburn, "The Myth of Occam's Razor," Mind, (1918) pp. 345-353.

show that no Medieval prior to, posterior to, and including Ockham ever held entia non sunt. . .as a maxim. That this is a difficult task is attested by the fact that Mr. Thorburn labels his well earned conclusions as provisional. Fortunately there is a broad historical argument one can give to establish part of the thesis. One can give independent corroboration for the thesis that no Medieval prior to and including Ockham ever held entia non sunt. . .

Briefly, the broad historical argument is this: the roots of what is called Ockham's razor can be traced back to Aristotle's Physica and De Caelo. One can pick up the medieval interpretations of Aristotle's principle in the Latin translations of Averroes' commentaries on the Physica and the De Caelo or the commentaries of the later Medievales (Aquinas, for example). One can then see how Ockham came about his principle of parsimony from these sources through his immediate predecessors, Peter Auriole and John Duns Scotus. Finally one can argue that entia non sunt. . .is incompatible with some parts of Ockham's philosophy whereas the medieval formulations of the principle of parsimony which are found in Ockham are not incompatible with Ockham's philosophy. One can also argue that Ockham's use of the medieval formulations makes it appear that he is not displeased with them and makes it seem that he would have no reason to change them.

The two main formulations of the principle of parsimony that Ockham held are as follows: "frustra fit per plura quod potest fieri per pauciora,"²¹ and "non est ponenda pluralitas sine

²¹William of Ockham, Summa Logicae, I c. 12 p. 43.

necessitate."²² These translated would read "in vain we do by many that which can be done by means of fewer," and "pluralities ought not be supposed without necessity."²⁵

What is important here is that these formulas, though reminiscent of "entia non sunt multiplicanda praeter necessitatem," are really different from it. Like entia non sunt. . . they are principles of parsimony, but they differ in intent. Only a superficial analysis of these matters can be put forward at this stage;

²²William of Ockham, Super 4 Libros Sententiarum, II Q. 15.

²³There are other Ockham formulations which ought to be considered as variants to these. Mr. Thorburn in the Mind 1915 and 1918 articles cites the following five in addition to the two I have emphasized:

- I "Pluralitas non est ponenda sine necessitate" [no real variation]
- (1) In Sententias lib. i, Distinctio i. QQ. 1 and 2.
 - (2) In SS., i. D.7, Q. 2.
 - (3) Quodlibeta, i., Q. 3.
 - (4) Do., iii., Q. 2.
 - (5) Do., iv., Q. 15.
 - (6) Do., v., Q. 5.
- II "Numquam ponenda est pluralitas sine necessitate" [no real variation: "numquam" means never]
- In SS., i., D. 27 Q. 2.
- III "Talīs species (intelligibilis) non est ponenda propter superfluitatem" [such species ought not be supposed because of its superfluosity]
- Expositio Aurea. Perierm. Proem.
- IV "si duae res sufficiunt ad ejus veritatem, superfluum est ponere aliam (tertiam) rem" [if two things are sufficient for the purpose of truth, it is superfluous to suppose another (third) thing]
- (1) Quodlibeta, iv., Q. 19.
 - (2) Do., iv., Q. 24.
- V "sufficient singularia, et ita talis res universales omnino frustra ponuntur" [a singular is sufficient, and so in vain we suppose such universals]
- In SS. i. D. 2, Q. 4.
- In addition Mr. Thorburn cites these references for "Frustra fit per plura quod potest fieri per pauciora"
- (1) In SS., i., D. 31, Q. 1.
 - (2) In SS., ii., Q. 15, sections 0 and Q.

nonetheless, a sketch of these differences is appropriate now. Entia non sunt. . . . appears to be a rule about entities (or real things) whereas the others do not. At the very least, the other two formulations can lend themselves to another interpretation. They are not bound to "entities." Frustra fit. . . . seems to be a rule about our explanations and pluralitas non est ponenda. . . . seems to be a rule about statements or concepts. Naturally these interpretations are not without controversy. The plura and pauciora of frustra fit. . . . may be read as many and fewer entities, or they may be read as many and fewer assumptions. Further, the pluralitas of pluralitas non est ponenda. . . . may be interpreted in a broad sense; the set of pluralities may include entities as a subset. Of course, the pluralities we are talking about may be pluralities of concepts. These problems cannot be solved by looking closer at the actual formulations. They should be set aside until they are put within the general context of Ockham's philosophy. What needs to be stressed is that these are possible interpretations. Prima facie Ockham is not committed to entia non sunt. . . . by his dicta. We will argue that entia non sunt. . . . is not the most suitable interpretation for frustra fit. . . . or pluralitas non est ponenda. . . . We will argue that frustra fit per plura quod potest fieri per pauciora is best read as "that which has already been explained needs no further explanations," and non est ponenda pluralitas sine necessitate is best read as "statements should not be affirmed without reason."

C. Delisle Burns in a note on Ockham's razor argued that the differences between entia non sunt. . . , pluralitas non est ponenda. . . and frustra fit. . . alone were enough to make us suppose that if Ockham had ever uttered entia non sunt. . . it must have been an aberration. At the very least, Ockham certainly preferred the other two formulas. These Mr. Burns argued are more consistent with Ockham's philosophy:

The force of Ockham's objection against Scotus was that logic and metaphysics were distinct. Both the thing and the universal are "entia," one "in re" the other "in mente." Only a Scotist could think that the law of parsimony had anything to do with "entia." This is perhaps a mere matter of words; but words to a man like Ockham were not unimportant, and he was very careful with his original razor to make it cut only hypotheses (ponere, etc.).²⁴

The real force of Mr. Burn's objection is this: Ockham makes a distinction between metaphysics, the real sciences and logic. This distinction is indicated by terms of absolute universality (ens, res, etc. . .), terms of first intention, and terms of second intention. For Ockham words like entia and res belong to metaphysics, and Ockham is careful in his use of them. In this light it becomes important to see whether Ockham does or does not use such words in his formulations of the principle of parsimony. It is interesting to note that Ockham's principles do not make use of metaphysical terms. Indeed, were Ockham to hold a metaphysical principle of

²⁴C. Delisle Burns, "Occam's Razor," Mind (1915), p. 592.

parsimony it probably would not read entia non sunt. . .but res absolutae non sunt multiplicandae praeter necessitatem. Ockham is constantly arguing that universals are not res absolutae, that relations are not res absolutae, that motion is not a res absoluta, that time and place are not res absolutae, and so on. Of course, this is not an extremely forceful argument, but it does carry some weight in determining how one ought to interpret a perhaps ambiguous passage in Ockham.

Another reason for affirming that entia non sunt. . .is inconsistent with Ockham's philosophy is that Ockham is careful to point out that God (or nature) must be allowed to act redundantly; or must be allowed to do by means of more what could be done by means of fewer simply because He wishes it:

God does many things by means of more which He could have done by means of fewer simply because He wishes it. No other cause must be sought for and from the very fact that God wishes, He wishes in a suitable way, and not vainly.²⁵

It would be inconsistent for Ockham to hold the above and entia non sunt. . . . It would be more rational for him to hold that we ought not suppose that more things exist than we have evidence for. If Ockham could hold entia non sunt. . .together with the above then the above would have to be viewed as a restriction or a way of limiting entia non sunt. . . . One can argue that this restriction

²⁵William of Ockham, Super 4 Libros Sententiarum, I, D. 14, Q. 2 G. "Ad secundum dico: quod deus multa agit per plura quae posset facere per pauciora quia vult nec est alia causa quaerenda, et ex hoc ipso quod vult convenienter fit et non frustra."

would weaken entia non sunt. . .so as to put it on a par with our interpretation of frustra fit. . .and pluralitas non est ponenda If God can do by means of more that which He could have done by means of fewer, then there is no reason to believe that entities are not to be multiplied without necessity; after all, God could have fabricated extra entities. It isn't that we are more likely to be right if we keep our entities to the minimum for there may exist useless entities by the will of God. God decides how many entities are to be; man decides how many concepts are to be.

Of course, it is possible to hold that only God's antecedent omnipotence is unlimited and that we ought not multiply entities without necessity because the world is simple (in actuality). It could be that in His goodness God created a simple world so that we are more likely to be right if we kept entities to the minimum. But Ockham cannot hold this view since he holds that God does by means of more that which He could have done by means of fewer. Ockham holds that we ought not seek the reasons for the fact that God wishes: that God wishes is sufficient in order for that which He wishes to be suitable.

It seems clear now that we are taking entia non sunt. . .to be a reductionist doctrine whose justification may stem from certain beliefs about the simplicity of the world. In its most naive form that kind of reasoning would run along these lines: The truths of the world are in themselves simple (perhaps because God created

the world from first principles). If we are to discover these eternal truths we must keep our hypotheses simple. The simpler the hypothesis the closer to the truth it may be. Naturally there are many types of simplicity; here the simplicity is that of keeping entities down to a minimum. There may be an objection that no philosopher would agree with this line of reasoning. But that is not the case. Many philosophers throughout the ages and up to this century have upheld principles for these and similar reasons. Most reductionist principles follow similar lines of thought. Ockham's razor as interpreted in this manner is what Bertrand Russell refers to when he states "Ockham's razor in its original form was metaphysical, it was a principle of parsimony as regards 'entities.' I still thought of it in this way while Principia Mathematica was being written."²⁶

Russell attempts to reinterpret the principle in his later philosophy. Russell shifts his interpretation of the razor to a non-metaphysical reading:

And if we can find any way of dealing with them [classes] as symbolic fictions, we increase the logical security of our position, since we avoid the need of assuming that there are classes without being compelled to make the opposite assumption that there are no classes. We merely abstain from both assumptions. This is an example of Occam's razor, namely "entities are not to be multiplied without necessity." But when we refuse to assert that there are classes we must not be supposed to be asserting dogmatically that there are none. We are merely agnostic

²⁶Russell, Bertrand, "My mental development," Library of Living Philosophers, ed. P. A. Schilpp, George Bouton Pub. Co., (Menasa, Wisc, 1944) p. 14.

as regards them: Like Laplace, we can say, "je n'ai pas besoin de cette hypothese."²⁷

Although Russell feels that his new "agnostic" position is philosophically more tenable than his old "atheistic" position, his reason for holding the razor is somewhat the same as before. Russell feels that he is increasing his chances of being right. As Russell himself states it: "one thing that our technique does, is to give us a means of constructing a given body of symbolic propositions with the minimum of apparatus, and every diminution in apparatus diminishes the risk of error. . .that is the advantage of Occam's razor, that it diminishes your risk of error."²⁸

More will have to be said about these rationales for holding the razor; it suffices for the present to point out that the line of reasoning discussed is not an unusual or rare species. There is reason to contrast what Ockham might have held with what entia non sunt. . .is taken to be. We have been arguing that there are compelling reasons why Ockham could not have held entia non sunt. . . . At least, we have argued that he could not have held it as the Russellian interpretation. Since God's omnipotence is unlimited the razor simply cannot guarantee the lessening of the risk of error. Certainly the razor itself cannot impinge on the Divine Realm.

²⁷Russell, Bertrand, Introduction to Mathematical Philosophy, George Allen & Unwind, (London, 1919) p. 184.

²⁸Russell, Bertrand, "The Philosophy of Logical Atomism," Logic and Knowledge, ed. Robert Charles Marsh, George, Allen & Unwind (London, 1956) p. 280.

Ockham's dictum on God restricts frustra fit to the human realm whereas entia non sunt. . . would have man's beliefs encroaching on the divine realm. Further the dictum is not an isolated aberration in Ockham's philosophy; Ockham did the same thing to pluralitas non est ponenda. . . when he stated "nothing is to be assumed as necessary, in accounting for any fact, unless it is established by evident reasoning or evident experience, or it is required by the articles of faith."²⁹ Non est ponenda pluralitas sine necessitate is to be read as "pluralities are not to be supposed unless they are established by evident reasoning or evident experience, or are required by the articles of faith." Ockham is unwilling to place any parsimonial restrictions on God's works. Again had Ockham said "entia non sunt. . .," he could not have meant it as a rule about how the world is. The full maxim seems to be a demand by Ockham that anyone who makes a statement must have a reason for its truth, either by the observation of a fact, by an immediate logical insight, or by divine revelation.

²⁹"Quod nulla pluralitas est ponenda nisi per rationem vel experimentiam vel auctoritatem illius, qui non potest falli nec errare potest convinci." William of Ockham, De Sacramento Altaris, Ed. T. Bruce, The Lutheran Literary Board (Burlington, Iowa, 1930) p. 318. Trans. by Julius Weinberg, A Short History of Medieval Philosophy, Princeton University Press (Princeton, 1964) p. 239. also P. Boehner in his introduction of William of Ockham, Philosophical Writings, calls it "the real meaning of Ockham's razor" and translates a similar passage as "we are not allowed to affirm a statement to be true, or to maintain that a certain thing exists, unless we are forced to do so either by its self-evidence or by revelation or by experience or by a logical deduction from either a revealed truth or a proposition verified by observation." Fr. Boehner cites two other Ockham texts where this statement occurs. Reportatio II qu. 150: "we must not affirm that something is necessarily required for the explanations of an effect,

In a way we are forced to bring forth a wholesale interpretation of Ockham's philosophy. The razor must be viewed as a restriction on men, not on God or any of his works.

One can view Ockham's philosophy as a reaction to Scotist philosophy but also as historically dependent on Scotist philosophy. Scotus' metaphysics was from a God-centered point of view; there was no way for man to separate the elements of the formal distinction. There was no way for God to separate the elements of the formal distinction either; Ockham, of course, could not accept this restriction on God's omnipotence. Ockham's rejection of this position together with his refusal to place any parsimonial restrictions on God and His works would force a distinction between logic, the sciences and metaphysics. For Ockham logic is a science concerned with the ways in which the human mind can construct the forms of significant expression from its pre-existent elements, the concepts of the real science, or terms of first intention. The terms which logic uses are terms of second intention, or terms which signify terms. Since the propositions of logic state truths about the propositions of the real sciences, the existence of logic presupposes the existence of the real sciences. The real sciences are a study of things that are. Ockham's science is a demonstrative empirical science. Metaphysics, on the other hand, is the science of being as

if we are not led to this by a reason proceeding either from a truth known by itself or from an experience that is certain." Ordinatio d. 30 qu. 1E: "Nothing must be affirmed without a reason being assigned for it, except it be something known by itself, known by experience, or it be something proved by the authority of Holy Scripture."

such; it is not a demonstrative science, but rather a kind of wisdom: an act of intelligence by which "being" is grasped through the attributes which belong to it in an unqualified sense.³⁰ The natural scientist works with changeable things apprehended by sense experience whereas the metaphysician works with "being" unchangeable, unapprehended by sense experience. Finally, a science that is non-demonstrative, like metaphysics, cannot yield the principles of the real sciences.

"Being" (ens), and the transcendental terms convertible with it, cannot, as Aristotle proves, be a genus or in a genus. From these two consequences may be drawn. The first is that metaphysics cannot be a demonstrative science, and the second is, that the principles of the demonstrative sciences are not demonstrated by metaphysics. . . . First, a science that is non-demonstrative cannot demonstrate the principles of another science, and secondly, since "being" and the other metaphysical terms are not genera nor included under a genus, they cannot be middle terms of any demonstration in a discursive science. Demonstrative sciences show how things that are differ in their being; but being as such, with which metaphysics is concerned, cannot be a principle of demonstrating differences in being, and hence metaphysics cannot yield the principles of any demonstrative sciences.³¹

Metaphysics, or the study of first principles, cannot be a demonstrative science. First principles cannot be the middle terms or

³⁰Herman Shapiro, Motion, Time and Place According to William of Ockham, The Franciscan Institute, (St. Bonaventure, N.Y., 1957) p. 132. also

Ernest A. Moody, The Logic of William of Ockham, Russell and Russell (New York, 1965) p. 120.

³¹Moody, The Logic of William of Ockham, pp. 118-9.

conclusions of syllogism;³² and if a proposition cannot be a conclusion of a syllogism, it is not demonstrable. Further, metaphysics, being non-demonstrative cannot demonstrate the first principles of a science.

For Ockham, in order that a proposition be a scientific proposition, it must be necessary, susceptible to doubt, and capable of being rendered evident by means of a demonstration.³³ Were Ockham to hold a metaphysical principle of parsimony, he would not expect it to engender a principle of the real sciences. Similarly, were Ockham to hold a methodological principle of parsimony, he would not expect it to have any metaphysical grounding. Of course, these comments would apply to other non-scientific principles, the principle of non-contradiction and the principle of absolute divine omnipotence, to name a few. Both these principles and Ockham's principle of parsimony may apply to scientific statements without actually entering into the demonstration. Non-contradiction being a logical principle deals with second intentions and would apply to

³²"Principia dicuntur illae propositiones quae non sunt conclusiones et tamen requiruntur ad demonstrationem, sive sint partes demonstrationis, sive non sint partes ejus. Et vocantur principia prima. . ."

Ockham, Summa Logicae, III, ii, c. 4, p. 511.

³³"Quarum una est quod omnis conclusio demonstrationis est dubitabilis, ita quod non est per se nota. Cum enim demonstratio sit syllogismus faciens scire, et nihil facit scire aliquid praescitum, necesse est, si apprehendatur illa conclusio sine praemissis, quod illa conclusio possit ignorari et per consequens de eas possit aliquis dubitare, cum non possit sciri esse falsa." Ibid., III, ii, c. 9 p. 521.

the form of the statement; it would not enter the demonstration. Absolute divine omnipotence, as Weinberg states, "is used negatively to exhibit the limits of demonstrative reasoning. When it is used positively, since divine omnipotence is an article of faith and not something that can be demonstrated, the argument on which this principle depends will be probable or persuasive, not demonstrative, strictly speaking."³⁴ Ockham's principle of parsimony applies in the same way as the principle of absolute divine omnipotence, when used negatively applies, in persuasive or probabilistic arguments. The principle of parsimony is a weaker principle than the principle of absolute divine omnipotence, when used negatively. One can argue that even if Ockham held a metaphysical principle of parsimony, it would not function as one would expect a metaphysical principle of parsimony to function. It could not be used to justify a scientific or methodological principle of parsimony.

Entia non sunt. . . does not seem to be the kind of principle that Ockham would formulate: it jars with Ockham's philosophy and his theology. We have given four reasons why entia non sunt. . . does not seem to be the kind of principle Ockham would hold. First, Ockham, when discussing such crucial metaphysical topics such as the reality of universals or relations, refutes their independent existences by means of a principle of absolute divine omnipotence, and not a principle of parsimony. Second, were Ockham to hold a metaphysical principle of parsimony, it would probably read "res

³⁴Weinberg, A Short History of Medieval Philosophy, p. 241.

absolutae non sunt. . .," instead of entia non sunt. . .. Ockham is careful with his language. Thus it is significant that his formulations of the principles of parsimony use words like pluralitas and ponere. Third, were Ockham to mean his principles (frustra fit . . . and pluralitas non est ponenda. . .) as metaphysical principles, it would be inconsistent with his view on God's omnipotence. Ockham cannot be deemed guilty of inconsistency since he specifically states that God can do things by means of more which He could have done by means of fewer. God and God's works (that is, nature) are not restricted by the razor. And fourth, Ockham's views on science and metaphysics do not allow for there being metaphysical principles demonstrating scientific principles or scientific principles which engender metaphysical principles. For Ockham, metaphysics and science are truly distinct. Were Ockham to hold a metaphysical principle of parsimony, he would not derive from it a scientific principle and vice versa. All this together is strong evidence suggesting that entia non sunt. . . does not belong in Ockham's philosophy; further, neither frustra fit. . . nor pluralitas non est ponenda. . . as we have interpreted them suffer these incompatibilities. This gives us good ground for believing that Ockham never uttered "entia non sunt. . ." We, like Thorburn in 1915, can tentatively conclude that Ockham's razor is not Ockham's.

Unlike Thorburn we do not have to conclude that entia non sunt . . . was invented in 1639 by the Scotist, John Ponce of Cork. We can at least attribute the razor to an Ockhamist, and date it a century earlier. One can find multiplicantur entia sine necessitate

in Alessandro Achillini's De Distinctionibus which was published in 1510.³⁵ Achillini argues that "relations of reason" cannot be defended because they introduce more entities than are necessary.³⁶ He then refers to Ockham-like reasons for the exclusion of the extra entities: reason does not deduce them and experience does not reveal them.³⁷

³⁵Alessandro Achillini, De Distinctionibus, chapt. 19, f. 171b as quoted in Herbert Stanley Matsen, Alessandro Achillini (1463-1512) and his Doctrine of "Universals" and "Transcendentals," Bucknell University Press (London, 1974) p. 291 f. 119.

³⁶"Si autem in objecto cognito intelligatur quendam respectum derelinqui, quo intrinsece denominetur obiectum comparatum cognitum vel appetitum, negantur relationes rationis, quia multiplicantur entia sine necessitate," Ibid.

³⁷"Sic quod ratio eas non concludit neque experientia illas ostendit." Ibid., f. 120.

CHAPTER 11

THE ORIGINS OF OCKHAM'S RAZOR

1. We have asserted that Ockham's razor is not Ockham's because Ockham did not articulate "Entia non sunt multiplicanda praeter necessitatem." We have argued that Ockham's razor, if it is to be interpreted as a metaphysical (or teleological or theological) principle is not Ockham's because it would not be consistent with other parts of Ockham's philosophy.

Of course, Ockham does hold two formulations of the principle of parsimony, so it may again be misleading to state that Ockham's razor is not Ockham's. The problem can be rephrased: using Ockham's razor to refer to the methodological principles that Ockham does hold, we can ask whether these originated with Ockham. The answer to this question can be more direct: frustra fit. . .and pluralitas non est ponenda. . .both occur in Scotus, who seems to have coined these actual formulations. One can find "numquam est ponenda pluralitas sine necessitate" in Scotus' Quaestiones Subtilissimae Super Libros Metaphysicorum Aristotelis.¹ One can find "frustra fit per plura quod potest fieri per pauciora" in Scotus' In Octo Libros Physicorum Aristotelis.² Closely related, but not identical to these formulas, are those of Scotus' predecessors, Peter Auriol and

¹Scotus, Opera Omnia Vol. 7, (1893) p. 56, i., Q. iv, sec. 3.

²Scotus, Opera Omnia Vol. 2, (1891) p. 395, i., Q. 8. One can find the following slight variation in Scotus, Opera Omnia Vol. 24, Reportata Parisiensis (1894) p. 64, ii., D. 15, Q. i., Sc. 2: "Quia numquam sunt plura ponenda sine necessitate."

Thomas Aquinas: "Multitudo ponenda non est, nisi ratio evidens necessaria illud probet aliter per pauciora salvari non posse."³ and "Praeterea, quod potest compleri per pauciora non fit per plura."⁴ One can also find early Medievals who held similar propositions. P. Boehner in his introduction to Ockham's philosophical writings states "the oldest Scholastic thinker, so far as we know, who formulated it, gives this version: 'Frustra fit per plura quod potest fieri per unum;'⁵ Odo Rigaldus, Commentarium super Sententias, M. S. Bruges 208, fol. 150a."⁵ This would place the formulation in the early part of the thirteenth century.

2. Ockham's razor, along with most medieval doctrines, finds its roots in Aristotle. Aristotle may have two separate doctrines on this matter, though they are difficult to differentiate. One of these doctrines seems closer in intent to entia non sunt. . . than to the other formulations. We have come full circle. According to Aristotle "we should always assume that things are finite rather than infinite in number, since in things constituted by nature that which is better ought, if possible, to be rather than the reverse."⁶ This is a metaphysical principle; we should restrict our explanations in some way because nature restricts itself

³Peter Auriol, as quoted in Etienne Gilson, History of Christian Philosophy in the Middle Ages, Random House (N.Y. 1955) p. 778.

⁴Thomas Aquinas, Summa Theologiae, Vol. II, McGraw-Hill (N.Y. 1963) p. 13.

⁵P. Boehner in William of Ockham, Philosophical Writings, p. XX footnote.

⁶Aristotle, The Works of Aristotle Translated into English, Vol. II, Physica, trans. R. P. Hardies, ed. W. D. Ross, The Clarendon Press (Oxford, 1930) VIII, 6, 259a.

in that way. The more common view is that our explanations should be as simple as possible because nature is simple. For Aristotle simplicity may be just a part of the overall scheme. The "better" indicates that there are teleological reasons for holding the doctrine. Elsewhere Aristotle, when discussing principles of motion states "it is better to assume a smaller and finite number of principles, as Empedocles does,"⁷ and "a finite number, such as the principles of Empedocles is better than an infinite multitude, for Empedocles professes to obtain from his principles all that Anaxagoras obtains from his innumerable principles."⁸ In these statements the "better" is not teleological; it is better for us. Aristotle could have continued his discussion of motion with "that which is better is not always found in nature." It is possible that these last two statements express different propositions from the first; they may be instances of a practical rule about how one ought to theorize or about which concepts we ought to hold without being imbued with the assumption that they receive their legitimacy for teleological reasons. Since Aristotle does not elaborate further we must assume that the first statement is given in order to clarify the status of the others; we must assume that the three statements express the same doctrine.

⁷Aristotle, The works of Aristotle Translated into English, Vol. II, *Physica*, trans. R. P. Hardies, ed. W. D. Ross, The Clarendon Press (Oxford, 1930) I. 4, 188a.

⁸Ibid., I. 6, 189a.

The three statements are expressions of a doctrine which decides between hypotheses with a finite number of principles and those with an infinite number of principles. Their rationale is teleological. George Boas, in his article, "Some Assumptions of Aristotle" states that this principle is "related to a curious idea which is expressed in the Metaphysics (1076 a 3) and which might be called the Principle of Good Government."⁹ Aristotle's good government is the monarchy of the Unmoved Mover governing in an absolutely uniform fashion. As Aristotle states it "the world refuses to be governed badly. . . the rule of many is not good; one ruler let there be."¹⁰ Preference for finiteness is not the only preference that nature has. Aristotle thinks that it is better that continuous rather than successive motion exists. As with finiteness, we should assume that the better occurs in nature.¹¹ This Aristotelian preference for the better is not an isolated quirk of the Physics. In On Generation and Corruption, Aristotle refers to coming to be and passing away as continuous because the continuous is the better and again nature strives for the better:

Coming-to-be and passing-away will, as we have said, always be continuous, and will never fail owing to the cause we stated. And this continuity has a sufficient reason on our theory.

⁹George Boas, "Some Assumptions of Aristotle," Transactions of the American Philosophical Society, n. s. vol. 49, (1959), part 6 p. 24.

¹⁰Aristotle, Metaphysics, Introduction to Aristotle, ed. Richard McKeon, The Modern Library, (N. Y., 1947) p. 296.

¹¹Aristotle, Physica, VIII, 7, 260b.

For in all things, as we affirm, Nature strives after "the better." Now "being" . . . is better than "not-being" but not all things can possess "being" since they are too far removed from the "originative source." God therefore adopted the remaining alternative, and fulfilled the perfection of the universe by making coming-to-be uninterrupted.¹²

The better, for Aristotle, is the regular or the orderly: "The regularity with which natural processes go on from beginning to end is proof to Aristotle of their purposiveness and hence their goodness."¹³ Aristotle's principle is teleological; for that reason it is metaphysical.

Aristotle, at times, utilizes a principle of parsimony which is not restricted to deciding between an infinite number of principles and a finite number of principles: "Motion, then, being eternal, the first movent, if there is but one, will be eternal also. If there are more than one, there will be a plurality of such eternal movents. We ought, however, to suppose that there is one rather than many. . ."¹⁴ This is a weaker assertion.

¹²Aristotle, The Works of Aristotle Translated into English, Vol. II De Generatione Et Corruptione trans. J. J. Joachim, Ed. W. D. Ross, The Clarendon Press (Oxford, 1930) 3366 25-32.

¹³Boas, "Assumptions of Aristotle," p. 25.

¹⁴Aristotle, Physica, VIII, 6, 259a. It may be thought that Aristotle's metaphysical principle might yield a principle opposite to a principle of parsimony, a principle of plenitude. The above quote shows that Aristotle holds that being is better than non-being and that nature strives after the better. Hence, one might conclude that nature strives after plenitude. But that would be reading "being" as the actualization of possibilities. Instead,

Immediately following this sentence Aristotle states that things finite are better than things infinite and that which is better ought to be. Aristotle then gives the weaker statement when it comes to deciding between the one and the many: "and here it is sufficient to assume only one movement. . ."¹⁵ The same thing seems to occur in a passage of the De Caelo. Aristotle appears to have two principles in mind when he states:

They need not assert an infinity of elements since the hypothesis of a finite number will give identical results. Indeed even two or three such bodies serve the purpose as well, as Empedocles' attempt shows. . . Obviously then it would be better to assume a finite number of principles. They should, in fact, be as few as possible, consistently with proving what has to be proved.

"being" in the above passage ought to be read as continued existence: "if nature's purpose could be fully attained, [everything] would always 'be,' i.e. would be individually eternal." Harold Joachim, Aristotle on Coming-to-be and Passing-Away, The Clarendon Press (Oxford, 1922) pp. 263-264. Of course, Aristotle holds that those things in the lower cosmos individually cannot be except for a limited time. They are too remote from the "originative source;" they can share in the eternal life in an imperfect way, as a species. These doctrines about the continued existence of existing individuals are independent of the doctrines that Aristotle might have held about plenitude. The reading cannot add fuel to the debate between Lovejoy and Hintikka about whether Aristotle holds a principle of plenitude (see Arthur O. Lovejoy, The Great Chain of Being, Harvard University Press, (Cambridge, Mass. 1936) and Jaakko Hintikka, Time & Necessity, The Clarendon Press, (Oxford, 1973). Aristotle can hold that it is better for individuals to have continued existence and that "it is not necessary that everything possible should exist in actuality." Metaphysics 11, 1003 a 2. That is, if one interprets "being" in the above passage as continued existence, it would be possible to attribute either doctrine about plenitude to Aristotle; Aristotle would be able to be interpreted as either Lovejoy or Hintikka would have him be interpreted with respect to plenitude, "being" as in the actualization of possibilities.

¹⁵ Aristotle, Physica, VIII, 6, 259a.

This is the common demand of the mathematicians who assume as principles things finite either in kind or in number.¹⁶

Aristotle's language shifts between the phrases "need not assert," "serve the purpose," "better to assume," and "consistently with proving what has to be proved." These phrases mark the differences between the weaker and the stronger assertions.

When Aristotle talks of the few and the many he uses such phrases as "serve the purpose" and "it is sufficient;" whereas whenever he talks of the finite and the infinite, he uses such phrases as "it would be better to assume" and "that which is better." Since we know the relationship of the better to nature, the obvious conclusion is that Aristotle has two principles of parsimony, a metaphysical doctrine which prefers the finite to the infinite, and a methodological doctrine which decides between the few and the many.¹⁷ Of course, since the weaker principle may be thought as being entailed by the stronger principle, one could predict

¹⁶Aristotle, The Works of Aristotle Translated into English, Vol. II, De Caelo, trans. J. L. Stocks, ed. W. D. Ross, The Clarendon Press, (Oxford, 1930) 302b.

¹⁷The point can be made using other translations or the original Greek as sources: The methodological principle is indicated by the word "sufficient" or "adequate" (ἰκανόν). It is well represented by the phrase "And

that Aristotle might, at times, have used the methodological phrases when talking about the finite and the infinite. What is important is that he does not use the metaphysical language with the few and the many.

In "Some Assumptions of Aristotle" Boas discusses Aristotle's principle of parsimony. Boas does not explicitly differentiate between Aristotle's strong (metaphysical) principle and his weak (methodological) principle. Instead, Boas refers in general to

a single principle is adequate, which as the first of the unmoved entities and eternal will suffice as the principle of motion for the rest."

Aristotle, The Physics, with a trans. by Phillip H. Wicksteed and Francis M. Cornford, Harvard University Press (Cambridge, Mass. 1934) Vol. II p. 345.

"ἱκανὸν δὲ καὶ ἕν."

Ibid. p. 344.

As for the metaphysical principle, it is indicated by the comparative "better" (βέλτιον) and represented by the phrase, "it is always better to assume that more limited antecedent, since in the things of nature the limited, as being better, is sure to be found, wherever possible, rather than the unlimited."

Ibid. p. 345.

"δεῖ τὸ πεπερασμένον καὶ τὸ βέλτιον, ἕαν ἐνδέχεται."

Ibid. p. 344.

The metaphysical principle is also represented in the De Caelo and the De Generatione et Corruptione by the following:

"it would clearly be much better to make the principles finite"

Aristotle, On the Heavens, with a trans. by W. K. C. Guthrie, Harvard University Press (Cambridge, Mass. 1939) p. 289.

"φανερὸν ὅτι πολλῶ βέλτιον πεπερασμένα ποιεῖν τὰς ἀρχάς."

Ibid. p. 288.

"For nature, as we maintain, always and in all things strives after the better."

Aristotle, On coming-to-be and Passing Away, with a trans. by E. S. Forster, Harvard University Press, (Cambridge, Mass., 1955) p. 317.

"ἕν ἅπασιν ἀεὶ τοῦ βελτιόνος ὀρέγεσθαι φαμεν τῆν φύσιν."

Ibid. p. 316.

Aristotle's principles and states "The principle of parsimony is rooted in the cosmic order and Aristotle's methodological and metaphysical principles are intertwined at this point, so that it is impossible to tell which were historically prior."¹⁸ Boas feels that Aristotle uses principles of parsimony in places other than the ones we have detailed. These are extremely difficult to make out or to categorize. According to Boas, Aristotle is supposed to be using a methodological principle of parsimony when he reduces the four kinds of locomotion, pulling, pushing, carrying, and twirling to two, pulling and pushing.¹⁹ Actually, the text makes no mention of any principles used in the reduction; one feels that there may be a principle of parsimony at work simply because there is a reduction. Other instances Boas cites are when Aristotle assails those who "posit ideas as causes," and when he argues that the ideas contribute nothing to sensible things, either to their being known or to their being.²⁰

It should be emphasized that Aristotle's principles are not variants of entia non sunt. . . . Although Aristotle's statements ought to easily convince one that the roots of Ockham's razor are to be found in Aristotle, one really ought to withhold the attribution of authorship from Aristotle. Aristotle's metaphysical principle is not as broad as those of some medievals and moderns.

¹⁸Boas, "Assumptions of Aristotle," p. 23.

¹⁹Ibid.

²⁰Ibid., p. 25.

And Aristotle's methodological principle is not what one normally refers to as Ockham's razor.

3. The passages in Aristotle which put forth a principle of parsimony because known to the later medievals through the commentaries of Averroes and afterwards Aquinas. It is interesting to see what the Medievals did with them. For example, Aristotle in Latin translation became "Et melius accipere principia finita sicut fecit Empedocles."²¹ which commented upon became:

Quod potest fieri per finita, magis est ponendum per finita fieri quam per infinita; sed ratio omnium quae sicut secundum naturam, assignatum secundum Empedoclem per principia finita sicut per Anaxagoras per principia infinita; ergo non est ponendum principia esse infinita.²²

What ought to be noted is that the wording of the commentary is neutral; the reference is to principles and what we should hold. There are no metaphysical reasons given why we should hold it. The principle is still restricted to deciding between finite and

²¹Averrois, *Aristotelis Opera cum Averrois Commentariis Vol. IV, De Physico*, Ed. Mantini (Venice, 1562) p. 26.

²²Thomas Aquinas, *Opera Omnia, Vol. II, Commentaria in Octo Libros Physicorum Aristotelis*, (1824) I. 6. 189a. "It is better to say that what can come to be from finite principles comes from finite principles rather than from infinite principles. But all things which come to be according to nature are explained by Empedocles through finite principles, just as they are explained by Anaxagoras through infinite principles. Hence an infinite number of principles should not be posited." Trans. by Richard J. Blackwell, Richard J. Spath and Edmund Thirlkel in Thomas Aquinas, *Commentary on Aristotle's Physics*, Routledge & Kegan Paul (London, 1963), pp. 43,44.

infinite numbers. The wording of the commentary is also close to both Ockham formulations of the razor; the first sentence for frustra fit. . .and the last sentence for pluralitas non est ponenda So far principles of parsimony from Aristotle's commentator have been about principles, not entities, and restricted to deciding between the finite and the infinite. All this changes with Aquinas' formulation:

If a thing can be done adequately by means of one, it is superfluous to do it by means of several; for we observe that nature does not employ two instruments where one suffices.²³

The wording of the above quote from Aquinas illustrates the problem that one confronts when trying to distinguish between methodological and metaphysical principles of parsimony. Aquinas' first sentence is sufficiently like Ockham's dictum "frustra fit . . ." to be confused with it. Indeed it seems to be a statement of methodological rule along the lines of "That which has been explained satisfactorily needs no further explanation." But Aquinas follows this immediately with "we see then that nature does not do by means of two instruments that which can be done by one." This further explanation or motivation of the principle in terms of the simplicity of nature renders Aquinas' principle a metaphysical principle: we do not explain by means of more because nature does

²³Quod potest fieri sufficienter per unum superfluum est is per multa fiat. Videmus enim quod natura non facit per duo instrumenta quod potest facere per unum." Thomas Aquinas, Opera Omnia, Vol. XIV, Summa Contra Gentiles, (1926) III. 70. Trans. by Anton C. Pegis, Ed., Basic Writings of St. Thomas Aquinas, Random House (N.Y., 1945) p. 129.

not do by means of more. Nature itself has few entities hence our hypotheses ought to limit themselves to as few entities as possible. This clearly echoes the Russellian "atheistic" position. Aquinas' principle may have the same intent as Aristotle's metaphysical principle, but it does break new grounds. It is clear that Aquinas' principle is about entities--nature does not employ hypotheses (or principles or concepts) at all. And Aquinas' principle is no longer restricted to finite versus infinite.

We have argued that Ockham holds a principle of parsimony which should not be thought of as a metaphysical principle. That is, Ockham holds that we ought to proceed simply not because the world is simple, but because it is a good procedure. This would be a methodological principle (or a practical or a pragmatic rule). Were Ockham to hold that we ought to theorize simply because the world is simple, or other teleological reasons, he would hold a metaphysical principle. This is a distinction between kinds of principles, not just a distinction between a weak principle of parsimony and a strong principle of parsimony. Yet it is difficult to judge whether a given principle is of one kind or another. In order to judge a principle to be metaphysical, one has to see how it is used and what motivates it, perhaps what its justification is. Form alone cannot decide whether a particular principle is methodological though form alone may decide that a particular principle is metaphysical. Were Ockham to state "*res absolutae non sunt. . .*" one would feel that he was stating a metaphysical principle. But Ockham could have stated "*pluralitas non est*

ponenda. . ." (which prima facie is methodological for Ockham) then have used it as a metaphysical principle.

4. We can claim to have traced the origins of Ockham's razor from an Aristotelian principle of parsimony through the commentaries of the later Medievals and up to Ockham and his immediate predecessors. Of course, we have also suggested that the origins of the razor are diffuse; those dicta which we have been quoting are normally found in the commentaries on Aristotle's Physics, but when they are found elsewhere, the medievals do not attribute them to Aristotle (which they are likely to do if they thought that the remarks were Aristotelian). Further, the dicta can be traced to scholastics prior to the twelfth century, which suggests that the medievals might have considered them to be old saws independent of Aristotle. In any case, the Aristotelian doctrines were different from that which we consider Ockham's razor to be. There is, nevertheless, a sense of tracing the origins of Ockham's razor where we can claim that there has been an evolution of interpretations and reinterpretations about similar doctrines throughout the times, from Aristotle to Ockham: One of the Aristotelian doctrines was a metaphysical doctrine restricted to deciding between theories which propose an infinite number of principles and those which propose a finite number of principles, the other a methodological rule broader in scope. In commentaries on Aristotle we found Aristotle's doctrines essentially intact but reformulated. These reformulations have had great currency

throughout the medieval period. The two strands of thought clearly manifested themselves in Aquinas' reformulation, a metaphysical doctrine unrestricted in scope. Aquinas' reformulation was a doctrine which opted for theories having few elements because nature has few entities. Scotus' reformulations seemed to stem from Aristotle's methodological doctrine. Scotus' reformulations were different in the important respect that they were neutral; they could no longer be labelled "metaphysical;" they no longer seemed to depend on teleological reasons. Finally, Ockham's formulations, wholly borrowed from Scotus, were clearly not metaphysical. Ockham must have regarded his principle as methodological and must have been careful not to state it as a metaphysical doctrine. Ockham's views on metaphysics and theology seemed to have been inconsistent with his holding a metaphysical principle of parsimony.

All this lead us to the conclusion that Ockham's razor is not Ockham's. Ockham was not the first to have coined "*entia non sunt multiplicanda praeter necessitatem*;" he had no part in formulating it. Ockham was not the most avid user of principles like entia non sunt. . . . The principle Ockham used to reduce the ontology of his realist opponents was his principle of absolute divine omnipotence, a principle of possible plenitude. Ockham did hold methodological principles of parsimony, but he was not the first to coin these either.

The question one may finally ask oneself is "how (in view of the above) did entia non sunt multiplicanda praeter necessitatem

come to be identified with Ockham?" There is an explanation which seems plausible but is highly speculative. Some time after Ockham's death, Louis XI, king of France, forbade the teaching of nominalism at the University of Paris. The king's edict said:

It has seemed to us that the doctrine of Aristotle and his commentator Averroes, of Albertus Magnus, of St. Thomas Aquinas, Aegidius Romanus, Alexander of Hales, Scotus, Bonaventura, and other realists ought to be taught in the faculties of arts and theology as more useful than that of the new doctors, Ockham, Gregory of Rimini, Buridan, Pierre d'Ailly, Marsilius (d' Inghen), Adam Dorp, Albert of Saxony and other nominalists.²⁴

The king therefore ordered that realism alone was to be taught as Paris, where all must take an oath to observe the edict under penalty of receiving no degree and of exile.²⁵ In response to this edict, the nominalists, followers of Ockham, issued a defense of nominalism in which the following was stated:

Those doctors are called nominalists who do not multiply things that are principally signified by terms according to the multiplication of terms. Realists, on the other hand, are those who contend that things are multiplied with the multiplication of terms. For instance, nominalists say that deity and wisdom are one and the same, but realists say that divine wisdom is divided from deity. Also, nominalists are called those who apply diligence and study to know all the properties of terms from which depend the truth and falsity of speech, and without which there can be no perfect judgment of the truth and falsity of propositions. . .realists

²⁴Lynn Thorndike, University Records and Life in the Middle Ages, Columbia University Press, (N. Y., 1944) p. 355.

²⁵Ibid.

involve themselves in inexplicable difficulties,
when they seek difficulty where there is merely
logical difficulty.²⁶

The above statement contained what might have become known as the "nominalists' razor," then, by association, "Ockham's razor."

One ought not to construe this claim as a scholarly reconstruction of the temporal order whereby entia non sunt. . . came to be known as Ockham's razor. The nominalists' defense is offered as an early instance of the sentiment expressed by what is called Ockham's razor: "Nominalists do not multiply things according to the multiplication of terms" is very close in intent to "One ought not multiply things beyond necessity." Albeit it is things (res) not entities which are referred to (although res may already be departing from the spirit of Ockham's dicta). Nevertheless we can emphasize the term "multiplication" which, along with "entities,"

²⁶Charles Du Plessis d' Argentre, Collectio Judiciorum de Novis Erroribus, 1755, I, ii, p. 286. "Sequentes articulos miserunt Nominales Universitatis Parisiensis ad regem Franciae Ludovicum XI, qui ad requisitionem magistri Johannis Boucard et Thomistarum jusserat doctrinam Okam et Nominalium condemnari et ulterius ibi non doceri neque legi.

An. 1473 Illi Doctores Nominales dicti sunt qui non multiplicant res principaliter signatas per terminos secundum multiplicationem terminorum. Reales autem, qui e contra res multiplicatas esse condendunt [sic], secundum multiplicatam terminorum. Verbi gratia, Nominales dicunt, quod deitas et sapientia dividitur a deitate.

Item Nominales dicti sunt, qui diligentiam et studium adhibuerunt cognoscendi omnes proprietates terminorum a quibus dependet veritas et fasitas orationis, et sine quibus non potest fieri perfectum iudicium de veritate et falsitate propositionum. . . .et subjungit idem quod dicti Reales se involvunt difficultatibus inexplicabilibus, dum difficultatem quaerunt, ubi non est nisi logicalis."

Trans. by Thorndike, University Records, pp. 335-356.

we take to be the oddest term of entia non sunt. . ."multiplication" is the term which seems most out of place in the modern translations.

The nominalists in their defense of nominalism might have been trying to emphasize the error figurae dictionis,²⁷ the error of attributing to things that which properly applies to terms, not any principle of parsimony. These two are not the same. One can hold that it is a great error to attribute to things that which properly applies to terms and hold anything with regard to parsimony including its negation, a principle of plenitude. It is when referring to the figurae dictionis and other such roots of error that Ockham appears to formulate a principle which seems almost identical to Ockham's razor. In the Summa Ockham states that the first root of error is to "lean too much on the peculiarities of speech found in philosophy books"²⁸ and that the second root of error "consists in the tendency to multiply entities according to the multiplicity of terms, so that for every term

²⁷"Fallacia figurae dictionis est deceptio proveniens ex aliqua similitudine dictionum ita quod causa apparentiae est similitudo dictionis ab dictionem et causa non existentiae est diversitas significatorum vel modorum significandi vel accidentium grammaticalium dictionum." Summa III, V, c. 10, p. 792.

²⁸"Una quidem radix est, quia nonnulli nimis innituntur sermonis propretati vulgatae philosophiae. . ." Summa I, c. 51, p. 170. Trans. by Michael J. Loux, Ockham's Theory of Terms, University of Notre Dame Press (Notre Dame, Indiana, 1974) p. 170.

there is a thing."²⁹ Here is an instance of Ockham using the key words, entia and multiplicare. If one were to confuse this formulation of the figurae dictionis with Ockham's principles of parsimony one would easily come up with Ockham's razor. But this evidence is, at best, inconclusive, for chapter 51 of the Summa in which this language is found is the one chapter in part I of the Summa whose authenticity is questioned. Both Boehner and Loux question the authenticity of chapter 51: "the style of chapter 51 deviates markedly from the style of the rest of the Summa. . .there are a number of points made there that are explicitly repudiated in other chapters."³⁰ It would seem that the credit or blame for Ockham's razor would be best allocated to those Ockhamists at the end of the 15th century and the beginning of the 16th. Ockham's razor might have arisen from a confusion between Ockham's principles of parsimony and the fallacy figurae dictionis.

²⁹"Secunda radix est multiplicare entia secundum multitudinem terminorum, et quod quilibet terminus habet quid rei. . ." Ibid. p. 171. Trans. by Loux, p. 171.

³⁰Loux, Ockham's Theory of Terms, p. xi. See also Boehner, in Ockham, Summa Logicae, pars prima, the Franciscan Institute (St. Bonaventure, N.Y., 1951), pp. x,xi.

CHAPTER III
THE RAZOR IN MODERN PHILOSOPHY

1. We have argued that Ockham could not hold a naive metaphysical principle of parsimony of the kind entia non sunt multiplicanda praeter necessitatem is sometimes taken to be. The main reason Ockham's principle could not have been metaphysical is that its justification could not have been teleological. For Ockham the world does not have to be simple; God could have easily fashioned an extremely complex world (and does so). We have also argued that Ockham's principle of parsimony may have originated from a metaphysical principle. In the process of tracing the origins of Ockham's razor we have given sketches of the positions that philosophers like Aristotle and Aquinas have taken on the razor. We have even mentioned some opinions that Bertrand Russell maintained about the razor. Our exposition of the positions of these philosophers, especially Russell, has been very brief. As with most philosophical matters, the actual doctrine that a philosopher might have held is a sophisticated statement not capable of being captured in a sentence or two. There is additional interest in a fuller exposition of some of the positions on the razor for, as we have already suggested, some of the doctrines have been at odds with each other. Further, if we are able to detail the spectrum of positions on the razor we should

have a better vantage from which we should be able to decide what Ockham's razor ought to be. This may coincide with what contemporary philosophers take Ockham's razor to be, or it may coincide with what Ockham thought. So far, we have two broad categories of principles, metaphysical principles and methodological principles. As examples of the former we have cited Aristotle's teleological principle, Aquinas' principle, and Russell's "atheistic" principle. As instances of the latter we have cited Ockham's principles, the weaker Aristotelian principle, and Russell's "agnostic" principle. Aristotle's teleological principle is that nature strives after the better. The better is the finite rather than the infinite, the continuous rather than the successive. Nature is purposive and regular and good; therefore our explanations ought to reflect these attributes. Aquinas' principle is that nature does not employ two instruments where one suffices. Nature is parsimonial; therefore our explanations ought to be economic. Russell's "atheistic" principle is presumably along the same lines as Aquinas' principle. Possibly it is the same as other naive metaphysical principles that were in fashion slightly before Russell's time. Certainly Russell must have been familiar with Hamilton's views on the razor and Mill's retorts. Aristotle's weaker principle is categorized as a methodological principle simply because no rationale is given for it, and it appears as if, whatever its rationale, it is not the same as that of the teleological principle. More will have to be said about Russell's

principle; for now it suffices to state that, like Ockham's principles, it is independent of the state of the external world (its complexity or its simplicity).

2. During the middle of the nineteenth century, Sir William Hamilton penned a new formulation of the principle of parsimony. Hamilton's rationale for holding this new formulation aroused John Stuart Mill's criticism. The dialogue which ensued further illustrated the distinction between metaphysical and methodological principles of parsimony and provided some arguments for and against these positions.

In an appendix to his Discussions on Philosophy Sir William Hamilton reformulates the principle of parsimony as the Law of Parcimony which he feels ought to be expressed as: "Neither more, nor more onerous, causes are to be assumed than are necessary to account for the phenomena."¹ He proceeds to defend his reformulation in two parts. He considers the prohibition of more causes and that of more onerous causes separately. Clearly it is the more causes part which interests us. Hamilton identifies the more causes portion of his law with the scholastic axioms Principia non sunt cumulanda, Frustra fit per plura quod fieri potest per pauciora, and Natura horret superfluum. Hamilton feels that these scholastic axioms simply embody Aristotle's dicta that God and Nature never operate without effect; they never operate superfluously; but always through

¹William Hamilton, Discussions on Philosophy and Literature, Education and University Reform, Longman, Brown, Green and Longmans, (Edinburgh, 1853) p. 626.

a plurality of means.² He cites these with approbation as the foundation for his Law of Parsimony. And he affirms that these, with a slight modification, are manifest of the Novaculum Nominalium or Ockham's razor Entia non sunt multiplicanda praeter necessitatem. Finally, he ties all this together by stating that "Newton's first and principal rule of philosophizing, in so far as it is accurately expressed, in like manner, simply repeats Aristotle's law; Effectuum naturalium causae, non plures sunt admittendae quam quae, et verae sunt, et effectibus explicandis sufficiunt."³

It is interesting to see so many and so varied principles all heralded to be the law of parsimony. One might have to suppose that the varied principles were weaker versions of the strong Aristotelian dictum. But we have already argued that Aristotle himself holds more than one principle of parsimony and that his metaphysical principle is limited. We have even argued for a distinction between Frustra fit per plura quod fieri potest per pauciora and Entia non sunt multiplicanda praeter necessitatem. Of course, if one holds an unlimited metaphysical principle of parsimony then one would think that methodological principles of parsimony are trivial consequences of the metaphysical principle. If nature is parsimonial then man's theories ought to be parsimonial. There would, however, still remain a distinction between

²Ibid. p. 629. This is probably a reference to Aristotle's Politics 1253 a 9 (Nature, as we often say, makes nothing in vain) instead of what we referred to as Aristotle's principles of parsimony.

³Ibid.

the metaphysical principle and the principles of theory formation which are thought to be justified by this metaphysical principle. One would think that Natura horret superfluum would be an instance of the former and that Frustra fit. . . . would be an instance of the latter. The same distinction ought to be drawn through the other principles which Hamilton mentions, those which he calls repetitions of "what was so clearly and so frequently inculcated in the Stagirite."⁴

Hamilton thinks that Natura horret superfluum, for example, is the same kind of principle as Newton's principle of two causes. Natura horret superfluum is phrased in the teleological language of Aristotle's metaphysical principle, nature strives for the better. It is clearly in the same family of teleological statements as "the ways of nature are perfect" and "nature abhors a vacuum." On the other hand, Newton's principle, "we are to admit no more causes of natural things than such as are both true and sufficient to explain their appearance"⁵ is not phrased in teleological language. One ought not think that Newton's principle of two causes is simply a repetition of Aristotle's metaphysical principle. It may turn out that Newton's principle is justified by a metaphysical principle, but prima facie it is more like Frustra fit. . . . than Natura horret superfluum. It must be possible,

⁴ Ibid.

⁵ Isaac Newton, Newton's Philosophy of Nature, Hafner Press (N.Y., 1953) p. 3.

at least in principle, to deny Aristotle's metaphysical principle and its broad medieval interpretation while maintaining Newton's principle.

Mill attacks Hamilton's reasoning at this juncture. In a chapter of An Examination of Sir William Hamilton's Philosophy entitled "Fallacious Modes of Thought Countenanced by Sir William Hamilton" Mill rejects all metaphysical first principles like "Nature abhors a vacuum" and Natura non habet saltum. This rejection is meant to cover Hamilton's Law of Parsimony since that law is grounded in an ontological theory which requires the truth of statements like "Nature never works by more and more complex instruments than are necessary." Mill asks:

Have we authority to declare that there is anything which God and Nature never do? Do we know all Nature's combinations? Were we called into counsel in fixing its limits? By what canons of induction has this theory ever been tried? By what observation has it been verified? We know well that Nature, in many of its operations works by means which are a complexity so extreme, as to be an almost insuperable obstacle to our investigation. On what evidence do we presume that this complexity was necessary, and that the effect could not have been produced in a simpler manner? If we look into the meaning of words, of what kind is the necessity which is supposed to be binding on God and Nature--the pressure they are unable to escape from? Is there any necessity in Nature which Nature did not make? Or if not, what did? What is this power superior to Nature and its author, and to which Nature is compelled to adapt itself?⁶

⁶John Stuart Mill, An Examination of Sir William Hamilton's Philosophy, Longmans, Green & Co., (London, 1865) p. 466.

In effect Mill asks for a justification of the principle given that the principle is not established by induction and it does not seem to be trivially true. Mill does think that there may be some theological reasons for the acceptance of Hamilton's metaphysical principle along the lines of Leibnitz's theodicy, but that the law of parsimony does not need such support. According to Mill the law of parsimony as a methodological principle rests on no assumption about nature at all: "it is a purely logical precept; a case of the broad practical principle, not to believe anything of which there is no evidence."⁷ Mill attempts to separate the two kinds of principles, the teleological principles and the principles about what we ought to believe, the epistemic principles. He rejects all teleological principles. Since these are often the ones cited to justify the epistemic principles, Mill seeks to justify his principle of parsimony independently as a logical consequence of an epistemic rule. Mill wishes to keep Newton's principle of two causes as a valid principle of parsimony while denying Aristotle's dicta. Whether or not Mill can succeed in this enterprise, it must be pointed out that it does not seem to be Newton's position.

As we have already stated, Newton's first rule of reasoning for natural philosophy is that "we are to admit no more causes of

⁷ Ibid., p. 467.

natural things than such as are both true and sufficient to explain their appearances."⁸ To this Newton adds Rule II, "Therefore to the same natural effects we must, as far as possible, assign the same causes."⁹ Rule II is seen as following from Rule I. Newton thinks a consequence of Rule II is that it is superfluous to posit separate principles for the "descent of stones in Europe and in America, the light of our culinary fire and of the sun, the reflection of light in the earth and in the planets."¹⁰ If we trace back the justification of this assertion we would encounter the following statement by Newton: "To this purpose the philosophers say that Nature does nothing in vain when less will serve; for Nature is pleased with simplicity and affects not the pomp of superfluous causes."¹¹ Newton himself uses the parsimonious tendency of nature as a justification for his Rules I and II; Hamilton seems vindicated in his interpretation of Newton's principle. This does not prevent Mill from interpreting Newton's principle in a different and perhaps more fruitful way.

Newton's principle, as Mill sees it, is that once a phenomenon is explained by known causes, there is no reason to admit a new cause. In broader terms, if Newton can show that planetary motion and falling bodies can be expressed by the

⁸Newton, p. 3.

⁹Ibid.

¹⁰Ibid.

¹¹Ibid.

same laws, it would be illogical to recognize two distinct laws of nature, one for the heavenly realm and the other for earthly bodies. If one of these laws is correct, then the other is superfluous, an instance of a belief without evidence. This conclusion applies to facts as well as theories. In the realm of causes it is clear that one ought not believe that there may be two causes operating on a specific stone, the regular cause and a special cause which does nothing more than the regular cause: "As if we were to suppose that a man who was killed by falling over a precipice must have taken poison as well."¹² Doing so could be likened to considering the same property as two different properties simply because it is found in two different kinds of objects. Mill suggests that what may be at stake is the identity of propositions. The superfluous law, when reduced to the expression of circumstances which influence the results, expresses the same proposition as the genuine law.

Mill's justification of Newton's principle of two causes can be thought to be a justification for Ockham's razor if interpreted as a methodological principle of parsimony. Indeed, Mill's justification echoes our interpretation of Ockham's razor as intended by Ockham; as Ockham would have stated it, it is possible to be consistent while holding both propositions: that God can do by means of more what could be done by means of fewer and that

¹²Mill, p. 468.

pluralities are not to be supposed unless they are established by evident reasoning or evident experience or are required by the articles of faith. As Mill states it:

The rule of parsimony, therefore, whether applied to facts or theories, implies no theory concerning the propensities or proceedings of Nature. If Nature's ways and inclinations were the reverse of what they are supposed to be, it would have been as illegitimate as it is now, to assume a fact of Nature without any evidence for it, or to consider the same property as two different properties because found in two different kinds of objects.¹³

Mill provides us with an epistemic reason for being parsimonious in our theories. The greatest difficulty with Mill's actual position is that Mill is not always consistent in his prohibition of teleological principles. When confronted with the problem of induction, Mill resolves it by referring to the uniformity of nature: "This universal fact, which is our warrant for all inferences from experience, has been described by different philosophers in different forms of language: that the course of nature is uniform; that the universe is governed by general laws; and the like."¹⁴ Whether or not Mill's interpretation of Newton's principle of two causes is a good philosophical foundation for the principle of parsimony, one is compelled to show that Mill in his solutions to the two problems

¹³ Ibid. pp. 467-468.

¹⁴ John Stuart Mill, A System of Logic, The Collected Works of John Stuart Mill Vol. VII, University of Toronto Press, (Toronto, 1973) p. 306.

is not consistent with regards to his prohibition of principles about nature (teleological principles or principles which state the limitations of nature). Naturally, if Mill can make use of the principles like the uniformity of nature there is no reason why he cannot make use of the principle of the simplicity of nature.

The justification of induction is a related problem to the justification of parsimony. One might ask, like Hume in his Inquiry Concerning Human Understanding,¹⁵ how we are to justify the inferences we draw about matters of fact when there is no logical connection between the reasonings about matters of fact. An answer one might give is that there is a metaphysical principle which is a suppressed major premise of every induction. The suppressed major premise may be a principle like the uniformity of nature; this solution to the problem of induction would be an instance of a metaphysical justification of the problem of induction. Mill and Russell are sometimes cited as proponents of such views.¹⁶

Certainly Mill makes use of the principle of the uniformity of nature as a suppressed major premise which justifies induction. But whether Mill thinks that the uniformity of nature is a metaphysical principle can be debated. Were one to read Mill's

¹⁵David Hume, An Inquiry Concerning Human Understanding, The Library of Liberal Arts (N.Y., 1957) pp. 186-189.

¹⁶Marguerite Foster and Michael L. Martin, Probability Confirmation and Simplicity, The Odyssey Press (N.Y., 1966) pp. 336-337.

own account, one would probably not come to the conclusion that Mill attempts a metaphysical justification. Mill himself holds that the principle of the uniformity of nature is "an instance of induction, and induction by no means of the most obvious kind. Far from being the first induction we make, it is one of the last. . ."¹⁷ Mill is attempting to justify induction inductively, and not by resort to metaphysical principles. This attempt may be doomed to failure, as Hume thinks.¹⁸ However, if Mill believes that he can come to hold the principle of the uniformity of nature by induction, he should also believe that he can come to hold the principle of the simplicity of nature by induction. Mill is providing an answer to his own question "Have we the authority to declare that there is anything which God and Nature never do?"¹⁹ And if Mill believes that a metaphysical principle is needed to justify the induction, then Mill must hold that we have the authority to declare what God and Nature do.

3. With philosophers like Hamilton and Mill discussing Ockham's razor during the mid-nineteenth century, it is not surprising to see the razor crop up in more substantial ways within the works of late nineteenth and early twentieth century philosophers. Of these,

¹⁷ Mill, A System of Logic, p. 307.

¹⁸ Hume, Inquiry Concerning Human Understanding, pp. 188-189.

¹⁹ Mill, An Examination of Hamilton's Philosophy, p. 466.

Bertrand Russell and Charles Sanders Peirce are the most significant. Bertrand Russell uses the razor as a guiding principle throughout his works. In his History of Western Philosophy Russell states that he himself found the razor "a most fruitful principle of logical analysis."²⁰ And Russell, commenting on himself in My Philosophical Development says that he first became devoted to the razor by reason of its usefulness in the philosophy of arithmetic and that, after he had done all he intended to do in pure mathematics, he began to think about the physical world and was led to apply Ockham's razor to philosophy as well.²¹ Russell uses the razor so extensively that it has been called his main philosophical occupation:

Here there emerges what was to become a principal driving force behind Russell's philosophy--the desire to reduce the number of entities and properties which must be presumed to exist in order to give a complete account of the world Russell was by now embarked upon what was to be his main philosophical occupation--'Occam's Razor.'²²

The razor is imbedded in Russell's philosophy; one cannot talk about the razor divorced from the rest of Russell's philosophy. As Russell himself once stated, "another purpose which runs through all that I have been saying is the purpose

²⁰ Bertrand Russell, A History of Western Philosophy, Simon & Schuster (N.Y. 1945), p. 494.

²¹ Bertrand Russell, My Philosophical Development, Simon & Schuster (N.Y. 1959), p. 12.

²² John A. Passmore, A Hundred Years of Philosophy, Basic Books (N.Y. 1967), pp. 222,231.

embodied in the maxim called Ockham's razor."²³ In order to begin to talk about the role of the razor in Russell one has to begin with Russell's epistemology. In fact, the logical starting place for a discussion of the role of the razor in Russell is the very first sentence of the Problems of Philosophy, Russell's recurring question, "Is there any knowledge in the world which is so certain that no reasonable man can doubt it?"²⁴ This is the epistemological problem which most interests Russell; it was this epistemological problem which stirred his original interest in philosophy: "I have been anxious to discover how much we can be said to know and with what degree of certainty and doubtfulness."²⁵ In another context Russell reaffirms the importance and the universality of this problem by stating "The demand for certainty is one which is natural to man."²⁶

Russell as a philosopher is known for two famous philosophical doctrines, the theory of definite descriptions and the distinction between knowledge by acquaintance and knowledge by description. Although one can argue that parsimony lurks in the former doctrine (Russell makes the Golden Mountain disappear by reparsing statements about it) it is in the latter doctrine that the razor becomes

²³Bertrand Russell, "The Philosophy of Logical Atomism," Logic and Knowledge, ed. R. C. Marsh, Allen & Unwin (London, 1956) p. 270.

²⁴Bertrand Russell, The Problems of Philosophy, Oxford University Press (Oxford, 1969) p. 9.

²⁵Russell, My Philosophical Development, p. 11.

²⁶Bertrand Russell, Unpopular Essays, Simon & Schuster (N.Y., 1950) pp. 26-27.

important. It is when he attempts an answer to the epistemological problem that Russell forms his distinction between knowledge by acquaintance and knowledge by description:

we have acquaintance with anything of which we are directly aware without the intermediary of any process of inference or any knowledge of truths. Thus in the presence of my table I am acquainted with the sense data that make up the appearance of my table--its colour, shape, hardness, smoothness, etc. On the other hand, my knowledge of the table (underlying the sense data) is of the kind which we call 'knowledge by description.' The table is 'the physical object which causes such-and-such sense data.' This describes the table by means of the sense data.²⁷

We are therefore directly aware of sense data but not of objects. The sense datum is that which we are acquainted with; it is the "hard data:" "I give the name 'data' or rather 'hard data' to all that survives the most severe critical scrutiny of which I am capable, excluding what, after the scrutiny, is only arrived at by argument and inference."²⁸ According to this doctrine we have no acquaintance with objects; "objects" are what are opposed by the "data"--"The essential characteristics of a datum is that it is not inferred"²⁹ whereas "objects" are not directly known. Russell's knowledge of the "object" is "not direct knowledge. . . it is obtained through acquaintance with the sense data that make up the appearance of the table."³⁰ This is precisely where

²⁷ Russell, Logic & Knowledge, p. 74.

²⁸ Bertrand Russell, "Professor Dewey's Essays in Experimental Logic," Journal of Philosophy, xvi, (1919), p. 21.

²⁹ Bertrand Russell, An Inquiry Into Meaning And Truth, Norton & Co., (N.Y., 1940), p. 155.

³⁰ Russell, Problems of Philosophy, p. 74.

Ockham's razor comes in. We have empirical evidence of the data; we only infer the thing. Our knowledge of the data is certain, whereas our knowledge of the object is inferred. Hence, "The supreme maxim in scientific philosophizing is this--whenever possible logical constructions are to be substituted for inferred entities."³¹

Ockham's razor pares down all the inferred entities, or all the entities that we are not acquainted with. As Russell states, "all my somewhat elaborate constructions are designed to reduce inferred entities to a minimum."³² Russell associates Ockham's razor with his "logical constructions" and therefore the epistemic certainty derived from acquaintance with sense data:

By the principle of Occam's razor, if the class of appearance will fulfil the purposes for the sake of which the thing was invented by the prehistoric metaphysicians to whom common sense is due, economy demands that we should identify the thing with the class of appearances.³³

The sensibilia are going to be the ultimate constituents of the physical world. Things are going to be reduced to logical construction of classes of sensibilia. Each step in the reduction will enable us to dispense with an inferred entity. Of course, Russell realizes that denying things will produce baroque results.

³¹Bertrand Russell, "The Relation of Sense-data to Physics," Mysticism and Logic, Doubleday Anchor, (N.Y., 1957), p. 150.

³²Bertrand Russell, "Reply to Criticisms," The Philosophy of Bertrand Russell, ed. P. A. Schilpp, Library of Living Philosophers, (Menasha, Wisc., 1944), p. 708.

³³Russell, Mysticism and Logic, pp. 149-150.

His logical constructions which are supposed to replace things are cumbersome. He predicts that he will have great difficulties defending them:

The above extrusion of permanent things affords an example of the maxim which inspires all scientific philosophizing, namely "Occam's razor": entities must not be multiplied without necessity. In other words, in dealing with any subject matter, find out what entities are undeniably involved and state everything in terms of these entities. Very often the resulting statement is more complicated and difficult than the one which, like common sense and philosophy, assumes hypothetical entities there is no good reason to believe in.³⁴

What is amusing is that Russell becomes so comfortable with his complicated constructions that he states "the more one studies logical constructions the more weight one feels inclined to attach to it. It rests upon a maxim which might be enunciated as a supplement to Occam's razor: 'What is logically convenient is likely to be artificial.'³⁵

In order to better understand Russell's parsimonious move one has to go back to Principia Mathematica where he proposed a method of using symbols for the classes which are essential to mathematics. He went on to affirm whatever he could about these classes without, however, assuming that there were any corresponding realities. Later Russell applied this same method when

³⁴Bertrand Russell, Our Knowledge of the External World, George Allen & Unwin, (London, 1926), p. 112.

³⁵Bertrand Russell, The Analysis of Matter, George Allen & Unwin, (London, 1954), p. 290.

dealing with the external world. As we have stated, objects, or "logical constructions" are constructed in such a way (out of entities we are acquainted with) that there is no need to postulate any other entities. This is the function of the razor in Russell. It should not be interpreted as denying the existence of "things," though. Russell does not do so. He explicitly states that, for him, Ockham's razor does not mean that it is necessary to deny the existence of a thing, but that it is merely expedient to abstain from asserting its existence. This is Russell's "agnostic" position with regard to entities with which the razor deals:

I want to make it clear that I am not denying the existence of anything; I am only refusing to affirm it. I refuse to affirm the existence of anything for which there is no evidence, but I equally refuse to deny the existence of anything against which there is no evidence. Therefore I neither affirm nor deny it, but merely say, that is not in the realm of the knowable and is certainly not a part of physics.³⁶

The motivation for this procedure is that by following the above doctrine one tends to minimize the risk of error:

Suppose you have constructed your physics with a certain number of entities and a certain number of premises, suppose you discover that by a little ingenuity you can dispense with half of those entities and half of those premises, you have clearly diminished the risk of error because if you had before 10 entities and 10 premises, then the 5 you have now are all right, but it is not true conversely that, if the 5 you have are all

³⁶Russell, "The Philosophy of Logical Atomism," Logic and Knowledge, pp. 273-274.

right, the 10 must have been. Therefore you diminish the risk of error with every diminution of entities and premises.³⁷

Similarly one minimizes the risk of error by refusing to allow the existence of objects. Russell minimizes his risk of error by replacing objects by a series of appearances or constructions of sense data:

You have, anyhow, the successive appearances and if you can get on without assuming the metaphysical and constant desk you have a smaller risk of error than you had before. You would not necessarily have a smaller risk of error if you were tied down to denying the metaphysical desk. That is the advantage of Occam's razor that it diminishes your risk of error.³⁸

Russell's doctrine is nicely illustrated by his views on time and space. Unlike Ockham, Russell does not deny the reality of time and space. Russell, in keeping with his wish to minimize the risk of error, asserts his belief that Ockham's razor shows that time and space should neither be affirmed nor denied:

Formally mathematics adopts an absolute theory of space and time, i.e. it assumes that, besides the things that are in space and time, there are also entities, called "points" and "instances," which are occupied by things. . . . There is as far as I can see, no evidence either for or against [this view]. . . . Hence, in accordance with Occam's razor, we shall do well to abstain from either assuming or denying points and instances.³⁹

³⁷ Ibid. p. 378.

³⁸ Ibid. p. 379.

³⁹ Russell, Our Knowledge of the External World, pp. 152-153.

Also in keeping with the spirit of the above Russell even refuses to assert that statements about points and instances are false (or true):

I do not mean that statements apparently about points and instances. . . or any of the other entities which Occam's razor abolishes, are false, but only that their linguistic form is misleading, and that, when they are rightly analyzed, the pseudo-entities in question are found to be not mentioned in them.⁴⁰

Points and instances are abstained from because of Ockham's razor, but so are images, sentences and propositions⁴¹ as were classes⁴² and objects before them. Numbers are also abstained from as "special hypothetical entities."⁴³ This leads Reichenbach to call Russell's definition of number "a standard example of an application of Occam's razor."⁴⁴

Russell's view as we have now detailed it is perhaps a more sophisticated view than the one we sketched in the first chapter. Russell feels that the razor will increase his chances of being right, but not for the reasons we advanced at first. For Russell

⁴⁰Bertrand Russell, Principles of Mathematics, Cambridge University Press (Cambridge, 1904), "Introduction" xi.

⁴¹Russell, An Inquiry Into Meaning and Truth, pp. 183, 230.

⁴²Russell, Introduction to Mathematical Philosophy, George Allen & Unwin, (London, 1919), p. 184.

⁴³Russell, "A Reply to Criticism," p. 698.

⁴⁴Hans Reichenbach, "Bertrand Russell's Logic" in Schilpp, p. 30.

the razor will increase his chances of being right regardless of what the external world looks like--whether or not it is simple or complex. Unlike Aquinas' principle which depends on the metaphysical assertion that the world is simple, Russell's principle stands by itself. In our terminology, Russell's principle is a methodological principle. Russell feels that his principle cautions him against stating that an object does not exist as well as stating that an object exists. Russell's principle must fall in the same category as such principles as "the least said, the better" and perhaps "if you say more you may contradict yourself." The appeal of such principles is simply that one cannot state a falsehood without stating. Hence, the less one says the less likely it is that what we say is a falsehood. Further, the fewer entities we are committed to the smaller the risk of our being wrong. Russell cannot be wrong about points, instances, images, propositions, statements, numbers, etc. if he refuses to make any substantial statement about them.

A preliminary criticism that ought to be advanced is that, contrary to what Mr. Russell states, his principle is not Ockham's razor. First, Russell really has two principles that ought to be distinguished, a principle of Cartesian certainty and a safety principle. Russell is misleading when he talks as if the motivation for his logical constructions is simply the elimination of entities. One has to feel that Russell is not eliminating entities at random. He is eliminating inferred entities in order to gain Cartesian

certainty or derivative Cartesian certainty by referring only to entities which we have acquaintance with or to constructions out of the entities which we have acquaintance with. Russell's primary motivation for what he calls "Occam's razor" is not to reduce the actual number of entities but to reduce the entities to those which we are acquainted with; it is not a question of number of entities but of kinds of entities. Hence, Russell's principle is not Ockham's razor.

Second, Russell's safety principle which supposedly deals with the diminution of the risk of error by the dispensation of entities is not really about the dispensation of entities. One diminishes the risk of error by making fewer statements about entities, not by making more statements about fewer entities. It is by stating less that one increases one's safety. Of course, there is no reason not to consider such principles as Russell's reformulation of Ockham's razor as extensions of Ockham's razor beyond a principle dealing with the multiplication of entities, including the multiplication of statements.

4. The razor is obviously an important element of Bertrand Russell's philosophy; it is seen throughout it, motivating and shaping every doctrine. The same cannot be said about Charles Sanders Peirce's dependence on the razor; the razor is only incidental to Peirce's philosophy. Peirce, a predecessor of Russell, does discuss the razor in a most detailed way, though. Peirce holds a very interesting twist with regard to the razor.

He feels that the razor is "a sound maxim of scientific procedure;"⁴⁵ putting it more broadly, he feels that it is a good scientific procedure when confronted with two equally good hypotheses to adopt the simpler one first. But Peirce also holds that the razor cannot force us to believe in the simpler hypothesis:

If the question be what one ought to believe, the logic of the situation must take other factors into account. Strictly speaking belief is out of place in a pure theoretical science, which has nothing nearer to it than the establishment of doctrines, and only the provisional establishment of them, at that. Compared with living belief, it is nothing but a ghost. . . . Ockham's razor is not worth the stout belief of a common seaman.⁴⁶

It is Peirce's view that the simpler hypothesis is less likely to be true than the more complex. This view is the exact mathematical complement to Aquinas' view. For Aquinas' nature itself is simple insofar as it has few basic entities; therefore, we are more likely to achieve a proper explanation (or get at the truth) if we restrict the number of basic entities we need in order to explain natural phenomena. Aquinas' principle of parsimony is tied to nature; it is justified by the simplicity of nature. That parsimony is justified by the simplicity of nature is not always the case. Certainly, it is not the case with Peirce.

⁴⁵Charles Sanders Peirce, "Lecture on Pragmatism," The Collected Papers of Charles Sanders Peirce, Vol. V, (Harvard, 1965), p. 41.

⁴⁶Ibid., pp. 41-42.

Peirce holds that nature is so complex that the prior probabilities favor the more complex hypotheses. For that reason he feels that it is sometimes more reasonable for individuals to believe in the more complex hypothesis rather than the simpler hypothesis which the scientist must defend:

Thus, in metaphysics, the maxim called Ockham's razor, to the effect that more elements must not be introduced into a hypothesis until it is absolutely proved that fewer are not sufficient, is a sound economic principle which ought to guide the scientific metaphysician. But centuries before it is absolutely proved that the simpler hypothesis is inadequate, it may have been extremely probable that it is so, and the individual's behavior may reasonably be based upon what the ultimate conclusion of science is likely to be.⁴⁷

Peirce's non-scientific individual (which must include Peirce, at times) is justified in holding a principle of non-parsimony, in fact. Peirce seems to suggest that entities ought to be multiplied at will because nature is very complex. The more complex a hypothesis is the more likely it is to be true.

Peirce's whole outlook is antithetical to the proposition that nature is simple. He is skeptical about any procedure which simplifies or any hypothesis which is itself simple:

One may very properly entertain a suspicion of any method which so resolves the most difficult questions into easy problems. No doubt Ockham's razor is logically sound. . . only we may very well doubt whether a very simple hypothesis can

⁴⁷Peirce, "Religion," Collected Papers Vol. VI, (Harvard, 1965) p. 363.

contain every factor that is necessary. Certain it is that most hypotheses which at first seemed to unite great simplicity with entire sufficiency have had to be greatly complicated in the further progress of science.⁴⁸

Peirce's principle of non-parsimony is a metaphysical principle; but Peirce's principle of parsimony is a methodological principle. Where Aquinas' principle of parsimony is a paradigm of metaphysical principles of parsimony, Peirce's principle of parsimony is a paradigm of methodological principles of parsimony. Methodological principles are not grounded in metaphysical or teleological assumptions. They need not lead us to the truth. Russell's principle, a methodological principle, is motivated by the likelihood of fewer errors, not the simplicity of nature. But it is still a principle which is supposed to lead to truth although getting to the truth is not the only possible motivation for a methodological principle. A methodological principle may distort the truth or keep us away from the truth and still be valid. It may be a rule of thumb which is just convenient in the long run. Peirce's justification for his principle of parsimony is that time will be economized by proceeding in an orderly manner in science:

There never was a sounder logical maxim of scientific procedure than Ockham's razor: Entia non sunt multiplicanda praeter necessitatem. That is to say; before you try a complicated hypothesis, you should make quite sure that no simplifications

⁴⁸Peirce, "Lecture on Pragmatism," p. 21.

of it will explain the facts equally well. No matter if it takes fifty generations of arduous experimentations to explode the simpler hypothesis, and no matter how incredible it may seem that the simple hypothesis should suffice. Still, fifty generations are nothing in the life of science, which has all the time before it; and, in the long run, say in some thousand of generations, time will be economized by proceeding in an orderly manner, and making it invariable to try the simpler hypothesis first.⁴⁹

It is clear, then, that Peirce's principle of parsimony is not metaphysical; it is not motivated by teleological reasons and it does not even lead to truth. One ought to point out that Peirce's principle of parsimony does lead to truth according to Peirce's definition of truth. For Peirce, truth is the predestined result to which inquiry would ultimately lead. So the razor would, in allowing for orderly scientific inquiry, lead to truth. In a different sense of leading to truth, a correspondence sense where there is something to get at, Peirce's principle does not lead to truth. Peirce's principle appears to be the kind of principle like "first things first" and "one ought to begin at the beginning." The only reason Peirce holds his principle is that he feels it is a good procedure to start with simple things and go on to the more complex later, as the need arises.

Peirce is so taken with the orderliness of his principle that he elsewhere refers to an entirely different economic principle as

⁴⁹ ibid., p. 41.

Ockham's razor:

Parsimony (law of): Ockham's razor, i.e. the maxim (entia non sunt multiplicanda praeter necessitatem). The meaning is that it is bad scientific method to introduce, at once, independent hypotheses to explain the same facts of observation.⁵⁰

One can see that Peirce's reasons for holding his principle of parsimony would be the same as his reasons for holding this last principle. This last principle is also one whose intent is to economize time in the long run by proceeding in an orderly manner. It is akin to principles like "one step at a time" which are closely related to "first things first." But it is not Ockham's razor at all; it is not about the simplicity of hypotheses and it is not about reducing entities. One would have to feel that only Peirce would think that this last principle adequately represents Ockham's razor.

There is a similarity between Ockham's principle and Peirce's principle which ought to be stressed. Peirce thinks of his rule as unrelated to truth and nature because he thinks that nature itself is complex. This is partially Ockham's view as we wish to represent him. Ockham holds that God can do by means of more simply because He wishes it; so nature may be complex for Ockham.

5. We have identified some new justifications for holding principles of parsimony, and we have added some details about the

⁵⁰Peirce, "Scientific Method," Collected Papers Vol. VII, (Harvard, 1966) p. 59.

justifications alluded to in previous chapters. The new principles can easily be categorized by our two broad categories, metaphysical principles and methodological principles.

The new metaphysical principles of parsimony are Hamilton's Principle of Parsimony and Newton's principle of two causes. Neither of these provides new justifications and adds to our understanding of parsimony since they merely refer to previous metaphysical principles. The justification of both lies in the belief that nature is simple. What is interesting is that the negation of this statement may also be tenable. The negation of "nature is simple" is the basis of Peirce's principle of non-parsimony, also a metaphysical principle. Peirce's belief that nature is complex is Peirce's justification for individuals basing their actions not on economic scientific principles but on what the ultimate conclusion of science is likely to be. It is possible to be more precise with respect to what we have been calling metaphysical principles. We can divide the metaphysical principles into metaphysical (or teleological, a subgroup of metaphysical) principles like Aristotle's "nature strives after the better" or the more general "nature is simple," and methodological principles with a metaphysical (or teleological) justification like Aquinas' principle, or Newton's principle. Previously we have been considering the methodological principles with metaphysical justifications as disguised metaphysical principles.

The new methodological principles of parsimony are those of Mill, Russell, and Peirce. We will refer to Mill's justification of

his principle as an epistemic justification, Russell's justification as an inductive justification, and Peirce's justification as a pragmatic justification. Mill's justification is an epistemic justification because Mill attempts to show that there are basic epistemic reasons for holding a principle of parsimony. In this case, the reasons deal with the identity of statements, what counts as a new cause, and how much evidence is necessary before it would be logical to recognize a new law. On similar grounds, one would have to categorize Ockham's own principle as a methodological principle with an epistemic justification if one accepts the interpretations of Ockham's dicta "that which has already been explained needs no further explanation" for "Frustra fit per plura quod potest fieri per pauciora" and "statements should not be affirmed without reason" for "pluralitas non est ponenda sine necessitate."

Peirce's justification is a pragmatic justification for obvious reasons. Pragmatism is a broad philosophical attitude toward our conceptualization of experience; the pragmatic approach to theorizing is fundamentally motivated by conditions of efficacy and utility serving our various aims and needs.⁵¹ Peirce does not seem to be interested in whether his principle leads to truths; in fact, Peirce thinks that in the short run his principle will lead to falsehoods. Peirce's justification of his principle is that time

⁵¹H. S. Thayer, "Pragmatism," The Encyclopedia of Philosophy, Ed. Paul Edwards, Macmillan Publishing Co., (N.Y., 1967) Vol. 6, p. 435.

will be economized in the long run. The efficacy of the razor is that it gives a rigid procedure to follow; the utility of the razor is its economy.

Russell's justification is not like Mill's justification or Peirce's justification. Russell thinks that there are features of simpler theories that render the simpler theory as more likely to be true than the more complex theory (without making the metaphysical assumption that nature is simple). For Russell the simpler theory is more likely to be consistent than the more complex theory; also, the simpler theory has fewer commitments which again might make it more likely to be true. This is not a pragmatic justification, like Peirce's, since it appeals to truth. Neither is it an epistemic justification, like Mill's and Ockham's, since the appeal of simplicity is not derived from considerations like what counts as a new cause, or more broadly, what it means to make a rational choice. Rather, the Russellian justification is that the simpler theories have turned out to be correct or are more likely to be correct. We can exploit the reason for the success of these theories so that our theories would stand the test of confirmation as well. An epistemic justification argues that it is a feature of epistemic procedures that simpler theories are to be preferred. An inductive justification argues that it is a feature of simpler theories that they are more easily confirmed.

There is a contemporary viewpoint about simplicity which can be seen as an extension of Russell's interpretation of Ockham's

razor. The viewpoint is that simple theories have a greater prior probability of confirmation than more complex theories. As W. V. Quine states it, "when two theories are equally defensible on other counts, certainly the simpler of the two is to be preferred on the score of both beauty and convenience. But what is remarkable is that the simpler of the two theories is generally regarded not only as the more desirable but also as the more probable. If the two theories conform equally to past observations, the simpler of the two is seen as standing the better chance of confirmation in future observations."⁵² Quine makes it clear that the prior probabilities favor simple theories for reasons other than that simple theories will more likely correspond to nature if nature is simple. Quine states that the belief in the simplicity of nature is just "wishful thinking."⁵³

Quine believes that a simple hypothesis may be confirmed by a result which may require the truth of the same simple hypothesis and some added complication, whereas an initially complex hypothesis may be refuted by the same result. He cites as an example the case of a measured quantity "reported first as 5.21, say, and more accurately in the light of further measurement as 5.23, the new reading supersedes the old; but if it is reported first as 5.2 and later 5.23, the new reading may well be looked upon as confirming

⁵²Willard Van Orman Quine, "On Simple Theories of a Complex World," *Synthese*, Vol. 15 (1963) p. 103.

⁵³Ibid., p. 105.

the old and merely supplying some further information regarding the detail of further decimal places. Thus the "simpler hypothesis," 5.2 as against 5.21, is quite genuinely ten times likelier to be confirmed, just because ten times as much deviation is tolerated under the head of confirmation."⁵⁴

The novelty of this approach is the attempted justification of simplicity by an examination of our confirmation procedures. It is assumed that the more easily confirmable hypothesis is to be preferred. Unlike some of the possible motivations for Russell's principle, the simpler hypothesis is not to be preferred because the more complex theories are more likely to be internally inconsistent. The simpler hypothesis is to be preferred because of a bias built into the way we confirm theories. It may be that the theoretician who claims the answer is 5.2 makes no claim about the second decimal place. And the theoretician who claims that the answer is 5.21 also claims that it isn't 5.22, 5.23, etc. But if the theoretician who claims that the answer is 5.2 is understood as claiming that it is exactly 5.2 (actually 5.20) then the new figure will be seen as supplanting his old figure. No benefit will accrue to the alleged simpler hypothesis. From our confirmation procedure viewpoint Quine's example might be indicating that vague theories tend to be more easily confirmed than less vague theories.

It is hard to see that there is more to Quine's example except that, in a Russellian way, vague theories, like simple theories

⁵⁴ Ibid., p. 106.

seem to require fewer commitments than less vague theories. Quine's theory closely resembles Russell's theory; instead of "the least said, the better" Quine seems to abide by "the more vague, the better." Quine's theory of simplicity, like Russell's theory, entails a methodological principle whose justification is inductive. We prefer simpler theories because simpler theories have been (or are more likely to be) more successful than more complex theories. Simpler theories are more easily confirmed than more complex theories. Here again we have to extend the scope of Ockham's razor. Quine's principle is not restricted to the multiplication of entities; it is about simplicity in general. Even if Quine's thesis is not about the multiplication of entities at all, we can consider the thesis that theories whose ontological commitments are vague are more likely to be confirmed than those theories whose ontological commitments are precise. This thesis is the extension of Russell's reinterpretation of Ockham's razor that is suggested by Quine's article.

Inductive justifications of parsimony do not have to be restricted to those which claim that the simpler theories are more easily confirmed or more likely to be true. Inductive justifications require that the simpler statement be thought as successful by any criterion. We can take confirmation theory in a very broad sense to include success criteria like corroboration (which stems out of an attempted falsification). For instance, Karl Popper in his The Logic of Scientific Discovery, argues that we prefer the simpler hypotheses because they are more easily falsified: "Simple

statements, if knowledge is our object, are to be prized more highly than less simple ones because they tell us more; because their empirical content is greater; and because they are better testable."⁵⁵

The general conception which Popper offers is that theoreticians seek the simplest hypothesis because it is the one with the most empirical content; therefore it is the most falsifiable. Popper's statement is misleading, though. Popper intends to leave the impression that it is the task of our theoreticians to construct theories that are easily falsified. But for any given theory there is another theory which can be constructed out of the given theory so that it may be more easily falsified. Any given theory can be reconstructed so that it can be trivially falsified without it being prized any more highly. The point is made by Stephen Barker in "On Simplicity in Empirical Hypotheses." The example which Mr. Barker cites in order to justify this assertion is the case of the maid who has been acting strangely and the silver spoons are missing from their cabinet in the dining room:

One hypothesis which we might entertain as a possible explanation of these observed phenomena would be the hypothesis that the maid has stolen the spoons. This hypothesis is consonant with the so-far-observed facts, and if true would explain the situation. But other more detailed hypotheses also are possible here. For instance, there is the hypothesis that the maid has

⁵⁵Karl Popper, The Logic of Scientific Discovery, Harper & Row (N.Y., 1959) p. 142.

stolen the spoons and pawned them to raise money which she has used in order to elope with the butler on the 10:30 plane to Acapulco. This hypothesis is also unfalsified by what we have observed, and if true it would constitute a more detailed explanation of the situation.⁵⁶

The second hypothesis because of its extreme details is clearly the more falsifiable of the two hypotheses; anything that would falsify the first hypothesis would also falsify the second, and the second hypothesis would be falsified by many observations which would not falsify the first hypothesis. But the second hypothesis is not any more acceptable than the first hypothesis. It cannot be the theoretician's concern to fabricate more easily falsifiable theories: The theoretician's task is to fabricate theories which are capable of being corroborated, theories which, although they appear highly falsifiable, nevertheless withstand the test of falsifiability. The most highly prized theory is the theory with the greatest empirical content which withstands the most severe tests.

The above example casts doubt on the assertion that the theory with the greatest empirical content is the most desirable. There still remains the question of whether the theory with the greatest empirical content, or the strongest theory, is the simplest theory. Certainly one could not attribute this view to either Russell or Quine. Both Russell and Quine feel that the simplest theory is the one with least content, the weakest (the

⁵⁶Stephen F. Barker, "On Simplicity in Empirical Hypotheses," Philosophy of Science, Vol. 28 No. 2 (1961) pp. 169-170.

one with the fewest commitments or the vaguest). They naturally add to this the belief that the theory with the least content is the theory that is most likely to be successful (most likely to be confirmed or most likely to be true). So Russell and Quine are in opposition with Popper with respect to the statement that the simplest theory is the strongest theory.

CHAPTER IV
AN ANALYSIS OF PARSIMONY

1. The attempted justifications of the principle of parsimony that we have cited are reminiscent of the more famous attempted justifications of the problem of induction. It is possible that there are parallels between the two problems that can be exploited; it may be fruitful to compare the metaphysical justifications, pragmatic justifications, inductive justifications, and epistemic justifications of the principle of parsimony with the metaphysical justifications, pragmatic vindications, inductive justifications, and linguistic dissolutions of the problem of induction.

The problem of induction, which we have previously mentioned when discussing Mill's rejection of metaphysical principles restricting science, is Hume's problem of justifying inferences about matters of fact. Briefly, Hume's problem is that if reasoning about matters of fact are non-demonstrative, then there can be no deductive nor any inductive justification of induction. Deductive justifications are ruled out because reasonings about matters of fact are non-demonstrative; and inductive justifications are ruled out because they would be circular. Of course, some logicians have insisted that there are ways of rendering non-demonstrative reasonings about matters of fact into demonstrative reasonings

by supplying a missing premise (or set of premises) dealing with the simplicity of nature or the orderliness of events. These attempted justifications have been termed metaphysical justifications. Other logicians have attempted to prove that the circularity of the inductive justifications of induction is illusory, that it is a hasty application of the standards of deductions to induction. The justifications held by these logicians have been termed inductive justifications.

Inductive justifications and metaphysical justifications are two approaches one might take to the problem of induction. These approaches, in effect, deny a premise of Hume's argument. Another approach would be to accept Hume's problem and to offer, not a justification, but something which would be almost as acceptable, a pragmatic vindication of the problem of induction. The pragmatic approach is characterized by the acceptance of Hume's argument and the attempt to prove that inductive policies are in some sense reasonable: what is offered is a vindication of induction, not a validation of induction. Finally, one might approach Hume's problem by rejecting it completely. One might feel that Hume's problem is engendered by a conceptual or linguistic confusion. One might feel that Hume's problem can be dissolved by looking carefully at what is meant by "being rational." This approach would result in a linguistic dissolution of the problem of induction.

It must be stressed that what we are looking at are the parallels between these justifications and the justifications of parsimony. We are not extremely interested in a unique solution to the problem of induction. We are using the literature on the problem of induction because we feel that some of the criticisms levelled at the attempted justifications of induction might be applicable to the attempted justifications of parsimony. Of course, some of the criticism is clearly inapplicable. For example, the claim that inductive justifications of inductions are circular would not be applicable to inductive justifications of parsimony. There can be no immediate reason why one could not justify the use of simpler theories inductively. Perhaps it is the case that the simpler theories have usually turned out to be correct in the past and we can infer by inductive generalization that they are likely to continue to be correct. One could argue, though, that the justification of parsimony is in some way prior to the justification of induction. One could argue that in making inductive generalizations one presupposes a principle of parsimony so that induction cannot be used to establish parsimony. Clearly one ought also look at the relationship between induction and parsimony, whether they are independent principles or interdependent principles.

2. The justifications of parsimony for which the clearest parallels can be drawn with the justifications of induction are the metaphysical justifications and the pragmatic justifications.

Some of the criticisms directed at the metaphysical justifications and pragmatic vindications of induction are directly applicable to the justification of parsimony. For instance, one of the most frequent criticisms of such metaphysical principles for induction such as the uniformity of nature is that even if the principle were true, it would not be required for making inductive inferences. The principle is too vague to be of use in any particular case. Let us assume that the principle that nature is uniform means "what happens once will, under a sufficient degree of similarity of circumstances, happen again." As Morris R. Cohen and Ernest Nagel argue, that principle is vague in so far as it does not tell us what counts as a sufficient degree of similarity. In any particular case we must rely on other criteria.¹ Further, "the principle does not affirm that every pair of phenomena are invariably related. It simply states that some pairs are so connected. To appeal to the doctrine in a particular investigation is therefore useless."² Similarly, one could argue that a principle like "nature is simple" is too vague to be of use in any particular situation. Even when the need for simplicity is recognized it is extremely difficult to realize where the path of true simplicity lies; the principle does not help. There are different kinds of simplicity which might even conflict.

¹Morris R. Cohen and Ernest Nagel, "The Doctrine of the Uniformity of Nature," Probability, Confirmation and Simplicity, p. 375.

²Ibid.

Let us suppose that the metaphysical principle from which parsimony derives its justification is more specific than "nature is simple;" let us suppose that it is Hamilton's ontological principle, "nature does not work by more and more complex instruments than are necessary." Without even considering the "more complex" part of the dictum, there is an ambiguity present. The instruments that nature is parsimonious with respect to could be laws or they could be entities. These two aspects of Hamilton's law of parsimony are well represented by two principles which Hamilton cites, "nature does nothing in vain" and "entities must not be multiplied without necessity." "Nature does nothing in vain" might require that everything nature does is in keeping with some set of laws. And "entities must not be multiplied without necessity" might require that nature do everything with a certain set of entities. The ambiguity of such laws of parsimony is not accidental. The ambiguity stems from the fact that nothing is just simple. A given thing, "A," is simple only with respect to some aspect, "B." (Actually, the analysis of simplicity is more intricate than that. Nothing is simple by itself either. A given thing, "A," may be simpler than another thing, "C," with respect to "B." We will discuss this in more detail later.) That fact that any "A" is simple only with respect to some aspect "B" indicates that there could be no general metaphysical principle like "nature is simple" which is applicable in particular cases. In particular cases it is very difficult to prove that anything is necessarily superfluous in

every regard; it may even be superfluous in one regard and necessary in another. Some things may be simpler than another in some way while being more complex than the other in another way. It is entirely impossible to legislate a priori on this matter by means of a metaphysical principle of parsimony.

Taking the Copernicus-Kepler system as an example for discussion, an example which has often been cited as a case where simplicity has "guided. . .the development of human thought,"³ we can demonstrate the different kinds of simplicity at work. If we can show that there is no single principle of simplicity that can be appealed to, we can argue that there can be no metaphysical principle of parsimony. The Copernicus-Kepler system is a proper example for discussion because Copernicus himself thinks that simplicity is a powerful argument in his favor. Further, the simplicity that Copernicus credits his system with is the ontological simplicity of having fewer basic notions, in this case, fewer circles, spheres or wheels. In the Commentariolus Copernicus proudly announces that "altogether thirty-four circles suffice to explain the entire ballet of the planets."⁴ Thirty-four circles would be fewer circles than the number needed by Ptolemy (around eighty). And in the De Revolutionibus Copernicus insists

³W. T. Jones, The Medieval Mind, p. 322.

⁴Copernicus, Commentariolus, Three Copernican Treatises, Trans. Edward Rosen, Dover (N.Y. 1959) p. 90.

that his system is simpler than Ptolemy's. Copernicus insists that the simplicity of his system makes it the better system because it follows nature which itself is simple: "I think it easier to believe this than to confuse the issue by assuming a vast number of spheres. . . . We thus rather follow Nature, who producing nothing vain or superfluous, often prefers to endow one cause with many effects."⁵ Copernicus is not the only natural philosopher of his era who has thought that the heliocentric system is preferable to the geocentric system because of its simplicity. Rheticus, a student of Copernicus, cites the simplicity of the heliocentric system as one of its major benefits:

Fifthly, mathematicians as well as physicians must agree with the statements emphasized by Galen here and there: "Nature does nothing without purpose. . ." Should we not attribute to God, the creator of nature, that skill which we observe in the common makers of clocks? For they carefully avoid inserting in the mechanism any superfluous wheel or any whose function could be served better by another with a slight change of position.⁶

Clearly, the statement that Copernicus and others have thought the heliocentric system preferable to the geocentric because it is simpler with respect to its number of circles is true. That

⁵Copernicus, De Revolutionibus Orbium Caelestium, trans. by John F. Dobsn & Selig Brodetsky in Occasional Notes of the Royal Astronomical Society Vol. 2, No. 10 (London, 1947) as quoted in Thomas Kuhn, The Copernican Revolution, Vintage Books (N.Y. 1957) p. 179.

⁶Rheticus, Narratio Prima, Three Copernican Treatises, pp. 137, 138.

they were right in their belief is probably not true.

Without a doubt the heliocentric system removes from the Ptolemaic system these epicycles which explain retrograde motion. But the heliocentric system's other difficulties would force Copernicus to add eccentrics and epicycles which are not needed in the Ptolemaic system. Copernicus would need so many of these that, depending upon how one counted, one could claim that Copernicus' system contains more circles than Ptolemy's system.⁷ There is even a defender of Ptolemy, Christopher Clavius who argued that the Copernican hypothesis is not as good as the Ptolemaic hypothesis because it is less simple: "It requires the assumption of an enormously greater number of spheres--and it is a well-known maxim of philosophy that "it is useless for something to be done by more that can be done equally well by fewer."⁸ Evidently, counting the number of circles needs not be the only way to judge whether a given system is simpler; one would also need to know which circles to count. There has to be

⁷See for example Derek de S. Price, "Contra-Copernicus A Critical Estimation of the Mathematical Planetary Theory of Ptolemy, Copernicus and Kepler," Critical Problems in the History of Science, Ed. Marshall Clagett, U. of Wisconsin Press (Madison, Wisc., 1969) pp. 198, 199, 217, or E. J. Dijksterhuis, The Mechanization of the World Picture, trans. C. Dikshoorn, Oxford University Press (Oxford, 1961) pp. 293-295.

⁸Christopher Clavius, In Sphaeram Ioannis de Sacro Bosco Commentarius, Gabiano (Lyon, 1602) as quoted in Ralph M. Blake, Curt J. Ducasse, Edward Madden, Theories of Scientific Method; The Renaissance through the Nineteenth Century, U. of Washington Press (Seattle, 1960) p. 34.

some truth to the thought that the Copernican system is simpler than the Ptolemaic system; yet one can point out thinkers who consider the Copernican system to be more complex. Copernicus' system is more complex than Ptolemy's system in a way other than "circle counting." Copernicus uses a different kind of epicycle, a more complex epicycle which Ptolemy refrained from using, a "second-order" epicycle; in order to explain some discrepancies Copernicus utilizes epicycles on epicycles. It is clear that there are different kinds of simplicities at work. It is not true that the only simplicity which counts is the simplicity with respect to the number of basic notions. That which one counts may vary depending upon the notion of simplicity one is using. And there is a simplicity with respect to the kind of notion used.

If one thinks that what counts is the simplicity of the number or kind of basic notions of any system, one is also disregarding the fact that the derivations of the system with the simpler number or simpler kinds of notions are bound to be complicated in kind. Assuming that one prefers the Copernican hypothesis for the reason that its basic notions are simpler, then one would have to reject the Keplerian addition for the same reason. As Nelson Goodman states,

The advocate of epicycles might argue that the more elaborate construction and computations required by his system are the symptomatic results of the greater simplicity of his elementary concepts. If we are tempted to dismiss the idea that circles are simpler than ellipses as a mere superstition, we shall be embarrassed by the fact that,

as remarked above, we employ some such notions of the relative simplicity of curves when we choose one to fit the plotted points in order to extrapolate from determined data to untested cases.⁹

These two kinds of simplicity may be termed semantical simplicity and syntactical simplicity, respectively. Mario Bunge in "The Weight of Simplicity in the Construction and Assaying of Scientific Theories," recognizes epistemological simplicity and pragmatic simplicity as well.¹⁰ He states "the various kinds of simplicity are not all compatible with one another and with certain desiderata of science."¹¹ Thus Mr. Bunge joins Mr. Goodman in formulating an injunction against a broad principle of simplicity. The Copernican hypothesis must have succeeded for reasons other than simplicity. Mr. Bunge states that the Copernicus-Kepler system satisfies criteria of external consistency, explanatory and predictive powers, representativeness, fertility, refutability, and world-view compatibility better than any of its rivals could.¹² These criteria, not simplicity, are more likely the good reasons

⁹Nelson Goodman, "The Test of Simplicity," Science Vol. 128 (1958) p. 1064.

¹⁰Mario Bunge, "The Weight of Simplicity in the Construction and Assaying of Scientific Theories," Philosophy of Science, Vol. 28, (1961) pp. 121, 122. See also Mario Bunge, The Myth of Simplicity, Prentice-Hall (Englewood Cliffs, N.J., 1963) pp. 66-84 and Mario Bunge, "The Complexity of Simplicity," Journal of Philosophy, Vol. 59 (1962) pp. 113-135.

¹¹Ibid., p. 132.

¹²Ibid., pp. 139, 140.

for the success of the Copernicus-Kepler system. Simplicity is not a single easily realized property of any system. It does not help us to think that nature is simple if one cannot tell in what way it is simple. A principle like "nature is simple" can only be too vague and useless when an application to a particular case is attempted. Worse, the principle is so broad that its application is likely to give rise to some inconsistencies.

It ought to be pointed out that a principle like "nature is simple" is so broad that such principles like "nature is uniform" are included under it. It is not true that "nature is simple" can be derived from "nature is uniform." If "nature is uniform" means that nature is constant with respect to its laws, then "nature is simple" cannot follow from it. The set of laws that nature is constant with respect to can be an extremely complex set, so complex that even without the considerations above it would not be useful to appeal to the principle when deciding any particular case. On the other hand, nature being constant with respect to its laws could be one of the ways nature is simple. One can derive the uniformity of nature from the simplicity of nature, but not vice-versa.

The problems with metaphysical principles of parsimony as discussed above might undermine the inherent appeal of such principles. But metaphysical principles of parsimony suffer another difficulty, a difficulty which can be demonstrated even if it were possible to have a unified metaphysical principle of parsimony. This problem deals with the fact that simplicity

is not absolute, but comparative. We can allow that there might be no problems with simplicity stemming from the fact that things are simple only with respect to some aspect or other, and focus on the fact that things are not simple, but simpler than others. "Nature is simple" might mean that the actual world is the simplest of all possible worlds. But no philosopher except Parmenides could hold that statement to be true. The simplest possible world must be a monistic world. Philosophers and scientists who hold that the world is simple do not normally also hold a monistic philosophy. They must then detail their reasons for maintaining their faith in the metaphysical principle that the world is simple and the fact that they do not think that it is as simple as it could be. In order to reconcile the two attitudes they must develop a teleology (possibly, they already have a teleology which determines their metaphysical principle of parsimony). Metaphysical principles of parsimony go hand in hand with teleological principles. The philosophers and scientists must refer to the creator's purposes so that "nature is simple" would mean that nature is the simplest possible system needed to achieve those purposes.

The criticisms developed above are meant to apply to Aquinas' principle, Russell's atheistic principle, Hamilton's principle, Newton's law of two causes, and Copernicus' principle. The criticisms do not apply to Aristotle's stronger principle. Aristotle's stronger principle does not depend on the simplicity

of nature; it depends on its goodness. It is an avowed teleological principle; and it is limited. Aristotle's strong principle of parsimony is philosophically more tenable than the unrestricted metaphysical principles of parsimony. It must be pointed out, though, that scientists have not restricted their theories to those which represent the universe as finite or to those which represent the universe as continuous.

3. Pragmatic justifications of parsimony suffer the same drawbacks as pragmatic vindications of induction. Reichenbach's pragmatic vindication of induction, which we will take as our paradigm of pragmatic vindications of induction, derives its plausibility from a broad analogy. We suppose that a fisherman on a lake wishes to catch fish. Convinced by Humean arguments he begins to wonder whether he ought to cast his net. Reichenbach points out that casting one's net may not get good results. There may also be no fish in the lake. Of course, the fisherman is surely not going to catch any fish if he does not cast his net, whether or not there are any fish in the lake. The only way one could catch a fish, if it is at all possible, is by casting one's net. Similarly, induction may or may not work. But if we are to succeed in predicting the future we must use induction; the question is not whether induction can be justified, but whether induction is preferable to other methods.

If we were to contrast induction with other methods, crystal ball gazing, for example, we would quickly perceive the superiority

of induction to that method. It may be that in a given world induction succeeds in its predictions and crystal ball gazing does not. In another world it is possible that both methods succeed and in a third world neither methods succeed. In all three worlds it makes sense to use induction instead of or along with crystal ball gazing. Finally in a fourth world crystal ball gazing succeeds whereas induction seems to fail. In that world the success of crystal ball gazing would be a regularity that can be exploited inductively. Induction is thereby shown to be the preferred method. If any method works, induction does. Induction is vindicated.

The problem with Reichenbach's vindication is that it vindicates too much. Any asymptotic rule is vindicated, an asymptotic rule being a rule which shares with induction by enumeration the property "of yielding inferences that converge to the limit of the relative frequency whenever such a limit exists."¹³ The reason that we are talking about relative frequencies and limits is that Reichenbach phrases his solution to the problem of induction within the framework of the frequency interpretation of probability. Essentially, Reichenbach's rule of prediction is "predict that the observed frequency or observed statistical uniformity of a series of events is the same as the limit of the sequence of events." Reichenbach's rule has the virtue of allowing us to make statistical generalizations as well

¹³ Wesley C. Salmon, The Foundations of Scientific Inference, U. of Pittsburg Press, (Pittsburg, 1966) p. 88.

universal generalizations. The inductive rule governing universal generalizations is the degenerate case where the observed relative frequencies are "1:" "When all observed A's have been B's predict that all A's are B's" is simply an edict to follow the rule of predicting that the limit is the same as the observed frequency. In this case the observed frequency with which A's have been B's is "1." The problem with all this is that there are an infinite number of possible asymptotic rules. We can construct an asymptotic rule by diverging from the observed frequencies by any amount we wish as long as the difference converges to zero as the number of frequencies increases. This thought is captured in the analogy for the pragmatic vindication of induction by the statement that any self-corrective rule will be judged as better than any non-self-corrective rule, but as well as induction. As long as this possibility exists, we have not vindicated induction.

Similarly, the pragmatic justification of parsimony as a method for proceeding in any orderly manner in science is not a sufficient justification. Certainly it is the start of a reasonable justification for parsimony, but it is also a justification for any method which can be agreed upon. The only reason given to uphold parsimony is that time will be economized in the long run by proceeding in an orderly manner. But time will be economized in the long run if we upheld any principle. We could agree upon "choose the second simplest hypothesis" or we could agree upon "choose the most complex hypothesis." One could argue

that "choose the most likely hypothesis" might even economize more time in the long run. It may be fruitful to conduct a survey of situations which have occurred and hypothesize over which rule would actually have economized time in reaching the present state of knowledge.

Peirce's justification for Ockham's razor justifies any principle which gives an ordering of the theoretical possibilities. There is no reason to prefer the ordering which starts with the simplest and works up; it is not as if the simplest possible theory is always known, either. And, if the criticisms which are applicable to metaphysical justifications of parsimony are applied here, one would have to consider that the simplest theory is not easily determined. It is difficult, if not impossible, to give an ordering of the possibilities in terms of simplicity. This points out that, for the sake of economy of time in the long run, it may be best to consider all hypotheses one at a time as they arise. In fact, this interpretation of parsimony is the interpretation of Ockham's razor given by Harold Jeffreys in the Theory of Probability: "Variation is random until the contrary is shown; and new parameters in laws, when they are suggested, must be tested one at a time unless there is a specific reason to the contrary."¹⁴ Mr. Jeffreys later clarifies what he means by "variation is random" by stating "variation must be taken as random until there is

¹⁴Harold Jeffreys, The Theory of Probability, The Clarendon Press (Oxford, 1939) p. 272.

positive evidence to the contrary."¹⁵

4. Inductive justifications of parsimony form a large family of justifications. They all have in common the belief that past experience has shown that simpler theories are preferred over the more complex ones. A subset of inductive justifications is the set of justifications which holds that past experience has shown that simpler theories are more often true or more probable. This is the set of justifications which is justified inductively (in the strictest sense of inductive justification). Russell and Quine's justifications of parsimony fall in the latter camp. In Russell's case, simplicity engenders safety and the safer theory is more often true. Popper's justification falls in the broader category. In Popper's case, simplicity engenders strength and the stronger theory can be corroborated more highly. In both cases one may wonder whether the simpler theory is always what it is claimed to be, the safer theory or the stronger theory. In Russell and Quine's case an additional question may be raised. In fact, the additional question which may be raised is relevant to any justification of parsimony which is justified inductively. It is the question of logical circularity. If it can be shown that induction presupposes simplicity, then induction cannot be used to justify simplicity. We will attempt to show that inductive justifications of parsimony are circular.

¹⁵Ibid., p. 345.

If Popper is right that the simpler theory is the stronger theory and the stronger theory is more likely false, then Russell and Quine must be wrong. Russell and Quine hold that the simpler theory is the safer theory and that the safer theory is the one which is more likely true. The reverse must be trivially true; if Russell and Quine are right, then Popper must be wrong. This point is independent of the point made in Chapter III that Popper is wrong in thinking that the more highly falsifiable theory is always preferred. Naturally, it is possible that neither position is right. Nelson Goodman argues that neither safety nor strength is the same as simplicity. He cites the following three hypotheses as examples:

- (1) All maples, except perhaps those in Eagleville, are deciduous.¹⁵
- (2) All maples are deciduous.¹⁶
- (3) All maples whatsoever, and all sassafras trees in Eagleville are deciduous.¹⁷

By some intuitive criterion of simplicity one would have to agree that (2) is simpler than both (1) and (3). But clearly, (1) is safer than (2) and (3) is stronger than (2). Hence strength, safety, and simplicity, if they are properties of hypotheses, are independent properties. Lest it be thought that perhaps the weaker

¹⁵Nelson Goodman, "Safety, Strength, Simplicity," Philosophy of Science Vol. 28 (1961) p. 151.

¹⁶Ibid.

¹⁷Ibid., p. 152.

statement "if it is a simpler hypothesis then it is a safer hypothesis," holds one ought to show that (2) is both simpler and less safe than (1). "If it is a simpler hypothesis it is a stronger hypothesis" is falsified by the fact that (2) is both simpler and less strong than (3). The only thing we can conclude is that sometimes when two theories are compared, the simpler theory might turn out to be the safer theory, or the simpler theory might turn out to be the stronger theory. There can be no general statement that the simpler theories are the safer theories; nor can there be any general statement that the simpler theories are the stronger theories. This must mean that the first step in Russell and Quine's justification of parsimony cannot be achieved. That same is true of Popper's first step.

But the second step remains. One can divorce inductive justifications of parsimony from the peculiarities of safety and strength. One can claim that the simpler theories are preferred to the more complicated theories because past experience has shown that the simpler theories are more often true. Stephen Barker points out that the induction from past experience of simplicity to the future is of a kind which involves passing from the statement "all observed A's are B's" to "all A's are B's." The justification of this particular induction conclusion itself rests on some principle of simplicity. Therefore, any attempt to construct an inductive argument which shows that it is probable that the simpler hypothesis more often is true would involve one in a logical circle.

Mr. Barker supposes that we are trying to set up an experiment whereby we can show that simpler hypotheses are more often true than the more complex ones. He supposes the sphere of inquiry to be the thermal expansion of various substances at different temperatures. He would collect some data from his experiments; then for each substance he would decide what was the simplest possible hypothesis which was consistent with the collected data. He would then collect more data to see whether the simplest hypothesis was consistent with the new data. If it were true that the simpler hypothesis was consistent in the many cases, one might claim that one had the start of an inductive proof that the simpler hypothesis was more likely to be true than the more complex one. Mr. Barker claims that the above experiments do not succeed in giving an inductive justification of simplicity. The experiments are "compatible with the generalization that considerations of simplicity are usually successful in predictions about thermal expansion; but they are compatible also with the generalization that simplicity considerations are usually successful in predictions in other spheres."¹⁸ Our data is also consistent with many other generalizations: that simplicity works for small American laboratories on weekdays, if those were the conditions under which the experiments were performed. Simplicity

¹⁸Barker, "On Simplicity in Empirical Hypotheses," p. 167.

might not work in large laboratories or in foreign laboratories, or on weekends. "Pure induction gives us no more reason for projecting one of these regularities than projecting the other. It is only if we appeal to considerations of simplicity that we have any reason for projecting the simpler regularity in preference to the more complex one."¹⁹ Mr. Barker concludes with the statement that his result is general. No matter how varied the data was, there would be unobserved regularities with which the observed cases would be compatible. It would then be necessary to appeal to some principle of simplicity to decide which regularity would be projected. Inductive reasoning cannot justify simplicity.

Mr. Barker's argument can be rephrased. We can consider the same laboratory experiments that we conducted: We make some observations about how some substances expand with temperatures. We take a sample of each substance and observe its length at different temperatures. We then plot a graph, using the simplest curve which fits our observations. We make some further observations. If the further observations corroborate our simple hypothesis, we might wish to make the inductive inference that the simplest hypothesis is consistent with our experiences. However, we can consider a new predicate, "implest" which is to be understood as applying to a hypothesis at a given time if, and only if, either the hypothesis is the simplest consistent with the facts

¹⁹ Ibid.

and the time is a weekday, or the hypothesis is not the simplest and the time is a weekend. In the experiment above, the "implest" hypothesis is also consistent with our experiences.²⁰ We could consider many other predicates; "amplest," simplest if the laboratory is American, not simplest otherwise, or "gimplest," simplest if the year is prior to 2000 A.D., but not simplest otherwise. The "amplest," "gimplest" and other hypotheses are also consistent with our experiences. We cannot consistently make all those conflicting generalizations.

The above version of Mr. Baker's argument is purposefully reminiscent of what is called "the new problem of induction," Mr. Goodman's problem with the un-projectible statements which use the predicates "grue" and "bleen," constructed as above.²¹ This problem was first detailed in Fact, Fiction and Forecast where Mr. Goodman proposed "entrenchment" as a criterion whereby one could decide which predicates engendered statements which are projectible and which engendered statements are unprojectible. In a later article Mr. Goodman states "I have discussed these matters in Fact, Fiction and Forecast; and the criteria of projectibility I have outlined there in terms of entrenchment is perhaps essentially a simplicity criterion."²² Mr. Goodman must

²⁰ See Stephen Barker, "Rejoinder to Salmon," Current Issues in the Philosophy of Science, Ed. Herbert Feigl and Grover Maxwell, Holt, Reinhart and Winston (N.Y. 1961).

²¹ See Nelson Goodman, Fact, Fiction and Forecast, Bobbs-Merrill (N.Y. 1965).

²² Nelson Goodman, "Safety, Strength, Simplicity," p. 151.

also think that induction presupposes simplicity. Induction cannot be used to justify simplicity.

The arguments of Mr. Barker and Mr. Goodman show that no general justification of simplicity can be given by induction. They do not show that specific inductive justifications cannot be realized. Mr. Barker's argument amounts to an argument that Goodman-type simplicity is presupposed by induction. In this Mr. Goodman agrees. The argument proves that an inductive justification of Goodman-type simplicity is bound to be circular. But some circles are not vicious. One is still able to give inductive justifications of some principles of simplicity. Since there are different kinds of simplicity, one can use induction to establish those varieties of simplicity that are not presupposed by induction. In effect, one can use Goodman-type simplicity to establish other kinds of simplicity as soon as Goodman-type simplicity is established by other means. There can be no objection to using one kind of simplicity to establish another kind of simplicity. The conclusion one can arrive at is that some principles of simplicity can be justified inductively. Other principles of simplicity cannot be justified inductively because induction presupposes them. Therefore, one cannot give a general inductive justification of simplicity.

5. We have indicated that metaphysical, pragmatic, and inductive justifications of parsimony are, in some way, defective. Metaphysical justifications are defective because they depend on

principles like "nature is simple." These principles are vacuous. Simplicity is a complex property; things are not just simple, but simpler than another thing with respect to some aspect. That which is simpler than another thing with respect to some aspect may be more complex than that thing with respect to another aspect. No single principle of simplicity can be appealed to. Pragmatic justifications are defective because they justify too much. Peirce's justification seems to justify any principle that gives an ordering for the testing of theories. Inductive justifications are defective because in some cases induction presupposes simplicity. Further, some of the inductive interpretations of parsimony (and simplicity in general) like safety and strength of hypotheses do not seem to capture the concept of parsimony (and simplicity).

It remains for us to discuss whether an epistemic justification of parsimony can be accomplished. An epistemic justification is a justification like the one proposed by Peter Strawson in Introduction to Logical Theory as a dissolution of the problem of induction. It argues that no general justification of induction is needed if one can show that induction is constitutive (or definitory) of reason (induction is necessary to our conceptual framework). The argument is as follows: The justification of a specific inference would consist in showing that the inference to be justified conforms with certain accepted rules of inference. These rules of inference can in turn be justified by reference to other rules. But to ask for a justification of all rules of inference is without sense. A parallel is drawn between the

justification of induction and the justification of deduction. To ask for a general justification of deduction would be to ask for the grounds for regarding that deduction as valid. But to say that a statement is valid is to imply that it is deductive. Therefore it is senseless to ask for a general justification of deduction. Pursuing the parallel, "if a man asked what grounds there were for thinking it reasonable to hold beliefs arrived at inductively, one might at first answer that there were good and bad inductive arguments, and that sometimes it was reasonable to hold a belief arrived at inductively and sometimes it was not. If he, too, said that his question had been misunderstood, that he wanted to know whether induction in general was a reasonable method of inference, then we might well think his question senseless in the same way as the question whether deduction is in general valid."²³ A general justification of deduction would be a proof that deductive arguments are valid; a general justification of induction would be a proof that inductive arguments lead to reasonable beliefs. But to call an argument valid is to apply deductive standards just as to call a belief reasonable is to apply inductive standards: "to ask whether it is reasonable to place reliance on inductive procedures is like asking whether it is reasonable to proportion the degree of one's convictions to the strength of the evidence. Doing this is what 'being reasonable' means in such a context."²⁴ The

²³Peter Strawson, Introduction to Logical Theory, John Wiley and Sons (N.Y. 1952) p. 249.

²⁴Ibid., p. 257.

argument depends on the notion that induction is in a strong sense constitutive of reason; reasonable beliefs are defined in terms of inductive standards just as valid statements are defined in terms of deductive standards.

Wesley Salmon in "Should we attempt to Justify Induction?" rephrases Strawson's argument; Salmon uses a distinction coined by Herbert Feigl to sort it out. Feigl distinguishes two kinds of justifications, validations and vindications. An inference is validated if it can be shown that it is governed by an acceptable rule. A vindication consists in showing that a given policy is well adapted to achieving a given end. Under this terminology, Strawson's thesis amounts to the claim that no general validation can be given for induction; only particular inferences can be validated. The question remains whether Strawson has shown that no vindication of induction is needed. Salmon thinks not. Even if there is an argument which purports to establish that reasonable beliefs are beliefs which have good inductive support, it would not be sufficient to vindicate induction. The further question would remain, "is it reasonable to be reasonable?"²⁵ That is, are the methods we consider reasonable the best suited to the attainment of our ends? Is being scientific or proceeding according to the standard inductive methods the best methods for establishing conclusions about matters of fact? Mr. Salmon states, "If we

²⁵ Wesley C. Salmon, "Should we Attempt to Justify Induction?" Philosophical Studies, Vol. 8 (1957) p. 41.

regard beliefs as reasonable simply because they are arrived at inductively, we still have the problem of showing that reasonable beliefs are valuable. . . it would seem that we use inductive methods, not because they enable us to make correct predictions or arrive at true explanations, but simply because we like to use them."²⁶ Salmon's challenge requires Strawson to demonstrate that induction is the best method for our purposes, and not to elevate "inductive methods to the place of an intrinsic good."²⁷

Perhaps more is needed in order to justify induction. Perhaps in the case of induction it would be necessary to demonstrate that inductive methods or the methods of science are the best suited methods to arrive at true explanations. It may even be that the best way to demonstrate that inductive methods are superior to other methods would be to show that inductive methods are self-correcting, as the pragmatic theorists would have it. But this does not mean that all epistemic justifications suffer that difficulty. It may be that some statements can be given an epistemic justification without requiring any further vindication. These statements would be in the class of statements for which it can be shown that the acceptance of the statement or the acceptance of its competing statement would make no cognitive difference. We can use Quine's "gavagai"²⁸ as an example of this class of

²⁶ Ibid., p. 42.

²⁷ Ibid.

²⁸ See Willard Van Orman Quine, Word and Object, M.I.T. Press (Cambridge, 1960) and Willard Van Orman Quine, Ontological Relativity and Other Essays, Columbia University Press (N.Y. 1969).

of statements. "Gavagai," a term to be translated by a field linguist, might mean "rabbit" or "undetached rabbit part" or "rabbit stages" or "temporal rabbit slices." There is no way of determining between these. Whenever one is true, they are all true. Quine calls this the indeterminacy of translation. One might think that it is arbitrary which meaning we choose, or which translation the linguist will opt for. It is not so; only one of the above possibilities is natural to us: We are forced to consider a "gavagai" as an object, a rabbit. As Quine states, "English general and singular terms, identity, quantification, and the whole bag of ontological tricks may be correlated with elements of the native language in any of various mutually incompatible ways, each compatible with all possible linguistic data, and none preferable to another save as favored by a relationalization of the native language that is simple and natural to us."²⁹ Although the translation of "gavagai" is indeterminate, one might say that it is part of our conceptual framework to consider "gavagai's" as rabbits, and not undetached rabbit parts or temporal rabbit slices:

The arbitrariness of reading our objectifications into the heathen speech reflects not so much the inscrutability of the heathen mind, as there is nothing to scrute. Even we who grew up together and learned English at the same knee, or adjacent ones, talk alike for no other reason than that society coached us alike in a pattern of verbal

²⁹Quine, "Speaking of Objects," Ontological Relativity, pp. 4, 5.

responses to externally observable cues. We have been beaten into an outward conformity to an outward standard; and thus it is that when I corrolate your sentences to mine by the simple rule of phonetic correspondence, I find that the public circumstances of your affirmations and denials agree pretty well with those of my own.³⁰

Although we are using Quine's example as a member of a class of statements which may be justified epistemically (using Strawson's argument) without the difficulties which Salmon points out, we do not mean to suggest that Quine and Strawson are in agreement on this matter. Quine states that his example suggests that these matters are more arbitrary and conventional than they are usually taken to be. If one thinks, as Quine does, that the adoption of an object language (instead of a language which deals with temporal slices) is a conventional matter, one might also think the same about the adoption of inductive methods. But one might take a different philosophical stance and consider both as "natural." As Strawson says of Hume (in a most approving manner), "He did not think that our 'basic canons' were arbitrarily chosen; he saw that this was a matter in which, at the fundamental level of belief-formation, we had no choice at all. He would, no doubt, have agreed that our acceptance of the 'basic canons' was not forced upon us by 'cognitive considerations' (by reason); for it is forced upon us by Nature."³¹

³⁰ Ibid., p. 5.

³¹ Peter Strawson, "On Justifying Induction," Philosophical Studies, Vol. 9 (1958) p. 21.

Clearly Strawson does not think that any further justification of induction is necessary because he thinks that these matters are not conventional but forced upon us by nature (he also thinks that these matters are not forced upon us by cognitive considerations for the same reason as above: we have no choice in this matter. We cannot decide which method to adopt, inductive methods or the method which may be better suited to achieve our ends.) That induction is forced upon us by nature is a debatable matter. That an object language is part of our conceptual system is less in doubt.

For some statements, a sufficient justification would be that they are constitutive of reason and that they are not forced upon us by cognitive considerations, that the adoption of the statement or the adoption of the rival statement would make no cognitive difference, would make no difference toward the achievement of our ends. Examples of such statements are those which require us to translate "gavagai" as an object instead of a temporal slice as long as it is part of our conceptual scheme to objectify. The same kind of justification can be given to principles of parsimony. If one were to ask for a justification of parsimony one would refer to principles such as "statements should not be affirmed without reason." "Statements should not be affirmed without reason" is Ockham's justification for his principle of parsimony. It is a principle of sufficient reason and it may be thought of as constitutive of reason. Similarly, one would think that an epistemic

justification can be given to Mill's principle of parsimony. Parsimony, according to Mill, is basic to all thought. One ought not suppose, without sufficient evidence, that a specific stone falling has a different cause than that which governs all stones falling. Doing so is likened to considering that a stone has a different property than other stones simply because it is a different individual. According to Mill, parsimony is dependent on principles of sufficient reason which are epistemic principles. The justification of principles of parsimony depends on principles of sufficient reason. Principles of sufficient reason, in turn, are justified (or need no justification) because they are constitutive of reason.

One must note that principles of sufficient reason are not forced upon us by cognitive reasons. Like the decision between rabbit and rabbit stage, if it is made at all, it is not made for cognitive reasons. One can think of principles of sufficient reason as requiring us to consider hypotheses in some order. It cannot make a difference to the truth of the hypotheses which order we consider them in. Principles of sufficient reason therefore satisfy the requirement that their acceptance would make no cognitive difference, if they are to be justified epistemically without needing any further vindication. These principles ask us to work with what we have, to assume that there will be no differences that matter solely because something is a different individual.

We have argued for a possible justification with regards to parsimony. One could hold that parsimony is justified by reference to principles of sufficient reason. These are justified by the fact that they are constitutive of reason, and that the adoption of these principles is not forced upon us by cognitive considerations. It remains for us to show, somewhat anachronistically, that this was Ockham's justification of parsimony. It is not sufficient, of course, to show that Ockham thought that parsimony was justified by reference to principles of sufficient reason because he could have justified the principles of sufficient reason in many different ways. It is open to Ockham to justify the principles of sufficient reason metaphysically, inductively, and pragmatically, as well as epistemically. We have already argued that Ockham could not have appealed to a metaphysical justification. We have also suggested that he was not likely to have appealed to an inductive justification either. It would depend on the status of the principle. If Ockham thought that his principle was justified inductively, he would have thought that it is a probabilistic principle. And of course, it may be too anachronistic to suggest that Ockham would have appealed to a pragmatic justification. The best evidence we have as to the kind of justification Ockham would have given his principle is Ockham's statement that his principle ought not be denied. It probably would be asking too much to be able to find in Ockham a statement to the effect that he thinks his principle is constitutive of reason; it may be sufficient to demonstrate that the status of

Ockham's principle is like that of definition. Ockham states:

In the first place it is settled thus: that, which can be accomplished through fewer, is needlessly accomplished through more; for this is a principle which ought not to be denied, that no plurality ought to be posited, unless it can be demonstrated through reason or through experience or through the authority of that one who can not be deceived or err.³²

In this passage Ockham formulates his principle of parsimony and justifies it by reference to a principle of sufficient reason which he says ought not be denied.

³²"Quod primo persuadetur sic: frustra fit per plura quod potest fieri per pauciora; hoc enim est principium quod negari non debet, quod nulla pluralitas est ponenda nisi per rationem vel experientiam vel auctoritatem illius, qui non potest falli nec errare, potest convinci." Ockham, *De Sacramento Altaris*, p. 318. Trans. by Birch, *Ibid.*, p. 319.

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