INFORMATION TO USERS

This manuscript has been reproduced from the microfilm master. UMI
films the text directly from the original or copy submitted. Thus, some
thesis and dissertation copies are in typewriter face, while others may
be from any type of computer printer.

The quality of this reproduction is dependent upon the quality of the
copy submitted. Broken or indistinct print, colored or poor quality
illustrations and photographs, print bleedthrough, substandard margins,
and improper alignment can adversely affect reproduction.

In the unlikely event that the author did not send UMI a complete
manuscript and there are missing pages, these will be noted. Also, if
unauthorized copyright material had to be removed, a note will indicate
the deletion.

Oversize materials (e.g., maps, drawings, charts) are reproduced by
sectioning the original, beginning at the upper left-hand corner and
continuing from left to right in equal sections with small overlaps. Each
original is also photographed in one exposure and is included in
reduced form at the back of the book.

Photographs included in the original manuscript have been reproduced
xerographically in this copy. Higher quality 6" x 9" black and white
photographic prints are available for any photographs or illustrations
appearing in this copy for an additional charge. Contact UMI directly
to order.
Constructive skepticism and the philosophy of science of Gassendi and Locke

Fisher, Saul L., M.A.

Rice University, 1992

Copyright ©1992 by Fisher, Saul L. All rights reserved.
RICE UNIVERSITY

CONSTRUCTIVE SKEPTICISM AND THE PHILOSOPHY OF SCIENCE
OF GASSENDI AND LOCKE

by

SAUL L. FISHER

A THESIS SUBMITTED
IN PARTIAL FULFILLMENT OF THE
REQUIREMENTS FOR THE DEGREE
MASTER OF ARTS

APPROVED, THESIS COMMITTEE

Mark A. Kulstad, Chair
Department of Philosophy

Steven Crowell, Associate Professor
Department of Philosophy

Donald Morrison, Assistant Professor
Department of Philosophy

Houston, Texas

April, 1992
Constructive Skepticism and the Philosophy of Science of Gassendi and Locke

Saul L. Fisher

Abstract

In the sixteenth and seventeenth century, empiricists such as Pierre Gassendi and John Locke accounted for the human capacity to know about the world by emphasizing sensory access to information. These philosophers entertained skepticist doubts concerning reasoned knowledge and concluded that sure knowledge of the world is won primarily by empirical or sense-based studies. These views on our general knowledge and certainty support a variety of claims concerning scientific knowledge in particular. On the basis of their constructive skepticist stances, these two empiricists support arguments for the reality of scientific objects and a strongly empiricist methodology of gathering and organizing scientific knowledge. The hallmarks of their empiricist philosophies of science are a background essentialism which motivates the search for underlying causes, a probabilism about theory confirmation, and a ranking of knowledge-types by degrees of certainty. The similarities of their views illuminate the influence of Gassendi’s writings on Locke. Their differences show us their varying conceptions of knowledge with certainty and of knowledge about the world.
Constructive Skepticism and the Philosophy of Science of Gassendi and Locke

Introduction

Pierre Gassendi and John Locke famously propose that there are general limits on our knowledge but their specific views on science and scientific knowledge are less well known. Their remarks on science are fragmentary and often indirect. Yet their straightforward epistemological views strongly suggest a picture of science marked by the limits on our certain knowledge. In this paper I demonstrate how their constructive skepticism supports fertile empiricist models of scientific knowledge, theory, and practice. These outlooks on the philosophy of science well suit the emerging new empirical science of Gassendi and Locke's day -- in which both philosophers played a parttime role.

What is Constructive skepticism?
The basic problem of traditional skepticism is whether we can judge that we have certain knowledge and thereby know about the world. The ancient Dogmatics claimed that we can make these judgements. The classic Academic skeptics reasoned that we have no grounds to assume that we can make those judgements, so we cannot judge that we know anything with certainty. Another group of skeptics, the Pyrrhonians, claimed that if we have no evidence by which to judge whether we have certain knowledge, then claims against the possibility of certain knowledge are as unprovable as the
claims for it. They therefore suspend judgement about the possibility (and "actuality") of certain knowledge and, like the Academics, accept appearances without certainty.¹

The ancient texts were generally lost or not read during the middle ages² and skepticism was revived in various forms in the Renaissance era. One such form is "constructive" or "mitigated" skepticism, the view that ancient Skeptics were right to claim that we cannot judge whether we can have certain knowledge but they were wrong in claiming that our knowledge of the world depends on its certainty. The constructive skeptic says empirical evidence provided by the senses allows us to judge whether we have knowledge of the world. The constructive skeptic divides the question of criteria for knowledge, asking if there is evidence by which we judge knowledge to be (i) certain or (ii) reliable. A traditional skeptic answers both questions negatively, whereas a constructive skeptic answers the second affirmatively. Empirical evidence provides a criterion by which we can judge the reliability of knowledge. Although the ancients thought that appearances can be trustworthy, constructive skeptics add the claim that this empirical knowledge -- though not certain -- is sufficiently reliable to supplement and build our understanding of the world.

Pierre Gassendi and John Locke are quite different philosophers in many ways but each holds constructive
skepticist views. Although the early Gassendi follows a Pyrrhonian line, in his later works he mitigates this skepticism. He differentiates between wholly certain and very reliable knowledge and claims that the latter is attainable given trustworthy sensory evidence. Locke devotes a considerable portion of his *Essay Concerning Human Understanding* to defining the limits of knowledge. He argues that while certain knowledge of the essences of objects is outside our grasp, probable understanding of the sensible qualities of objects is not. The two writers doubt we have certain knowledge about the world, and they contend we have a dependable if probabilistic understanding of sensible phenomena. Gassendi and Locke maintain principled skeptical doubts about knowing the innermost structure of reality yet they reject the anti-empiricist bent of classic Skepticism. This balance of doubts about our access to essences and of faith in empirical research is the main achievement of their constructive skepticism. I focus on their particular renditions of constructive skepticism since few other philosophers argue for this perspective as prominently or thoroughly.

The purpose and structure of the paper.

My paper elucidates how Gassendi and Locke address the problem of justifying and characterizing — from a sixteenth and seventeenth century perspective — the theory and practice of empirical science given limited access to, and
knowledge of, the material world. Their constructive skepticism proposes just such limits; yet their views support positions that imply a deep human capacity for understanding the world. These epistemological positions support robust implications concerning three issues in the philosophy of science: the nature of scientific objects, the methodology of experimental science, and the guidelines for building scientific theories.

The purpose of this paper is to demonstrate how the constructive skepticism of Gassendi and Locke supports scientific realism, the thoroughly empiricist character of research in the natural sciences, the empirical adequacy of theories, and hierarchies of types of theoretical propositions corresponding to degrees of certainty.

I argue that their limits on empirical knowledge shape these views on natural science. In this way, the bounds of empirical knowledge keep scientific practice reliable and free of unwarranted and potentially misleading dogmas. Gassendi and Locke are notably concerned to bar conceptions of the essential nature of material objects.

My approach is to delineate their epistemological views relevant to a constructive skepticisit stance and demonstrate how that stance supports these claims about the nature of scientific objects, research methodology, and theory construction. I show how constructive skepticism suggests
not only the nature of empirical knowledge, but also the
calacter of scientific knowledge and related metaphysical
matters such as reasons for scientific realism. I explain
the attempts of Gassendi and Locke to establish limits and
licenses for empirical knowledge, and demonstrate how those
limits and licenses sustain relevant and coherent positions
on the character of scientific knowledge and practice.

To demonstrate the support for these positions I draw on
implied and direct links Gassendi and Locke make between
empirical and scientific knowledge. Also, I propose
"rational reconstructions" of arguments for claims about
scientific realism and the empirical adequacy of theories.
I "reconstruct" arguments for those claims based on the
views of Gassendi and Locke: the conclusions to these
arguments are not explicitly claimed in the original texts.
I do not pretend that Gassendi or Locke held these
positions; instead, I show that they are the positions their
views logically imply and suggest. I propose that these
arguments show the positions that best fit their stated
views on related philosophy of science questions. Given a
comprehensive constructive skepticist stance, I offer the
most felicitous and coherent interpretation of their overall
perspectives on scientific knowledge and the theory and
practice of science.

The organization of this paper is in three chapters. In the
first two, I explicate the particular constructive skeptic views of Gassendi and Locke, and the philosophy of science positions these views suggest. In the concluding chapter, I present an overall picture of a constructive skeptic philosophy of science that emerges from these individual views.

I follow a few notable standards throughout the paper. First, I use "mitigated skepticism" and "constructive skepticism" interchangeably. The first term accentuates a retreat from full-blown rejection of our capacity to find definite criteria for knowledge. The second term emphasizes a pragmatic compromise of the skeptical attitude with our apparent capacity to know about the reality around us to some small degree. Thus the two terms cover the convergence on the same position from polar extremes. Second, I follow the convention of using an upper case "S" for ancient Skeptics and the lower case "s" for all other skeptics. Thus "skepticism", "skepticist", and "skeptical" all refer to the general position based on that developed by the ancient school and not to the specific views of the Skeptics themselves. Finally, I have devised the adjectives "modal" and "substantival" for Locke's terms "modes" and "substances". "Substantival" is less intuitive than "substantial" but appropriately more distinctive.
Notes

1. For example, the Pyrrhonian Sextus Empiricus indicates that suspending judgement prevents certain knowledge of the world with respect to ethics with no loss of correct behavior.

2. As Popkin (1979) points out, the disappearance of ancient Greek and Roman texts did not mean an absence of skeptical thought. The works of al-Ghazali and Yehuda ha-Levi richly illustrate this point.
Chapter One

Limits on Scientific Knowledge: the Constructive Skepticism of Pierre Gassendi

Introduction

Gassendi is a noted, influential, yet relatively little-researched philosopher and theoretician of the new science of the seventeenth century. Several authors explicate his views on science [e.g. Gregory (1961), Joy (1988), Messeri (1985)]. Others discuss his views on skepticism [e.g. James (1987), Popkin (1979), Walker (1983)].

My objective is to show how Gassendi's "constructive skepticism" elucidates his views on scientific theory and practice. His skepticism casts doubt on much of theoretical or reasoned knowledge, yet accepts empirical or sensory knowledge. Hence he thinks we can have knowledge of appearances but not knowledge of essences. I show that diverse elements of Gassendi's writings on skepticism give us a coherent picture of scientific theory and practice. I demonstrate that Gassendi's writings significantly contribute to the empiricism and scientific theorizing of the seventeenth century.

In Section I, I examine how Gassendi's epistemological writings --including passages on skepticism and general theory of knowledge -- relate to questions of scientific knowledge. The reliability of sensory data gives us
knowledge of the world with some degree of certainty. By way of signs and our ability to use criteria to test them we can confidently relate appearances to things.

In Section II, I demonstrate how these passages bear on specific problems central to philosophy of science, such as how we define the objects of scientific study, and how we gather and organize scientific knowledge. His version of empiricism supports a scientific realist stance and the mere empirical adequacy of scientific theories. Thus Gassendi's constructive skepticism accommodates an unusual combination of views in seventeenth-century philosophy of science: we know enough about the objects of science to know they are real, yet our knowledge is never certain so we constantly need to confirm it anew through experiment and observation.

I The background elements

A. An overview of Gassendi's skepticism.

The central elements of Gassendi's mature skeptical viewpoint are found principally in two works, the Disquisitio Metaphysica (1644) and Syntagma Philosophicum (1658). In the Disquisitio Gassendi develops a skeptical stance in a series of replies to Descartes's Meditations. Gassendi also argues for his version of skepticism in the Logic of his Syntagma. That argument (similar to the one presented in his Disquisitio) may be reconstituted as follows:
1. Skeptics don't doubt appearances and don't doubt that we can characterize and reason about appearances.

2. But they do doubt knowledge of essences, that is, that which is "concealed" by appearances.

3. In order to know the truth about objects we must draw on knowledge of appearances.¹

Clearly this argument requires some additional premise. The conclusion will follow, for example, if we stipulate that to know the truth about objects we must draw on either knowledge of appearances or knowledge of essences. Unfortunately, Gassendi offers no such premise; he simply limits the field of choices to knowledge of appearances or knowledge of essences, and asks whether either can provide understanding of the material world. Although this limited choice is not an explicit premise in Gassendi's argument, it is supported by his background constructive skepticist view. The crux of this view is that we cannot know essences at all but we can know appearances. He embraces classic skepticism with respect to knowledge of essences but he views empirical information as a primary source of knowledge. Sensory knowledge is relatively certain, so we most likely have certain knowledge of the world through knowledge of appearances. In this part of Section I, I explain Gassendi's claim that we can know appearances. I begin by showing that his skepticist view permits knowledge (with some certainty) from the senses. Next, I show that sensory information gives us knowledge of appearances and knowledge
from hypotheses. I conclude Section I by showing how Gassendi thinks we can reason from appearances to gain further knowledge with some certainty.

1. Knowledge of appearances.
Throughout the Disquisitio, Gassendi challenges Descartes’s arguments for knowledge based on clear and distinct ideas. Gassendi wants to show that any means of knowing facts about the world will meet insuperable obstacles if based solely on demonstrative reason. He views knowledge that is demonstrated as partial and confused, not clear or distinct as Descartes claims. Gassendi argues that knowledge reached by logical argumentation does not have the immediacy of empirical knowledge. The ideas we attain by deductive proof give us merely analogous notions of objects and events in the world. To know facts about the world without the mediation of ideas, we need to draw on empirical knowledge.

Gassendi suggests that the most careful and productive approach to empirical knowledge is through the senses. Our sensory knowledge may be occasionally misleading or inconsistent. However, such failures are not as grave as the faults and contradictions which can result from reasoning about sensory information. The senses report information about the outside world, which may not cohere with our previous knowledge. Yet our judgements and
interpretations of that information are themselves prone to error:

...although deception, or falsity, is not to be found in the senses themselves, which merely behave passively and only report things as they appear and as they must appear given their causes, it is to be found in the judgement, or mind, when it does not act with enough circumspection and does not perceive that things which are distant...appear more indistinct and smaller than they do close up....

Here Gassendi offers a model of mental capacities in which the senses are separated from the capacity for judgement about sensory information. The apparatuses of the senses and judgement differ in that the senses play a passive role in collecting information and the judgement plays an active role organizing or relating information. Whatever problems may arise with the collection of sensory information, that information is subject to many more problems at the filing and processing stages.

According to Gassendi we can know about the collecting stage with at least some certainty. He says we can doubt neither our sensations that some things appear to us, nor that those things appear to have just those qualities. Our senses may be fooled sometimes, as in the classical Skeptic's cases of a round tower which appears square to us at close range or a straight oar that appears bent in water (cf. Sextus Empiricus's Pyrrhoniae Hypotoses I. 36 - 163). Yet our senses are reliable in many other cases, such as when we pull the oar out of the water and it appears straight.
Gassendi holds that we can be sure of the oar's straightness (out of water) just as we are sure of geometric proofs. So we must admit minimally some knowledge of the appearances of things, and knowledge of the versimilitude of those appearances.4

This is the only knowledge Gassendi says is not always subject to skeptical doubt. Reasoned knowledge is certainly permitted and practiced according to Gassendi, but there is always the possibility that the mind's active reasoning will engender "false" or confused impressions and so dubious knowledge. In contrast, knowledge of appearances gained from the senses is passively collected and thus likely to fail only if our senses themselves fail. According to Gassendi even our knowledge of the truths of reason is empirical and so influenced by knowledge gained from the senses. We may be quite sure about knowing the qualities of a triangle and assume our knowledge to be reasoned. Yet this is at least partly the product of empirical knowledge. Every person learns about universal qualities (that is, universally quantified predications) of triangles (such as the number of sides) through inductive reasoning about all the triangles viewed in the past.5 After we have gathered empirical information concerning a class of particulars we will often attribute universal characteristics to members of that class. But Gassendi holds that we cannot know
universal qualities of triangles. He views attribution of universal characteristics as a misstep: it is drawing a certain conclusion from a probabilistic argument.

Gassendi claims that truths of reason can be known only with some empirical input. He reasons that we gain knowledge of truths of reason only after conducting empirical research and then arriving at universal conclusions. Although we take those conclusions to be certain, we really should view them as tentative, based on the occurrence of similar events in the past.

This view faces some apparent objections. One difficulty is that his example -- universal truths concerning triangles -- involves truths that are not dependent on past events. Those truths would hold not only if triangles were never sensed, but even if triangles never existed. Gassendi’s view would seem rather strange if he thought those truths were dependent on past physical events. But this difficulty dissolves when we realize Gassendi intends that our knowledge of truths about triangles is dependent on past knowledge. We may know such truths only if we have prior experiences that gives us relevant knowledge about triangles.

Another difficulty remains. Gassendi also neglects at least one class of reasoned truths -- those which may be
stipulated or conventional, and not discovered or learned. Imagine that triangles were stipulated by early geometers as any three-sided figure containing three angles adding up to 180 degrees -- before particular instances of triangles were discovered. Then we could pick out shapes that conform to the definition of triangle, and our knowledge of what is a triangle would precede our ever having seen one. Yet Gassendi claims that we cannot know truths of reason without some empirical input. Despite all its flaws, this view is a strong case of Gassendi's claim that certain knowledge is gained through the senses.⁷

Gassendi's skeptical position leads him to the view that empirical knowledge, gained through the senses, is a necessary condition for knowledge of truths of fact and truths of reason. We will always be able to doubt the proper functioning of our reasoning apparatuses or the general conclusions reached from probabilistic arguments. Although knowledge from the senses can also lead us awry, this knowledge can at least be certain in two respects. We can be certain that we sense some things and that our sense-based conceptions of those things are accurate.⁸

Just as clear and distinct ideas may falter, it is possible that empirical knowledge based on the senses may not be reliable. Gassendi discusses a couple of examples of unreliable knowledge borrowed from the Greek Skeptics: that
honey tastes sweet to me, though bitter to you; and that fire seems hot to us, though not so to insects that live near fire. In both cases, our sense-based empirical knowledge is relative to our individual experience. Since different people have different experiences, our knowledge of honey's taste or fire's heat differs from person to person and thus is not a reliable guide to essential characteristics of, for example, the honey or fire. So there are some cases where we may know how something appears to us but this knowledge does not give us knowledge of the essence of the thing. It simply gives us knowledge of appearances. Gassendi agrees with the Skeptics that in these instances we cannot rely upon knowledge of appearances to learn about essences and that even our knowledge of how honey or fire appears may be unreliable. However, he does not endorse the Skeptical conclusion that there can be no criterion for judging reliable knowledge of appearances. In other words, he admits that knowledge of appearances can be uncertain and are likely unreliable guides for knowing essences yet he insists that knowledge of appearances can be judged as reliable (by criteria discussed below; cf. I.B.1.)

Gassendi suggests knowledge of appearances encompasses a wide range of information. This range includes knowledge about things which appear to the senses and knowledge about such appearances. The former category consists of
characterizations of the properties of objects based on the objects's appearances. Gassendi writes that all we can know of an object are the properties which are "evident from experience". The latter category consists of characterizations of those appearances. Such characterization includes the extent to which things appear and the manner in which they appear. Gassendi does not make explicit the meaning of "extent" [quatenus apparent] or "manner" [quomodocumque appareant] of appearance. However, he seems to rule out certain knowledge of essential properties of appearances. Gassendi approvingly quotes the ancient Skeptics as saying that knowledge of appearances does not provide decisive information about the truth, causes, effects, properties, or modes of those appearances. By "properties", he apparently cannot mean to include the "extent" or "manner" of appearances, which he thinks we can know. Perhaps unknowable properties of appearances include underlying characteristics of appearances which cause their extent or manner, such as their visibility under certain intensities or wavelengths of light. We can recognize the "extent" and "manner" of appearances and these qualities alone give us limited information about the appearances.

Whatever little we know about appearances of things, we know still less about their essences. Appearances do not give us
very much direct information about those essences. It is possible to detect from something's appearance that the thing has -- or appears such that it has -- a particular mass, shape, motion, and position. Gassendi cites Pyrrho as saying that we are able to build upon this basic information so long as we do not attribute essential qualities to the things we perceive. Hence Gassendi endorses a skeptical stance about knowledge of essences, but he thinks we can reason (for example, by analogy) about the things that appear to us.\textsuperscript{12} One acceptable way of building upon basic knowledge of appearances is to carefully draw hypotheses.

2. Knowledge from hypotheses.
According to Gassendi we can have several forms of knowledge about the world. These include straightforward sensory information, reasoning by analogy about appearances (which I discuss in I.B.1.), and -- to a degree -- hypothetical reasoning. Gassendi's use of the term "hypothesis" suggests he is referring to the antecedents of implication statements used in geometrical demonstrations. By "hypothesis" he apparently means antecedent propositions or sets of events which imply some consequent propositions or sets of events.\textsuperscript{13} He defends a view (attributed to the Skeptics) that we may make predictions or produce proofs using assumed hypotheses so long as we do not impute any truth or correctness to those assumptions. Dogmatist opponents of
the ancient Skeptics reportedly held such hypothetical assumptions to be true and produced demonstrations based on those assumptions. Gassendi argues that the conclusions Dogmatics attained were fallacious because they did not demonstrate the truth of their assumptions. His view apparently does not take into account axiom systems, in which proofs are produced on the basis of assumptions that are undemonstrated yet accepted for the sake of constructing the system.

By claiming we cannot ascribe truth to undemonstrated hypotheses, Gassendi endorses the guarded, tentative use of hypotheses. His view would be hard to sustain if scientists viewed hypotheses as unqualifiedly true prior to experiment or observation. Some axiom systems may be constructed from only a conventional set of axioms devised without regard to empirical facts -- mathematical systems are apparent examples. Physical sciences may be built on axiomatic hypotheses that are not demonstrated, as in the case of the fundamental laws of Newton's *Principia*. Yet a staunch empiricist with regard to theory formation might want such systems to incorporate empirical facts into the formulation of physical axioms. Gassendi appears to be such an empiricist: he worries that hypotheses are not absolutely true and thus inadequate for scientific reasoning. He nevertheless accepts that hypotheses can teach us about
phenomena to which we do not have current access, as in the case of predicted future events.\textsuperscript{17}

B. Certain knowledge and Gassendi's skeptical stance.
In this section I show how Gassendi elaborates on his view that certain knowledge of the world is gained from the senses. In a later work, the \textit{Syntagma Philosophicum}, he proposes that we can have knowledge with some certainty by reasoning about knowledge of appearances. Gassendi retains a skepticist distrust of knowledge of essences (as in the \textit{Disquisitio}). However, he says we can have certain knowledge of the world from empirical evidence and the "intelligence" or intellectual capacity for judging appearances. Gassendi amplifies his view of certain knowledge by suggesting how we may have greater access to knowledge of the world: he argues that we can reason by analogy about objects in the world. His claim is that knowledge of appearances may give us \textit{signs} of the truth, and that we need some \textit{criteria} by which to recognize such signs. I begin this section by explaining Gassendi's view of \textit{signs} or indirect evidence and \textit{criteria} or our capacity for judgement. Next, I explain why he thinks signs and criteria can give us knowledge about appearances with some certainty. Finally, I show that he holds empirical information to be our most important source of information about the world.

Gassendi voices skepticist concerns about our access to
certain knowledge of the world, but he allows that we may have tentative knowledge that is not gained through direct empirical means. We can know signs and criteria with certainty but it is certainty by degrees. Our newly-acquired knowledge of appearances must pass the tests of reason and experience; the generally sure character of empirical information makes experience the truer of the two tests.

1. Signs and criteria.
Signs are two types of evidence. **Empirical** signs indicate something we do not see immediately and previous experience tells us we eventually can or will. **Indicative** signs indicate something we cannot see though on the basis of other (empirical) information, we judge that, if the sign exists, then the thing exists.\(^1\) Empirical signs show a signified thing we can see at a later time; Gassendi’s example is that smoke shows us there is fire. Indicative signs cannot exist unless a signified thing exists; Gassendi gives the example of sweat not existing unless pores do. He concurs with Sextus Empiricus’s view that these are the only two kinds of signs.\(^2\)

Gassendi notes that classical Skeptics reject evidence by indicative signs: they deny we can empirically (or otherwise) detect such signs. Gassendi counters that we can have evidence by indicative signs because we can recognize
them by some criteria. He says an indicative sign

...is of such a nature that it could not exist unless the thing exists, and therefore whenever it exists, the thing also exists. 20

He does not explicitly describe empirical signs in these terms. Yet it is easy to see that, if empirical signs are dependably regular evidence of future observations, then those signs are such that they "could not exist unless the (future observation) exists." 20a Gassendi maintains signs constitute evidence that allow us to extend our knowledge beyond what we directly sense. He remains true to his own earlier writings by seeking to identify criteria we can use to definitely establish that something is a sign.

Gassendi distinguishes himself from skeptics of the past by admitting the possibility of identifying such a criterion. He says we have "in ourselves" two criteria for recognizing signs. 21 There is "...one by which we perceive the sign, namely the senses", and another "...by which we understand something hidden by means of reasoning, namely the mind, intellect, or reason." 22 His description of these criteria indicates he views them as human capacities (sensory and intellectual); they are not marks or characteristics by which we recognize signs. Each of these capacities has a primary function relative to one of the types of signs. The senses are most relevant for recognizing empirical signs, and the intellect is most relevant for recognizing
indicative signs.

Gassendi defends indicative signs from the dismissive criticism of the Skeptics. He says we can have knowledge about things for which we have only indicative signs and no direct empirical evidence. We can reason from indicative signs because past experience shows this methodology is successful. There are cases of theories that were based on indicative signs and empirically proven after the relevant empirical sensing devices were created. One example is Democritus’s suggestion of the starry character of the Milky Way. That suggestion was confirmed in Gassendi’s day by the telescope. He concludes from such cases in the history of science that knowledge similarly derived from indicative signs is "...true with equal authority [to those derived by direct empirical means] though they are perceived by the mind above."25 Gassendi ascribes "equal authority" of truth to knowledge gained through direct empirical means and indirect indications by means of signs.

It is not apparent from his writings why he holds the authoratative equality of direct and indirect evidence. This claim agrees with his characterization of empirical and indicative signs as regular and dependable evidence for objects and events we either do not or cannot sense. The high dependability of signs surely suggests that our knowledge from those signs is accompanied by a high degree
of certainty.

2. On certain knowledge and proof.

Gassendi says we can have certain knowledge of empirical truths, signs, and criteria. He emphasizes the sure nature of empirical truths and the less than fully sure nature of knowledge gained by indirect and intellective means. This range of sureness indicates that he thinks knowledge is certain by degree.

**Empirical truths.** We know with certainty the truth of empirical knowledge when it is not possible for the phenomena which is the subject of our knowledge to be otherwise. Gassendi gives us the example of knowing that pores exist from the (indicative) evidence that sweat is present on the skin:

...a certain truth does exist, namely that there are pores, and this is demonstrated fully, not from the fact that there are pores, but from the fact that if there were not, two bodies would have to be in the same place at the same time.

He suggests an absurd situation would result if we did not know with certainty that there are pores from the fact that sweat appears on the skin. The absurd situation is that two bodies -- skin and (particles of) sweat -- would be present in the same place at the same time. This is not a tenable situation, so it must be the case that the countervailing situation is true and our knowledge of that situation certain. Sweat is evidence that there are pores in the skin
because without pores the sweat's appearance is not possible.

Gassendi reasons that given the implausibility of an opposite situation, the situation is only accurate or true as originally described. This is a credible conclusion if the description of an opposite situation exhausts the possible alternatives to the original situation. His further conclusion is less convincing: demonstrating the implausibility of the opposite situation does not tell us our knowledge of the original situation is certain. We may establish only that the opposite situation -- that is, the simple negation of the proposition best describing the original situation -- can be known with certainty to be false. Gassendi mitigates his skepticism by a surprising trust in our ability to consider all alternative accounts of phenomena and thus attain true explanations about which we may be certain.

Signs. Gassendi says we base our knowledge of signs on "the proof of experience". He says our knowledge must adequately explain the phenomena:

...when it is said that someone denying this argument may legitimately assert the opposite, the answer must be that he may if he wants to, but let him just see whether his experience supports or rejects his assertion.

Knowledge of signs consists of having empirical evidence for some phenomena not immediately apparent to the senses. We
may be certain about the truth of this knowledge when experience supports the accounts or descriptions of the phenomena which we make on the basis of those signs.

In his major discussion of signs (Syntagma 81a – 82a), Gassendi’s stated position is that we know signs with certainty based on proof of experience. But elsewhere he tells us signs provide no more than "some truths".\textsuperscript{29} In other words, signs do not give us wholly certain knowledge. Hence his claim (at 81a – 82a) that our knowledge is completely certain is not justifiable; it seems we know about hidden phenomena from signs with merely high probability.

Gassendi holds that our knowledge from signs is merely certain by degrees, a matter of probability. Indeed, Gassendi endorses a probabilism when he spells our his "middle way" between Skeptics and Dogmatics:

\begin{quote}
...the occasion arises only too frequently in the physical sciences to declare that we are fortunate if we attain not what is true but what is probable. As you see, we feel that in such an incapacitated state it should be considered a great gain if we can rise to the point where we may glimpse not the truth itself (in its very body, so to speak) but some slight image of it, or even its shadow.\textsuperscript{30}
\end{quote}

When Gassendi claims that we can be certain about knowledge of signs he is suggesting that we can be sure about the probabilistic degree of accuracy those signs provide concerning hidden phenomena. Thus he responds to Dogmatist
claims that we know with certainty about the nature of objects in the world: we can know about those hidden natures from signs that are probably true, and we can be certain that such signs have such-and-so probability. This interpretation of his remarks confirms that knowledge cannot be accompanied by total certainty. A high probability that the evidence is true simply confers a high degree of certainty on our knowledge. Gassendi's discussion suggests that the knowledge we gain by inference from empirical evidence can be no more certain than the evidence itself.

Criteria. Gassendi holds that we can have certain knowledge of criteria for recognizing signs. He attempts to argue, by reductio, that we can know with certainty the intellectual criteria by which we recognize indicative signs. Gassendi begins with the premise that many different minds produce equally authoritative knowledge claims. He perceives this diversity of intellects and intellectual judgements to be the central challenge to certain knowledge of intellectual criteria. He argues against this challenge by appealing to authority. An authority is anyone "...who, having weighed all considerations, presents an argument that cannot be legitimately contradicted." The claim that there could be such authorities fairly shows that many different minds will not necessarily come up with equally worthy knowledge
claims. Yet Gassendi advances to an additional conclusion, that he or she who develops sufficient knowledge relevant to the question at hand will be best equipped to make valid claims. This additional claim requires some further justification which Gassendi does not provide, for example, that in actuality the best authority can be accurately chosen, or that his or her claims will provide certain knowledge. The most significant facet of this argument for certain knowledge of criteria, though, is its reliance on the authority’s past experience with individual cases. If his or her knowledge depends on experience, the claim of certain knowledge is better understood as certain by degree, that is, not wholly certain at all.

3. The primacy of the senses and empirical adequacy of theoretical knowledge

Gassendi generally regards empirical information as our primary means of knowing about the world. Experience and observation can even be used to correct our mental judgements. Although he allows that the intellectual criteria are a significant means of recognizing signs and thus gaining knowledge, Gassendi is more impressed with the sensory criteria:

...when it sometimes happens that reason seems to be in conflict with the senses, Aristotle teaches most strikingly that we must decide more on the basis of the senses than on the basis of reason; this because such reasoning cannot really penetrate the matter, but remains only apparent, while the real reason why the matter appears as it does to the senses lies hidden.
Reason does not always give us access to the truth about empirical phenomena ("cannot really penetrate the matter") because reason only seems to lead us to empirical knowledge ("remains only apparent"). Also, reason does not get us closer to the truth than the senses because our knowledge of appearances is based on sensory information which cannot be fathomed by our reasoning capacities.

Gassendi gives us two examples to explicate this passage. We intuit where an arrow shot straight from the stern of a moving ship will land in the sea, and we intuit that people cannot live on the opposite side of the globe. He says in both cases our intuitions lead us astray and must be corrected by sensory information. We can detect that the moving ship -- in addition to the bow that shoots the arrow -- will cause the arrow to move further than the bow alone will, and we can find people who have not fallen off the opposite side of the globe.

Gassendi suggests we might have reasoned differently in each case with more complete empirical information because reason alone may not truly lead us to empirical knowledge. However, the physical calculations in each case are actually not dependent on the particular empirical information, or on eyewitness accounts. A mental experiment would undoubtedly suffice to demonstrate the correct account, especially in the case of the arrow shot from the ship. Perhaps the
tenuous state of astronomy and knowledge of gravity in Gassendi's time made empirical demonstration more informative in the second example. Surely some cases of experiments give us empirical knowledge not possibly reasoned from mental figuring alone.

These two examples also show a related point, that knowledge of appearances can be obscured by insufficient evidence. Some knowledge of appearances will become more certain, or corrected, as we refine our means of detection (such as the telescope). Our knowledge of appearances must fit the gathered information: this is more important than fitting our reasoning. Thus Gassendi says experimental and observed data need to be empirically adequate first and foremost.35

In the Disquisitio Gassendi describes varying degrees of doubt we need to apply to different forms of knowledge. We can have certain knowledge of appearances because the senses give us more reliable information than does reason. We can only be certain about reasoned knowledge to the extent that we inform reasoned truths with empirical information. We may gain knowledge from hypotheses insofar as we view hypotheses as tentatively accurate, without imparting truth to such assumptions. These varying degrees of certainty have two common factors: the reliability of sensory information and the inability of the human mind to know essences.
In the *Syntagma* Gassendi amplifies his earlier view by delineating the means by which we have some form of certain knowledge. He does this by proposing that we can have knowledge by means of recognizing signs of phenomena for which we do not have direct empirical knowledge. This elaboration on the earlier *Disquisitio* viewpoint marks Gassendi’s turn from mild skepticism towards an even more modified version. Popkin calls this "mitigated" or "constructive" skepticism.\(^{36}\) It is mitigated in the sense that Gassendi carves out a path between extreme versions of skepticist and dogmatist doctrines. We can have knowledge with certainty, but it is certainty by degrees. Skeptics say there is no criterion for determining the truth; Gassendi says there are such criteria. Dogmatists say we have access to knowledge of essences; Gassendi says we have no such access. The combination of these two views constitutes Gassendi’s middle way (*media quaedem via*).
II Aspects of Gassendi’s philosophy of science

Gassendi writes extensively on empirical knowledge but little on scientific knowledge per se. In this section I show how elements of Gassendi’s skepticisit viewpoint support scientific realism, a strongly empiricist scientific methodology, and a hierarchical organization of scientific knowledge. Gassendi did not write specifically on all these issues; I draw on his views of knowledge and certainty to suggest some conclusions that do not appear in his writings. I offer a picture of Gassendi’s philosophy of science that is internally coherent. This set of views is striking for balancing scientific realism and the empirical adequacy of theories.

A. Knowledge of scientific objects and their reality.

Are the objects of science real? Scientific theories employ terms and constructs that are stipulated to refer to objects in the world. Scientific realists claim those terms and constructs actually refer to real objects, whether or not those objects are observable. Anti-realists generally maintain that theoretical terms do not always refer to real objects (as when those objects are not observable), or that they do not refer to any objects but simply group observed phenomena in convenient linguistic terms. How do Gassendi’s writings bear on this debate? I address three questions in particular: Does the reality of
scientific objects rest on our knowledge of them? Does it matter what kind of knowledge we have, e.g., knowledge of appearances or of essences? Can Gassendi support a scientific realism? I propose the answer is "yes" to these questions. My argument is based on Gassendi’s views that empirical information or data are accurate, such information is built on descriptions of objects in the world, and those objects are real. Here is my argument in outline form:

1. Our descriptions of appearances are based on sensory data.

2. Our descriptions of appearances constitute highly certain and accurate knowledge since they are based on sensory data.

3. Scientific or empirical descriptions describe real objects.\(^{39a}\)

4. Theoretical terms in science refer to real objects just in case scientific descriptions that employ only theoretical terms do.\(^{39b}\)

5. Theoretical vocabularies refer to real objects.\(^{40}\)

I consider each point in turn and show how Gassendi supports points (1-3) and thus [with (4)] how his views support a scientific realist position.

1. Our descriptions of appearances are based on sensory data. Gassendi embraces knowledge of appearances, which grants that there are things in the world that appear to us. He says we gain knowledge about the world primarily through sensory data. Sensory collection of data consists of gathering knowledge of the world directly by collecting
information about appearances. Reasoning about the world gives us knowledge that is mediated by ideas and thus indirect. Although appearances do not tell us the essential properties of things, they do tell us that such things appear to us. Gassendi states that the Skeptics did not doubt the "things that appeared" and the descriptions of those appearances\textsuperscript{41} though they did doubt we can know essential properties of appearances, including their truth.\textsuperscript{42} Knowledge of appearances is knowledge of things that appear to us and this knowledge takes the form of descriptions. Moreover, knowledge of appearances is based on sensory data; hence our descriptions of appearances are based on sensory data as well.

2. Our descriptions of appearances can be known with a high degree of certainty and accuracy. Gassendi tells us skeptical doubts apply least to knowledge of appearances since it is based on sensory information. We can have some doubts but we are closer to having secure knowledge about the world as we experience it than with any other form of knowledge. He also says we have knowledge of the accuracy (in part) of some appearances (see pp. 11 - 12) and he blames lack of accuracy on the confusing mediation of ideas, such as are employed in reasoning. His view is that our descriptions of appearances constitute highly certain and accurate knowledge since they are based on sensory data.
3. These accurate descriptions of appearances describe real objects in the world. This can be concluded from two points: descriptions of appearances refer to objects in the world, and the objects are real or existant according to the descriptions. The first point is made by Gassendi when he says knowledge of appearances is knowledge of things appearing to us [as (1) above]. The second point is established when Gassendi describes the knowledge we can have from appearances. Our knowledge of appearances consists of knowing the properties of objects as they appear to us. If we can know those properties then we can conclude that the objects exist. Gassendi writes:

...the existence of anything shows itself simply if one exhibits it and presents it, either by an action or a necessary effect.\(^{42a}\)

and

...anything recognized as existing, is recognized as such either in virtue of its action, or of its quality, or of some other element (adjuncto) belonging to it,...\(^{42b}\)

Hence knowledge of appearances tells us not only about the qualities of objects (as they appear to us) but also that those objects exist.

Moreover, Gassendi says we can know particular physical properties of the things that appear to us:

...of a certain thing one can say that it is or appears such, in the sense that it is endowed with such a mass, shape, motion, [and] position...\(^{43}\)
Scientists may describe those physical properties in theoretical terms. However, Gassendi views this kind of property as existing independent of theoretical considerations or descriptions. He claims knowledge of such properties is not necessarily subject to doubt because it comes from empirical observation. 44 This degree of certainty could not be matched by purely theoretical descriptions. Our empirical knowledge consists of characterizations of the properties of objects under observation, and we can observe that objects have actual properties like mass or motion. Since Gassendi's view supports the position that properties of the objects are actual or real it is hard to see how he can claim the objects were not. Thus scientific or empirical descriptions describe real objects. 45

One objection to the line of reasoning for (3) (raised by M. Kulstad) recalls Gassendi's view that we do not have knowledge of real essences. Gassendi indicates knowledge from the senses gives us knowledge of the apparent properties of bodies; can this give us knowledge of their real properties as well? True, the real essences and real properties of bodies may be two different qualities, e.g. the real essence of a chair likely includes some quality which accounts for its seating capacity, whereas it need not include a quality which explains the chair's real (though
accidental) properties such as its color. So if we lack knowledge about the real essences that does not mean we lack knowledge of the real properties. Nevertheless, Gassendi's mitigated skepticism should make us wary of suggesting that he thinks we have knowledge of any real qualities (essential or otherwise) of bodies in the world. Hence the burden of proof rests with demonstrating that Gassendi holds we can know some real qualities of bodies in the world.

At least one piece of evidence suggests Gassendi holds we sometimes know the apparent qualities and the real qualities of bodies. In the passage just noted, he tells us that "...of a certain thing one can say that it is or appears such,..." (my emphasis). In other words, we can sense some qualities of bodies (namely: mass, shape, motion, and position) such that our sensory familiarity with them enables us to say (i) the bodies appear to us to have those qualities -- and (ii) the bodies actually are endowed with those qualities. This passage could even be read as suggesting that Gassendi holds knowledge of these apparent qualities just is knowledge that they are real qualities: he does not differentiate here between "is such" and "appears such". This last point also supports the claim (ii) that real qualities of bodies can be known according to Gassendi.

4 and 5. Scientific descriptions refer to real objects;
thus some theoretical vocabularies do. Scientific theories employ terms that refer to phenomena studied by empirical research. These terms are designed for theoretical and experimental discourse alike; they provide a vocabulary for empirical descriptions of the same phenomena. So if the descriptions refer to real objects then the terms refer to real objects. Since empirical descriptions refer to real objects [as (3) above], theoretical vocabularies do as well.

I anticipate two significant counters to this argument. One is the intuitive notion that Gassendi should be considered an anti-realist. After all, he describes empirical and theoretical knowledge as always subject to review. Hence he would hold that theoretical descriptions merely capture constantly changing observed phenomena. Then scientists could not rigidly designate any particular grouped phenomena as real because their descriptions of observed phenomena, and so their referents, are subject to change.

Gassendi emphasizes the empirical adequacy of theoretical knowledge, but he also says our empirical knowledge has a high degree of certainty and accuracy. So empirical knowledge incorporates accurate descriptions of objects, and the objects are real. Whether or not the descriptions shift, though, the objects referred to remain real. Scientists sometimes change the designation of the referents of theoretical terms. The descriptions and terms may change
-- just as their accuracy may be questioned -- yet the reality of the various objects referred to do not. Hence Gassendi can support the view that scientists use theoretical terms to refer to real objects.

Another counterargument suggests Gassendi cannot be a scientific realist because he denies we can have knowledge of essences. Realism may be affirmed if we know terms used in science refer to essential properties of an object. Suppose the reality of theoretical terms were based on our knowledge not of appearances but of essential properties, and that our only way of knowing essential properties was by knowing the essences of objects. Since Gassendi says knowledge of the essences of scientific objects is not possible, he would seem to be an anti-realist.

Yet knowledge of essential properties cannot provide the only way to judge the reality of objects or their non-essential properties. If our knowledge about non-essential properties depended on our knowledge of essential properties, Gassendi could not distinguish the two types of properties such that we can know non-essential properties and we cannot know essential properties. However, he does distinguish them in just this way, and he says we know that objects exist and have particular non-essential properties from the appearance of those properties (that is, not from any appearance of essential properties.)
Gassendi's views as explicated above support affirmative answers to the three questions posed in the beginning of the section. The reality of the objects scientists identify is an empirical affair; sensory information refers to real objects and we build our empirical knowledge out of such data. The only knowledge which gives us a high degree of certainty and accuracy concerning objects in the world is knowledge of appearances; other forms of knowledge are more subject to doubt. Knowledge of appearances is the most certain component of scientific knowledge and it is in turn composed of sensory data that refer to objects in the world.

We know these objects are real. Their basic physical properties must be real: we describe them with a degree of certainty that merely theoretical descriptions could not fulfill. If the objects are characterized by such properties then they must be real as well. Thus Gassendi's constructive skepticism supports scientific realism.

B. Gathering scientific knowledge: a practical methodology.
In this section I identify a coherent approach to scientific practice supported by Gassendi's writings on knowledge and certainty. This approach features primary tools, guiding principles, and correction mechanisms. These factors taken together constitute an early significant contribution to empiricist methodology of knowledge-gathering in science.
1. Primary tools: the senses, analogy, and hypothesis. Various passages in the Disquisitio and the Syntagma suggest a hierarchy of means for gathering scientific knowledge. Gassendi says the senses, reasoned analogy, and hypothesis are basic tools.

The Senses. Gassendi holds that the senses provide us with the most accurate and productive means of acquiring knowledge. The senses are low risk because they require no added or prerequisite information. Sensory information is received passively. The risk factor increases as knowledge is more "actively" acquired, that is, gained with the help and influence of ideas already present to the mind. The senses are also productive because of their elemental character. We make use of sensory information to build our entire canon of knowledge including reasoned truths.

Reasoned Analogy and Hypothesis. As an example of reasoning by analogy, Gassendi cites the case of knowing that fire is hot by nature -- in virtue of the fact that the Persians as well as the Greeks found that fire burns. We can demonstrate the hot character of fire by showing that fire was thought to be hot by the Persians and Greeks in separate but analogous instances. Sensory data enables us to know only some physical properties, but we can also construct useful analogies given the same data. Scientists employ analogies to demonstrate what makes some qualities or
phenomena apparent, by showing that a set of analogues shares those qualities or phenomena.

To take another example, given empirical data about two distinct body parts, we can point out how the data agree in some respects, and conclude that the parts resemble one another. This case fits the scheme of reasoning by analogy: we know the resemblance of the body parts by virtue of the fact that the data concerning each part agree. Analogies enhance our knowledge of appearances by connecting pieces of sensory information and demonstrating common qualities of the various pieces. In short, scientists use analogies to show the unifying aspects of sensory data.

Analogies are necessary for reasoning on the basis of signs. We get information from signs about objects or events which we cannot observe (either now or here) by drawing analogies with objects or events we can observe presently (cf. I.B.1.) For example, in many cases we judge that present observations or experimental settings are analogous to past ones. The strength of these analogies insures the accuracy of inductive judgements we make on the basis of signs.

Analogies describe relevantly similar or shared qualities. One empirical use of analogies consists of highlighting the different relationships between distinct data. Another main task of reasoning with analogies is demonstrated by the case
of judging signs: analogies serve as a fundamental basis for inductive claims.

A similar purpose is served by hypothetical reasoning. An hypothesis is an assumption that something is or will be the case, based on prior information. Scientists cannot use hypotheses based on undemonstrated premises because these are subject to skeptical doubts. But they can fashion hypotheses by citing demonstrated empirical data. Gassendi thinks hypotheses should serve as the concluding steps of inductive proofs. For example, the future motion of planets might be hypothesized on the basis of past planetary motion. Hypothetical reasoning contributes to scientific knowledge by indicating the relationship of past events to current or future events and by illustrating how we discover things. Hypotheses are not used like the senses to collect data. They are rather used like analogous reasoning to infer from data. Scientists use hypothetical reasoning to organize data for predictive use (and for propadeutic settings). This view of information collection suggests a preliminary picture of scientific practice according to Gassendi. The senses and sensory equipment collect empirical data passively by observing and monitoring phenomena in experimental settings. Scientists reason or theorize by using ideas to transform and organize empirical data. In current day thinking, this view of scientific practice would be only roughly accurate. Gassendi tells us the senses are
the primary tool for collecting empirical data and the other tools -- different forms of reasoning -- are distinct. Few philosophers or scientists today accept such a clear theory/observation distinction. To wit, theory guides selection of particular experimental equipment and observation and so likely biases empirical research results.

The theory/observation distinction may be suspect in contemporary thinking, yet Gassendi clarifies one aspect of scientific methodology by indicating the passive low-risk nature of sensory data collection. He also argues that the senses are a more reliable source of empirical information than are the faculties of reason. His remarks on collecting and using data point out the value of analogies and hypotheses for inductive reasoning. Gassendi's view of different kinds of scientific reasoning places high premiums on the input of sensory information and induction on past observations, and so follows an early empiricist approach.

2. Guiding principles.
Gassendi's views on gathering knowledge represent a strong empiricist approach: sensory data necessarily inform empirical and theoretical knowledge. Both truths of fact and of reason are known empirically. This strong approach supports a set of methodological principles in science by which speculation plays a small role and experiment is paramount. I list three guiding principles of scientific
research drawn from Gassendi's constructive skepticism.

Different empirical data indicate the spatial and temporal extent and manner of appearances. Knowing appearances includes knowing the degree to which things appear to us (their "extent" or spatial and temporal position) and the way those things appear (their "manner" or particular characteristics such as brilliance or dimness). So empirical data encompasses several kinds of information, likely including descriptions of the duration, environment, and relative position (location) of appearances. For example, we can describe parameters for particles of matter according to Newtonian mechanics by giving the motion equations for the particles' coordinates $c_1 \ldots c_n$ and momenta $m_1 \ldots m_n$. The parameters $c_1 \ldots c_n$ and $m_1 \ldots m_n$ tell us the extent and manner of the particles' appearances to us, and the equations which describe $c_1 \ldots c_n$ and $m_1 \ldots m_n$ give an account of our observations of those appearances. Descriptions of these parameters are closely based on sensory data; we can know them with a high degree of certainty. The sure description of the extent and manner of appearances may be the minimal certain information we cull from experiment. Such descriptions provide an empirical foundation upon which scientists hypothesize and reason.

The primary aim of research is gathering knowledge of particular phenomena in discrete experimental settings.
Empirical knowledge consists of knowing particular phenomena. For example, we know that some proposition $p$ is true of an object $o$ at a particular time $t$ because it was observed to be so. Empirical research gathers knowledge of particular phenomena in discrete experimental settings: we could not know that $p$ of $o$ at $t$ unless we observed as much in at least one case or series of individual cases. Theoretical or reasoned knowledge may involve compiled particular instances and inductively reached general conclusions, but these too are ultimately based on and subject to empirical review by individual cases. Gassendi's example is that we cannot know about triangles generally unless we learn their qualities from individual observations. We may derive knowledge of particulars from general laws or rules but we base those laws on particular phenomena; otherwise they are missing empirical foundations.

Theoretical terms used in experimental settings are subject to experimental verification. Experiments use theoretical terms. To take one case, when scientists use laboratory equipment to measure phenomena, they stipulate units of measurement and the meaning of a measurement in theoretical terms. A turn of the dial on an oscilloscope alters its "sensitivity" in volts/cm. The choice of volts/cm as a unit of measure and the interpretation of change in volts/cm as change in sensitivity are two uses of theoretical terms.
Each choice draws on theoretical knowledge.

According to Gassendi, theoretical or reasoned knowledge is necessarily shaped by empirical knowledge. Our theories are built with series of generalizations we make about descriptions of appearances. The members of these series can change the course of our reasoning and thereby foster new theories and theoretical terms. Let us consider once again the case of our theoretical model of triangles (and the term "triangle"). Gassendi holds that we interpret this model and its terms as general accounts of a class of entities (namely, closed figures bounded by three lines) because past descriptions of those entities have led us to precisely these generalized accounts. Since theoretical terms used in experiments are continuously subject to empirical verification they remain tentative.

Each of these principles emphasizes that researchers need to focus almost exclusively on empirical data to obtain knowledge of the world with great certainty. It is possible to enhance scientific knowledge by introducing truths of reason. But theoretical knowledge is constructed with building blocks of empirical knowledge.

3. Correction mechanisms.
Scientific researchers need correction mechanisms to achieve greater certainty about theoretical and empirical knowledge. Reasoned knowledge has a higher failure rate than empirical
knowledge. Hence empirical knowledge can be used to correct or adjust reasoned knowledge. Surprisingly, Gassendi also tells us there are cases where reason may guide our sensory knowledge. However, this is at root an empirical mechanism as well.

**Empirical data can correct theories.** Theoretical knowledge is built with sensory information. Therefore if the information changes so too must the theories. We need to alter theoretical terms, constructs, schematic explanations, etc., if research produces sufficiently novel data not covered by the theory currently in use. Gassendi offers only hints of a model of theoretical change in science. He does not, for example, specify how much novelty is needed to overturn or correct theoretical knowledge. But his view implies scientists should accept theories only tentatively, and not at all in the face of recalcitrant empirical data.

**Reason can help us adjust our means of gathering empirical data.** In the *Syntagma*, Gassendi writes:

> ...although it is admitted that the senses are sometimes misleading and that therefore the sign may not be reliable, still reason, which is superior to the senses, can correct the perception of the senses so that it will not accept a sign from the senses unless it has been corrected and then at last it deliberates, or reaches its judgement of the thing.48

This is a fairly complex correction mechanism: (1) a sign is perceived by the senses then (2) the sign is transmitted to the faculty of reason but (3) reason may reject the sign
for lack of reliability and (4) reason may adjust the senses until (5) reason accepts the sign and (6) reason "deliberates" on the sign. This deliberation (or "judgement") is apparently something like trying to fit the data to an existent theoretical framework.

This scheme looks like a reversal of Gassendi's usual ranking of certainty in empirical and theoretical knowledge. The faculty of reason is called "superior to the senses". Yet this correction mechanism, like all reasoned knowledge, requires prior empirical input to operate. Reason could only accept or reject a particular sign or sensory datum on the basis of preceding signs or data:

Whenever there is some doubt about something which can be perceived by the intelligence alone, then we must refer to reason, which deduces the existence of something not perceived by the senses from some other thing which is perceived by the senses....

This "other thing" the senses perceive is a sign: indirect evidence provided by sensory information. As with the first mechanism, Gassendi prescribes checking and adjusting scientific research by empirical data -- even when the check itself is outwardly theoretical.

Gassendi describes two means by which we can correct theoretical knowledge. We use reason to build scientific theories from sensory information, and we use theories in turn to conduct empirical research. But reason may fail or confuse us; then we need to check our theories empirically.
Both mechanisms ultimately yield more sure and accurate knowledge by drawing on empirical information. As with other elements of empirical methodology (tools and principles), Gassendi's constructive skepticism bases correction mechanisms on the certain foundations of sensory knowledge.

C. Organizing our scientific knowledge: a theoretical methodology.

According to Gassendi, our knowledge of the world is never totally certain and it is always partly empirically informed. One result of this view is that theoretical knowledge can be only empirically adequate. This outlook allows science theoretical accounts of phenomena but denies that certain truths about essential properties of phenomena can be assigned by those theories. It is very much a constructive skepticist viewpoint: theoretical knowledge cannot give us certain truths, so we can never have knowledge of essences. Theories are always subject to revision because of new evidence. In this section first I explicate Gassendi's empirical adequacy stance. Next I show ramifications of that stance for organizing different types of theoretical knowledge in science.

1. The empirical adequacy of scientific theories.

Gassendi's views suggest that scientific theories are empirically adequate. In other words, if theories do not match new data -- if they are not empirically adequate --
scientists trust the data and revise the theories. This is a case of empirical knowledge directly influencing theory formation. Empirical knowledge also influences theory formation indirectly by guiding efforts to keep theories in line with the data. Gassendi writes that the intellect -- a faculty of reason -- refines theoretical descriptions of objects by selecting from various sensory information:

...properly speaking, it is not the senses themselves, but the intellect which makes the error, and when it makes a mistake, it is not the fault of the senses but of the intellect whose responsibility it is as the higher and dominant faculty before it pronounces what a thing is like to inquire which of the different appearances produced in the senses (each one of which is the result of a necessity that produces them as they are) is in conformity with the thing.\(^{50}\)

Gassendi assigns an important role to reason: the intellect chooses among appearances for accuracy. He even calls the intellect "the higher and dominant faculty". This is a faculty of reason that guides the senses. The intellect decides if appearances are "in conformity with the thing", that is, if they resemble the object. If so, then those appearances can be described and discussed in a theoretical framework: "the intellect...pronounces what a thing is like". This hardly seems like an empiricist viewpoint.

Yet an analysis of the accuracy mechanism shows otherwise. The intellect makes a judgement that must agree with empirical information. Appearances are matched against previously available concepts of the object. According to
Gassendi’s view of theoretical knowledge those prior conceptions of the object draw on empirical data. Hence the intellect is influenced indirectly by empirical knowledge.\textsuperscript{51} Appearances are actually judged on their empirical adequacy: they are admitted in theoretical terms if they fit prior data. Gassendi’s view is consonant with a strong empiricism.

This capacity for gauging empirical adequacy of theories affects theoretical knowledge in the same way as more direct correction mechanisms (described in II.B.3). If the descriptions fit our prior knowledge of appearances, scientists can accept them as tentatively true, that is, having a high probability of being accurate.\textsuperscript{52} Even descriptions and models with a high probability of accuracy are not endowed with the degree of certainty accorded sensory information. Next I show how this range of accuracy supports a hierarchy of the different types of theoretical knowledge in science.

2. Various types of theoretical knowledge and varying degrees of certainty.

Gassendi writes on various types of theoretical or reasoned knowledge but his accounts generally fall into two categories: theory used in instruction and theory used in discovery. Scientists employ theory in instruction by articulating the logical relationships between elements of
scientific knowledge.\textsuperscript{53} They employ theory in discovery by first describing empirical data in formal terms and then organizing those descriptions systematically.\textsuperscript{54} Gassendi’s empirical adequacy view largely bears on the use of theory with respect to discovery.

There are two fundamental types of theoretical knowledge used to describe empirical data: theoretical accounts of appearances and of empirical or indicative signs. Another type of theoretical knowledge -- based on knowledge of appearances -- is derived from hypothetical assumptions. I suggest these different types give us knowledge with a degree of certainty that is a function of empirical data on which the theoretical accounts are based.\textsuperscript{55} Thus descriptions of appearances and signs are more certain than knowledge from hypotheses. Such a view is consonant with Gassendi’s view that hypotheses are primarily tools of inductive reasoning.

\textbf{State descriptions and signs.}

In the \textit{Disquisitio} Gassendi says we have limited knowledge about appearances that includes their "extent" and "manner". His claim is not spelled out in great detail; I suggested in II.B.2 that his view supports well-grounded knowledge of various parameters of appearances, such as duration, environment, and relative spatial position. We can develop Gassendi’s notion further to account for modern day
recording of empirical data. Scientists describe these parameters in theoretical terms by assigning variables to represent each. Various combinations of variables yield different state descriptions that describe instances of appearances in theoretical terms. For example, a physicist recording energy levels of a subatomic particle describe different states of the particle first by assigning variables to describe the parameters of the particle's appearance (actually, the appearance of its trace). Then the physicist combines the variables to describe energy levels of the particle at discrete moments. This theoretical knowledge should be as certain in proportion to the certainty of the empirical knowledge on which it is based. Hence the descriptions of how and how much we sense appearances can be formulated with great certainty.

Gassendi extends our knowledge of the world to include not only direct appearances but also indirect evidence of phenomena that appears to us at a later point -- either through the naked eye or refined instruments. This is knowledge from empirical or indicative signs. Scientists fashion theoretical accounts from signs when they stipulate the meaning of indirect physical evidence or data drawn from experimental instruments. Gassendi claims our empirical knowledge from signs is fairly reliable. We can reason once more from the principle that theoretical knowledge should be known with a degree of certainty proportional to that
accorded the base data. If this principle holds, we can draw from Gassendi the implication that theoretical accounts of empirical or indicative signs give us knowledge with a fairly high degree of certainty.

Scientists use descriptions of appearances and theoretical accounts of signs throughout their experimental work. To record experiments it is necessary to describe sensory data in theoretical terms. To design revisable theories from experimental results it is often necessary to use revisable theoretical terms. Theoretical accounts of appearances and signs fulfill these requirements by providing theoretical terms that are empirically adequate. These descriptions account for data without suggesting essential knowledge of the objects that appear. Theoretical accounts cannot be known with total certainty but their empirically adequate character makes them essential components of scientific knowledge.

Hypothetical assumptions.
Gassendi's writings suggest the view that hypothetical assumptions generally imply one proposition or set of results is the case if another proposition or set of antecedent conditions holds. When scientists offer hypotheses, the implied consequences refer to phenomena for which there is no sensory data currently available; the assumptions are perforce theoretical. Like other elements
of theoretical knowledge according to Gassendi, hypotheses have an empirically derived component: they refer to present or past phenomena (on the basis of which some new phenomena will occur). The use of empirical data in forming hypotheses limits the certainty of knowledge from hypotheses by the degree of certainty with which we know the data.

The certainty of knowledge from hypotheses is also limited by our inability to know whether they are true prior to empirical investigation. Gassendi suggests that ancient Skeptics rejected the absolute truth of hypothetical assumptions such as geometric axioms, though they did not reject the predictive utility of hypotheses. He notes that astronomers may account for eclipses by some hypothesis, yet another hypothesis may account for the same eclipses by citing incompatible causal events. His view is that truth cannot be imputed to any single hypothesis: for any claim based on a particular hypothesis there are alternate assumptions that may support the claim yet contradict the initial hypothesis. According to this view hypotheses are judged on their empirical adequacy alone (he mentions no other criterion as, for example, elegance). Gassendi denies the value of hypotheses prior to empirical investigation and so diminishes the contribution of hypotheses in general to certain scientific knowledge.

Gassendi nonetheless claims that we should accept and use
hypotheses if by making such assumptions we advance our capacity to predict or our grasp of the logical structure of the sciences. Hypotheses may be formed if they are supposed to account for current and future data. Empirical adequacy of hypotheses is likely to constrain their formation by grounding them in currently available data. But Gassendi does not want to accept hypotheses as true on theoretical grounds [for example, on the basis of theoretical consistency] because such hypotheses yield less certain knowledge. The resulting reasoning would not produce purely empirical or sensory information; thus it would be more subject to doubt. Empirical adequacy therefore guides a scientist's choice from among hypotheses posed and even the choice of posing such assumptions.

These different types of theoretical knowledge -- state descriptions, empirical and indicative signs, and hypothetical assumptions -- vary in degrees of certainty. Descriptions of appearances and of indirect evidence (signs) lend a high degree of certainty to theoretical models. Hence they are indispensable building blocks in empirical research. The level of certainty for theoretical knowledge is maintained only insofar as it remains empirically adequate. Theories must account for relevant sensory data without speculating that such accounts give us knowledge of essences. The empirical adequacy of theories reflects Gassendi's view that we can have neither empirical nor
theoretical knowledge with absolute certainty.

Hypothetical assumptions are generally less attractive than state descriptions and indicative signs to Gassendi, but they can provide knowledge with some degree of certainty. What degree depends on the level of verification further research provides -- and this too is a function of empirical adequacy.

IV Conclusion
I propose that the views suggested in the last section are coherent despite the intuitive incongruity of claims for scientific realism and empirical adequacy of theories. Gassendi's constructive skepticism supports a strong empiricist philosophy of science that nevertheless concedes the power and utility of reasoned knowledge -- if only because of its intrinsic empirical component.

Gassendi accords knowledge of appearances the highest level of certainty. This central claim is the foundation of a scientific realist stance and a view that scientific theories need to be merely empirically adequate. Knowledge of appearances gives us highly accurate knowledge of physical properties of objects; the reliable nature of knowledge of appearances indicates these properties are real. We have empirical knowledge of real properties and thus of real objects. If theoretical and empirical knowledge employ the same vocabulary then theoretical terms
refer to real objects because empirical terms do.

Only empirical knowledge may achieve such a high degree of certainty. Through a variety of empirical mechanisms we can ascertain that theories explain phenomena in a way that accommodates all available data. Theoretical knowledge helps scientists group empirical information but does not give us access to the essence of objects or their essential properties.

Since theoretical knowledge lacks the certainty of empirical knowledge and is subject to empirical review, scientific theories can be no more than empirically adequate. Yet if theories are merely empirically adequate, how can scientists attribute to objects the seemingly essential property of being real? Intuitively, for an object to be studied by natural scientists, it must have the property of being real; if a theory is merely empirically adequate, we should reserve judgements about any properties an object must have. Hence it seems difficult to maintain both the mere empirical adequacy of theories and scientific realism.

I propose Gassendi's constructive skepticism supports both views comfortably. First, that properties or objects are real is not an additional property but a categorization or class description of properties or objects. We can class properties or objects in many ways, and we can class those classes as real or not. It is possible to class phenomena
as real or not regardless of their diverse physical properties. Gassendi makes a similar point about the existence of objects in the Disquisitio. Second, scientists do not need to attribute essential properties to view phenomena as real. The reality of phenomena does not rest on whether or not its properties change. Real phenomena may have no essential properties we can know or even no essential properties at all. Nevertheless Gassendi's views support our capacity to know that phenomena are real.

Gassendi's stance sustains the view that scientific theories minimally need to account for the objects of empirical data -- which are real. Scientific knowledge is theoretical and empirical, and the latter is more certain than the former. But this higher degree of certainty does not preclude holding the objects of either type of knowledge to be real. According to Gassendi empirical data suggests those objects are real.

In general, Gassendi's constructive skepticism supports an empiricist view of scientific practice. The senses give scientists basic data and act as arbiters of how that data is represented by empirical and theoretical knowledge. In addition scientists use reasoning by analogy, empirical and indicative signs, and hypotheses to draw inferences from collected data and to build theories. Yet theoretical
knowledge in science is tentative, incapable of offering definitive models that describe phenomena essentially. Gassendi concedes reason's capacity to give us knowledge of the world, but he insists that sensory knowledge has greater certainty and accuracy. The primacy of sensory knowledge means that scientific knowledge according to Gassendi is largely determined by experiment and observation. Constructive skepticism -- clearly an empiricist stance -- sustains the new science in its hardiest empiricist form.
Notes


1. p 329, R.

2. "...it is not the same thing for us to conceive something by a veritable idea or a true image, and to conceive that thing by a conclusion that follows necessarily from an anterior hypothesis. In the first case in effect we conceive of the thing as absolutely so; in the second, that it should be some such thing; and also in the first case we know the thing distinctly and as it is in itself, and in the second case we know it only in a confused manner and by analogy, that is, in referring to it as something that must be known by way of some Idea." (p 234 R, p 322b, v III, Q; translation from Rochot mine.)

In this passage Gassendi contrasts two ways of attaining knowledge. We can have a direct idea or image of an object, or else we can have indirect ideas and images of an object that we deduce from some other ideas. We use those other ideas -- which he calls "hypotheses" -- to conclude with necessity the character of the object. The general use of hypotheses (I discuss their specific scientific use in II.C.2.) provides us with knowledge ("conceptions" of a thing) that are necessary yet "confused", that is, indirect. There is a fairly close analogy with Locke's later terminological distinction between demonstrative and intuitive knowledge.

Gassendi may mean "essentially" when he says "the thing...as it is in itself" though this is contrary to his view that we have no access to knowledge of essential properties.

2a. By "empirical knowledge", I mean knowledge of the material world which is gained largely or wholly by experience. Perhaps knowledge of the world can be gained outside experience; for example, Gassendi thinks we can know about spiritual aspects of the world from revelation. [He does not, however, propose that we can know about the material world from revelation.] I suggest that Gassendi views sensory knowledge as the surest source of information upon which to base our
experiential understanding of the material world. Further, Gassendi thinks that knowledge of the truths of reason is gained in part through our empirical knowledge (cf. p. 12 in the text).

3. p 266 - 267, B, p 532, R, p 388a, v III, Q.

4. "...quod res tales appareant; nec potest non esse verisimum taleis apparere." (p 535 R, p 388b, v III, Q)


7. Gassendi does not anticipate Quine's view that analytic truths are always subject to revision (See Walker's illuminating discussion of Gassendi and Quine). One problem with Gassendi's view is that his geometry example represents a plausible case of a stipulated or conventional truth. While such truths are clearly subject to revision on the basis of empirical information, the verdict is less clear with respect to truths of reason that represent essential properties of some thing or class of things. He holds that if there are essential properties, we cannot know them with any certainty whatsoever. It follows from his view that if we could not know truths of reason about essential properties, we would not need to worry whether such truths were subject to revision upon learning new empirical information.

8. p 535, R, p 388b, v III, Q.

8a. By "essence", I mean the underlying defining character of a thing; "essential characteristics" accordingly refers to the elements which comprise that character. Gassendi writes that for us to know an essence of an object requires a "perfect interior examination" of the object, and until we complete such an inquiry we cannot know that essence. (311b - 312a, v III, Q) Elsewhere he says we cannot know the "profound nature" of things though we can know their appearances (cf. note 12).

9. Gassendi writes: "Quicquid possamus cognoscere, est, hasce, vel illas esse hujusce substantiae, sive naturae proprietates, quando id observando patet, et experientia perspicuum fit...." (p 189, R, p 312b, v III, Q)

10. "Je tiens pour assuré que les sceptiques, tout en
admettant les choses qui apparaissent, dans la mesure où elles apparaissent et de la façon même dont elles apparaissent, sans rien décider cependant sur la nature profonde de chacune de ces apparences, sur sa vérité, ses causes, ses effets, ses propriétés, ses modes, n'ont pas cessé de mener méthodiquement toutes leurs recherches, et que, tout en se laissant aller comme tout le monde aux impressions de la vie courante, ils sont demeurés exempts de tout préjugé et ont conservé une entière liberté de jugement." (p 70, R, p 286b, v III, Q.)

10a. Ibid. If Gassendi agrees with the Skeptics that we cannot decisively judge the truth of appearances, then he apparently cannot endorse the accuracy of our sense based conceptions of things which appear to us. [This is D. Morrison's point (personal communication).] I agree that this would be a conflict in Gassendi's writings. Here is a way to resolve the conflict: Gassendi may hold that some appearances are judged to be accurate and at a future point we may change our accuracy judgement. Consider the part of the passage (quoted in note 10) where Gassendi notes that the Skeptics preserved their free judgement by withholding final decision, e.g., regarding the truth of appearances (...ils sont demeurés exempts de tout préjugé et ont conservé une entière liberté de jugement....) Thus the Skeptics might well have held that, pending final judgement, the appearances are or can be accurate. It seems Gassendi may hold that we view at least some appearances as accurate, though we reserve the right to change our accuracy assessments. I argue in II.B.3. that Gassendi holds just this kind of view.

11. In Section II.C. I suggest his view imposes limits on empirical knowledge -- and these limits shape a view of scientific descriptions and theories as merely empirically adequate.

12. "...d'une certaine chose on peut dire qu'elle est ou apparaît telle en ce sens qu'elle est douée de telle masse, figure, mouvement, position; et qu'en même temps elle présente quelque analogie, par rapport à tels ou tels organes; par rapport à tel ou tel être animé ou humain; par rapport à tel ou tel tempérament ou manière d'être, [et autres] semblables [circonstances]; mais non pas qu'elle soit pour autant telle en soi ou dans sa nature profonde...." (p 70, R, p 286b, v III, Q.)

13. p 252, B, p 265, B, p 340, B.

15. Craig Brush claims Gassendi did not understand the nature of an axiom system (p 266n, B). However, Gassendi apparently understood axiom systems insofar as he understood that there are arguments based on undemonstrated hypothetical assumptions. I think he grasped the character of axiom systems, but he rejected (axiom systems and) arguments based on undemonstrated assumptions. He could reject such arguments because of his view that we can know only appearances and never essences; since undemonstrated assumptions are neither apparent nor sensed, they must be known only by way of some essential truth. Gassendi writes that the dogmatists held hypotheses to be "...so right and true to nature that actual things would be assumed to be exactly the way the hypothesis supposed they were...." (p 265, B, p 510, R, p 384a, v III, Q.)

Viewing hypotheses as "absolutely true" (pro germanis p 265, B, p 510, R, p 384a, v III, Q) prior to experiential confirmation simply conflicts with Gassendi's view that we know facts about the world primarily through appearances.

16. This worry resembles claims concerning the contemporary question of whether hypothetical assumptions at the basis of science are believed to be true or only tentatively accepted as true, pending further investigation. I discuss this issue further in II. A. and C.

17. p 265, B.

18. pp 332 - 333, B.

19. Ibid.

20. p 333, B.

21. Note that it is the signs that we recognize by the available criteria and not the objects or events indicated by those signs. Gassendi's discussion of signs and criteria addresses two problems. The first is how we recognize non-apparent objects or events, and he says we do this with signs. The second problem is how we recognize the signs, and he says we do this with the criteria of the senses and the intellect.

22. The latter clause follows as the contrapositive of the former: \((-T \rightarrow \neg S) \lor (S \rightarrow T)\). (p 33, Ibid.)
23. p 335, B.

23a. D. Morrison suggests (personal communication) that we cannot assess empirical knowledge as true with certainty unless we reason that it is not possible for the phenomena in question to be otherwise; then by the use of reason, our knowledge is not wholly empirical. Nor is it wholly certain, according to Gassendi: the more that we employ the intellect to reason about our experiments and observations, the greater the risk of error. Empirical knowledge cannot be wholly empirical unless it consists wholly of pure observational data reports. Such reports are also not always certain since, as the Skeptics charge, our observations may only be adequate or certain relative to the observer. Yet Gassendi thinks it is possible for us to judge knowledge from experience as true by the standard of the criteria he outlines. Further, we may use reason to make this judgement and that does not strip our empirical knowledge of its experiential or observational basis.

24. p 347, B, pp 81 - 82, v I, O.

25. It is not clear whether he believes this absurd situation to be logically as well as physically impossible. That two bodies would be in the same place at the same time is manifestly a physical impossibility, yet Gassendi intends the absurd situation as a premise to be refuted in a reductio style argument. Descriptions of the inconsistent events would represent logical impossibilities.

26. As M. Kulstad indicates (personal communication), the "opposite" situation needs to be specified thus, as a necessary first step. What exactly constitutes the "best" description of the original or opposite situations of course remains vague.

27. p 347, B, pp 81 - 82, v I, O.

28. Ibid.

29. p 327, B.

30. pp 326 - 327, B.

31. Popkin makes a similar suggestion. He says Gassendi intends we can have no certain knowledge: we have only instrumental knowledge that remains useful so long as it is empirically verified (pp 862 -864, Popkin). Popkin's resolution does not squarely address Gassendi's many
references to certain knowledge derived from signs. Moreover, Popkin's view does not suit the realist position I attribute to Gassendi in II.A.

32. p 347, B, pp 81 - 82, v I, Q.

33. Ibid. Perhaps arguments given elsewhere for certain knowledge via the senses serves as Gassendi's proof (or lemma thereof) for certain knowledge of the sensory criteria.

33a. Ibid.

34. p 372, B.

35. Gassendi generally emphasizes empirical knowledge although he is not consistent throughout the Syntagma:

...although it is admitted that the senses are sometimes misleading and that therefore the sign may not be reliable, still reason, which is superior to the senses, can correct the perception of the senses so that it will not accept a sign from the senses unless it has been corrected and then at last it deliberates, or reaches its judgement of the thing. (p 333, B.)

There is a clear tension here between this view and the view that empirical information is primary and can overrule reason. Gassendi elsewhere suggests one kind of compromise, which I discuss in II.C.1. In this context, suffice it to say the view of empirical knowledge as primary is reinforced throughout Gassendi's writings, in the Syntagma and elsewhere.


37. B Ellis (1985) writes: "The laws and theories of science are genuine claims about reality....This is the central thesis of scientific realism....the idea is that there are things in the world to which our laws and theories refer and of which they are true or false." p 52.


39a. According to Gassendi, an empirical description
describes worldly objects as they appear to us, and we can use empirical descriptions to characterize the real or actual qualities of such objects. Since Gassendi holds that empirical descriptions refer to real world objects (as they appear to us) and those qualities belong at least accidentally to objects, he is committed to the view that the objects are real, too. Hence empirical descriptions refer to real world objects by referring to their real world (accidental) qualities.

39b. I take premise (4) to express an uncontroversial idea about theoretical terms in science, namely, that such terms refer to real objects whenever the scientific descriptions that employ those terms refer to real objects. By saying that a theoretical term refers to a real object, I mean that the term is formulated to describe a worldly object and there is an object in the world which corresponds to the term, according to one of several candidate standards: the term regularly indicates some set of observable effects, or accidental qualities, or essential properties, of a worldly object. If Gassendi were committed to (4) he would likely endorse the referential standard of observable effects or qualities, since he places greater confidence in sensory knowledge than in non-sensory knowledge.

According to Gassendi, what could be the connection between (i) a theoretical term referring to a real object and (ii) an empirical description describing a real object as it appears to us (cf. note 39a)? It would likely be that those empirical descriptions, based on our sensory knowledge, employ theoretical terms to express that knowledge. If (4) is a premise Gassendi could support, then both the empirical descriptions and the terms they employ refer to real world objects.

Let me emphasize that I do not intend to show that Gassendi holds (4), though his writings on science might show that he does. I introduce (4) to make the point that if Gassendi would accept such an uncontroversial premise as (4), then he could be viewed as a scientific realist. Even though Gassendi does not openly maintain (4) in his philosophical writings, he otherwise maintains sufficiently many necessary premise to constitute -- with (4) -- an argument for scientific realism.
40. This argument may be symbolized as follows:

\([(\text{Ex}) (x)]\) symbolizes existential quantification over \(x\)

**Predicates**

\(Ax\) = \(x\) is an appearance.
\(Dxy\) = \(x\) is a description of \(y\).
\(Sx\) = \(x\) is based on sensory data.
\(Kx\) = \(x\) constitutes knowledge.
\(Cx\) = \(x\) is certain and accurate.
\(Nxyw\) = \(x\) is knowledge of \(y\) by description \(w\).
\(Rxy\) = \(x\) refers to \(y\).
\(Ox\) = \(x\) is a real object in the world.
\(Mxy\) = \(x\) is a description that employs terms of type \(y\).
\(Tx\) = \(x\) is a theoretical term.

**The Argument**

1. \((x) (y) (Ay & Dxy \rightarrow Sx)\)
2. \((x) (Sx \rightarrow (Kx & Cx))\)
3. \((x) ((Kx & Cx) \rightarrow (y) (w) ((Ay & Dw & Nxyw) \rightarrow (Ez) (Oz & Rwz))\)
4a. \([(\text{Ex}) (Ey) (Ev) (Av & Dvx & Oy & Rxy & (z) (Mxz \rightarrow Tz & z = \phi))] = df \phi\)
4b. \((w) (Ow & R\phi w \rightarrow (\text{Ex}) (Ey) (Tx & Oy & Rxy))\)

5. \((\text{Ex}) (Ey) (Tx & Oy & Rxy)\)

The conclusion (5) follows from the premises (1 - 4) by conditional proof at each step, with the assumptions (4a, 4b) not specified by Gassendi. A thorough version of this argument might also take into account this premise:

1'. Constructive skepticism permits knowledge of scientific objects through indirect (indicative) signs. Hence we can describe even more objects in the world, based on reasoning about sensory data.

41. p 70, R, p 286b, v III, 0.

42. The truth of appearances has no direct bearing on the reality of objects of those appearances. Appearances are true if they actually appear to us. Appearances refer to real objects just in case the objects are real -- whether or not the appearances are actual, partial, or wholly false.

42a. pp 311b - 312a, v III, 0.

42b. p 290b, v III, 0.
43. p 70, B, p 286b, v III, O.

44. Assume to the contrary that Gassendi recognized the theoretical character of terms like "mass" and "position". We might think attributing theory-determined properties cannot be used to attribute reality to objects described with such terms. But Gassendi's view supports real properties of objects even if they must be described theoretically.

Theory construction involves reasoning, and reason always defers to empirical knowledge. Our descriptions of properties may be theoretical and yet those descriptions are subject to empirical review. Therefore physical properties like mass and position can be known with a high degree of certainty, according to Gassendi. If they were merely theoretical constructs, they would be knowable with far less certainty. One reason descriptions would have a high degree of certainty is that they refer to real properties.

45. Gassendi's view of indicative signs also supports the view that empirical descriptions describe real objects. We know about some phenomenon or object existing indirectly through the existence of some other phenomenon or object that would not exist otherwise. So our description of the sign would not give us any knowledge of the signified thing if we did not attribute existence to the sign.

46. p 265, B, pp 510 - 513, B, p 384, v III, O.

47. p 70, B, p 286b, v III, O.

48. p 333, B.

49. p 372, B. In this passage, Gassendi writes about things "perceived by the intelligence". He does not define "intelligence" but one possibility is that he means the mind. True, the only theory of perception Gassendi overtly discusses is sensory-based and does not indicate how the mind can perceive anything. Nevertheless, he talks about abstract ideas and dreams we perceive and so he needs some account of "perception" independent of outwardly-directed senses. Such an account would facilitate this interpretation.

Another possibility is that Gassendi intends the "intelligence" to mean what he calls the "intellect". The intellect is a faculty of reason, just as the senses are a faculty of perception (cf p 345 B, and my discussion in II.C.1.) This, however, raises the
question of what separates those two faculties if the intellect is also a faculty of perception.

Still another possibility is that Gassendi means to equate the "intelligence" with "reason". Gassendi makes it difficult to figure out which alternative is more plausible; he uses these terms (intelligence, intellect, reason, mind) so interchangeably (cf. for example, p 332, B) that it is hard to see exactly how he conceives they are related.

50. p 345, B.

51. As I indicate in note 35, Gassendi does not consistently emphasize the superiority of the senses to reason. Yet he unambiguously holds that empirical information molds our patterns of reasoning and theoretical outlooks. I try to show in this paper that his view on this latter issue helps us sort out his inconsistencies on the former one.

52. If the descriptions do not fit, scientists revise accordingly (as per direct correction mechanisms). The descriptions or models are altered until they are empirically adequate. If they are adequate now, introduction of new data may render them inadequate later on. So theoretical knowledge is constantly subject to change.

53. I do not explore his views on instruction, which are no doubt relevant to a history of theories of explanation (cf pp 373 - 379, B, passim).

54. pp 367 - 373, B, passim.

55. p 335, B.

56. p 234 B, p 322b, v III, Q.

57. ...the same appearances could be predicted and preserved by contrary hypotheses which could not be true at the same time as the first. (p 265, B, p 510, R, p 384a, v III, Q.)

Take the case of two hypotheses, h₁ and h₂. According to h₁, objects of sufficiently great size pull the moon across the sky which thus blocks the sun. However, h₂ suggests objects pull on the moon's surface and cause no regular lunar motion but cause lunar agents to move the moon into an eclipsing position. These hypotheses are not compatible since h₁ suggests gravity alone is
sufficient to pull the moon into solar eclipse and $h_2$ suggests an additional agency is needed to bring about the eclipse. Nevertheless both hypotheses support the predictive claim that there are such eclipses -- conceivably at the predicted times. These are surely fantastical hypotheses. Yet for Gassendi, the only criteria hypothetical assumptions need to meet is that they account for the phenomena in question, independent of any other information.

Hence until each hypothesis is subjected to empirical review, there is no reason to believe one or the other is true. For example, there is no consideration of a contemporary commonplace, the practice of assigning relative probabilities to different hypotheses based on other relevant theory.

58. Gassendi writes that "existence" is not a property of objects. Properties are physical characteristics that inhere in objects and attributes are logical characteristics that are assigned by the intellect to objects. Properties can be changed or subtracted from objects without doing away with some remaining substance. This is not true of existence. Ergo, existence is not a property of objects but a transcendent class of classes of objects (sive transcendentale genus, quod omnibus generibus). In short, existence is a logical attribute rather than another property. (pp 258 - 260, B, pp 496 - 501, R, pp 381a - 381b, v III, Q.)

59. Scientific theories need to account for phenomena whether they are real or simply hypothetical, but the latter kind represent phenomena that could be real with no other alterations to their description.
Chapter Two

The Skeptical Element in Locke and His Views on Scientific Knowledge

Introduction

Locke's *Essay Concerning Human Understanding* (1690) is the English philosopher's best known work and his clearest statement on questions of epistemology, theory of mind, and philosophy of language. Several authors indicate that the *Essay* is also a source for grasping Locke's views on some issues in the philosophy of science [e.g. Osler (1970), Woolhouse (1971), Yolton (1969)].

I show how Locke's epistemological views support his empiricist view of scientific theory and practice. He develops a complex typology of ideas and knowledge in the first books of the *Essay* and draws on it to designate the limits and extent of our possible knowledge of objects in the material world. He does not allow that we have access to the real essences of substances, and he severely limits the range of our certain knowledge of real world entities. Many of Locke's views are specific to a theory of empirically and experimentally derived knowledge. He describes the character and extent of our experiential knowledge about objects or "substances" in the world. I focus on these views to show that Locke’s *Essay* contains an important constructive skeptic statement on the nature of scientific inquiry.
In Section I, I explain Locke’s general views of ideas and knowledge and his specific views of our limited access to ideas of essences and the constraints on our empirical inquiries. We do not have access to essential ideas about substances in the world because we get such ideas from less than certain sensory information. Although the senses give us highly reliable information we must resort to probabilistic judgements in empirical studies.

In Section II, I show how Locke’s views on the overall limits of knowledge suggest a mitigated skeptical picture of science and scientific knowledge in particular. He advocates research and theorizing with an empiricist methodology and does not allow scientists the seductive security of certain knowledge. This view of science endorses sensory information as the primary source of data, as a corrective tool in research, and as a reliable indicator of the referents of theoretical objects. Because Locke maintains a skeptical distrust of dogma in science, he views scientific theories as bound by the confines of probabilistic judgement.

I. Locke’s constructive skepticism

A. An overview of Locke’s theory of knowledge

Locke’s theory of knowledge is largely if not thoroughly empiricist. He tells us that we gain knowledge by judging our ideas to be in agreement or not. Experience is a
partial yet essential source of our ideas and it is our means of judging their accord. Also, we sometimes use information gained from the senses to judge non-sensory components of knowledge, namely, the ideas we get from reflection and our intuitive perceptions of the agreement between ideas. We gain certain knowledge only from intuition or from non-empirical demonstration or proof. Thus Locke's empiricism is balanced by a rationalist element. Still, the best cases of empirically detecting agreement between ideas yield assurances with high probabilities. These assurances may not constitute certain knowledge but they are the most secure means of gathering knowledge about matters of fact. Hence Locke upholds an empiricist brand of constructive skepticism: we cannot have certain knowledge about objects in the world and their relations, but we can formulate and use some propositions about empirical objects and phenomena if we have trustworthy (highly probable) sensory information, ideas, and means of judging agreement of ideas.

1. Ideas: the immediate objects of perception, thought, or understanding

According to Locke the nature of knowledge depends on the character and relations of ideas. He bases his theory of knowledge on his concepts of the origin and classes of ideas. By "idea" Locke means the "immediate object of perception, thought, or understanding".¹ Ideas are the
fundamental elements of knowledge. The particular class of ideas about "substances" constitutes the basis of empirical knowledge.

We can have ideas about the world or about other ideas. In either case we accrue ideas by two means: sensation and reflection. Sensation is the perception of the qualities of objects in the world. Reflection is the perception or awareness of mental operations on ideas already present in our minds. Locke offers another name for reflection -- "internal sense". He means that the operations we reflect upon -- psychological events such as knowing, believing, and thinking -- are acts that produce new ideas, and in reflection we sense these ideas just as our "normal" or "externally-oriented" senses sense external objects. Hence reflection is like sensation in that both are means of becoming aware of new ideas either by employing sensory experience or something very analogous to it. Thus all our ideas are gained from some form of sensation.

i. Different classes of ideas
Locke proposes two main classes of ideas, simple and complex. Simple ideas are those that we sense discretely: some examples he gives are singular tastes and smells. Complex ideas are those that we form by combining simple ideas through comparison, repetition, unification; and the abstraction of simple ideas.
Locke says we can have three kinds of complex ideas: ideas of substances, modes, or relations. Complex ideas vary by the ways we combine their constituent simple ideas and the degrees of access we have to their definitive qualities or essences. Ideas of substances are discrete representations of individual objects. These representations are formed by the combination of simple ideas. An example Locke provides is the idea of man, formed by combining ideas of figure, motion, thought, reasoning, and substance. Ideas of modes are representations of objects or concepts also formed by the combination of simple ideas. These representations are not discrete; they are dependent on, or affect, autonomously subsisting substances.

Locke differentiates between simple and mixed modes. The former are merely variations on simple ideas, such as a dozen, which is a multiple instance of a simple idea. The latter are compounds of different kinds of simple ideas, such as theft, which is a combination of simple ideas such as propriety, change, consent, and concealment. Theft combines these ideas and is not a substance because it cannot subsist on its own without, for example, the substance property.

Finally, ideas of relations are comparisons of distinct ideas. We can take simple ideas and describe how they match, connect with, or suggest other ideas; these
descriptions are complex ideas of relation. For example, "Caius is a man" is an idea of him as a singular substance while "Caius is a husband" is an idea of him that necessarily leads us to at least one other, namely, the idea of another person (Caius's wife, Sempronia). Substances, modes, and relations classify complex ideas by the particular manner in which their component simple ideas are combined.

Locke distinguishes between substances, modes, and relations because he thinks our degree of knowledge varies according to the type of idea with which we build our knowledge. He says the objects of our ideas have constitutions that allow us to differentiate among the distinct "species" of objects. These heterogenous constitutions are their essences: the "measure and boundary" of one idea from another. For example, objects that conform to a particular description of a general class (that is, conform to an abstract idea) have an essence that distinguishes members of that class from members of other classes. Our access to essences varies according to the type of idea we use. Hence we build knowledge with varying degrees of access to essences. As a result our knowledge also varies by degree, from certainty to fallible judgement. A hallmark of Locke's constructive skepticism is the view that there are degrees of knowledge. In order to chart this view, I
first show how the type of idea determines the level of access to its essence.

ii. The essences of species of ideas
Each object belongs to a species (class) and has two types of essences: real and nominal. To belong to a class of objects is just to have the essence that corresponds to that class. Real essences are that which give an object its characteristic properties. Nominal essences are those properties of an object by which we recognize the object (as distinct from others). Locke gives the example of a gold ring. The real essence of the gold is whatever gives rise to its observable properties (for example, color, weight, fusibility, and "fixedness"). Its nominal essence is the set of observable properties by which we call the substance gold and not anything else. These types of essence yield different ways of distinguishing among objects. When real essences are accessible (for example, as with our ideas of triangles) these essences allow us to distinguish their objects by their defined properties (to wit, we know the essential properties of triangles before experience). Nominal essences allow us to distinguish their objects by their sensed properties -- and only tentatively. Sometimes the real and nominal essences of objects coincide as is the case in objects of simple ideas and modes. In the case of substances, though, real and nominal essences do
not coincide. The sets of properties we associate with species of substances are nominal essences only. We do not have ideas of their real essences since we do not have access to the constitutional properties that give rise to all their observable properties. The only properties of substances about which we have ideas are unfixed. Locke cites the case of the substance man. If we had an idea of the real essence of man -- that which accounts for all his faculties and physical characteristics -- we would have an idea of man that gave a complete account of his (or her) interior organization. Such an idea is available only to God (and possibly the angels) just as the idea of a clock's inner workings is known only to those with special access -- for example, clock makers.\textsuperscript{25}

Thus we have ideas of an object's nominal essence in all cases but ideas of its real essence only with respect to species of simple ideas and modes. Locke suggests that species of substances have real essences even though we do not know them:

\begin{quote}
...as to the real essences of substances, we only suppose their being, without precisely knowing what they are.\textsuperscript{26}
\end{quote}

We assume that species of substances have underlying constitutions or real essences; something must exist that gives rise to the observable properties which constitute their nominal essences.\textsuperscript{27} In sum, we have ideas (the
objects of our thoughts or perceptions) about objects in the real world and those real world objects have constitutive essences about which we can have no ideas. This proscription rules out a general and rather large class of ideas. Locke's theory thus limits significantly our available materials of knowledge by defining many ideas as inaccessible to us.

iii. The adequacy, reality, and truth of ideas

Locke classifies ideas according to their agreement with sensory information and their resulting accessibility. In the last part of Book II of the Essay, Locke divides ideas along the lines of three dichotomies: ideas are either adequate or inadequate, real or fantastical, and true or false. These distinctions highlight Locke's emphasis on sensory information in the gathering of ideas, and they spell out some preliminary restrictions on the accessibility of ideas. The last distinction constitutes his view of the empirical accuracy of ideas. Locke's three-fold classification distinguishes ideas by the extent to which they accurately inform us about the world. Scientists make these distinctions to weigh the contributions of sensory and reasoned information.

Ideas can be adequate or inadequate. Adequate ideas fully represent an associated general class of objects (their archetypes). For example, an idea of the scent of a rose
is adequate because it is based on accurate sensation and so represents the archetype of rose-scent. Simple ideas are always adequate; they are based on sensations produced by their objects. Since the senses give us reliable information, simple ideas necessarily represent archetypal patterns of their sensed objects in the real world.\textsuperscript{31}

Modes and relations are also always adequate ideas because they represent mentally-constructed combinations of simple ideas. All the objects or actions to which they refer are mental designations; so ideas of those objects and notions necessarily represent those designations adequately.

Ideas of substances, however, do not represent their objects adequately. We do not have access to the real essences of substantival objects and we never know all their qualities. Hence our substantival ideas cannot completely capture or perfectly refer to the whole general class of their objects.\textsuperscript{32} Locke defines a limit on our access to, and use of, ideas of substance.

Ideas can be real or fantastical. According to Locke, an idea is real if it describes a quality of a worldly object and has a "foundation in nature", that is, the quality which corresponds to the idea causes us to have that idea.\textsuperscript{33} Real ideas indicate that their corresponding qualities are "really in things themselves".\textsuperscript{34} They also indicate qualities which distinguish one real object from another.
We judge ideas to be real if they are regularly produced by distinct qualities, objects, or classes of objects in the real world; their reality generally does not consist in their representation of real objects in the world. In sum, ideas are real if they correspond with "the distinct constitutions of real beings [that is, objects]."

Simple ideas are always real, because they are produced by the senses or objects of the senses, and so regularly correspond to sensory information concerning distinct qualities of real world objects. Complex ideas are real when they combine simple ideas such that their combination conforms to their objects. Ideas of modes and relations are real when it is possible for these ideas to conform to the meaning that is attached to their names. Since we assign meanings to modal or relational ideas when we define them as this or that mode or relation, such ideas are always real unless they are formed with inconsistent ideas. Ideas of substances are real insofar as their constitutive simple ideas are real and their combination is real. Thus the idea of a centaur is fantastical because the combination of a horse's head and a human body does not resemble any real unity in the world. Locke views simple ideas as real if they are produced by sensory information. He views complex ideas as real if they conform to the way the world is, either with respect to the meanings we assign to our ideas
of modes and relations or with respect to the configurations we discover in the shapes and forms of existing substances.

Ideas can be true or false. True ideas are those that conform to both their objects (that to which they refer) and their names (according to previous usage and custom). By "conform" Locke means that ideas are accurate to a "sensible standard", that is, something that is sensed and constant. Ideas conform to names when they meet the standard of previous usage. Simple ideas and substantival ideas are likely to conform in this way. The names of simple ideas can be checked against their objects. The names of substantival ideas can be matched with particular species that are easily distinguished by "some remarkable sensible qualities". The conformity of modal ideas with their names cannot be measured by an external standard. The standards against which their names are measured are only internally "sensed". Names of modal ideas are mental constructs just like the ideas they label and so they are easily associated with those same ideas.

Unlike ideas conforming to names, ideas conforming to objects involves meeting some constant standard in the real or material world. Ideas conform to "the real existence of things" if they agree with whichever things produce them. Simple ideas are true because they are produced by
some aspects of material objects that give rise to the same ideas consistently. We are able to rely on a high degree of accuracy, or truth, of simple ideas because they are "...answerable to the powers in external objects to produce by our senses such appearances in us...."\textsuperscript{46} Modes also meet a constant standard by matching their own description; however, since modes do not refer to any objects in the real world, they cannot be said to be true or false, accurate or inaccurate.\textsuperscript{47}

On the other hand, ideas of substances refer to real world objects. If they are thought to give us ideas of the (real) essences of those objects, they are always false.\textsuperscript{48} If they are considered as not representing real essences, substantival ideas are true so long as they do not represent inaccurate conjunctions of simple ideas, such as the false unions of ideas of objects that are not physically compatible.\textsuperscript{49} Ideas of substances are true or false depending on whether, as collections of simple ideas, they represent accurate groupings. In all cases, the object-conformity of ideas is determined by the accuracy of simple ideas and their conjunctions.\textsuperscript{49a} This accuracy is guaranteed by either the sensory source of our simple ideas or the observations which lead us to judge that a substance’s constituent ideas are always conjoined in a particular fashion. Locke’s constant standard for the truth of ideas
consists in the measure of sensory information given by objects in the real world.

Locke's theory classifies ideas as adequate, real, and true (or inadequate, fantastical, and false). These characterizations emphasize his view that ideas are the primary materials of knowledge. The foremost standard by which ideas are to be judged is their degree and manner of agreement with our sensory perception of objects in the real world. Also, our judgement of ideas of substances is cautious and requires sensory verification. These ideas do not represent their objects adequately and they are real and true only if the simple ideas they contain are real and true -- individually and as combined. Substantival ideas bring together simple ideas to represent objects in the real world yet they are limited in their capacity to represent those objects in the most adequate, real, and accurate sense. In Locke's catalogue of ideas one particular class -- substances -- is singled out as less capably serving as a building block of certain knowledge. He thus builds into his theory of ideas a restraint on the trustworthiness of empirical knowledge.

2. Knowledge: the perception of the agreement or disagreement of ideas

When we perceive the relations between ideas we build knowledge. We draw on ideas from sensation and reflection -- and compare at least two ideas to see if they agree with
each other. If we perceive agreement or disagreement definitively, then we have knowledge. If we cannot reach a definitive conclusion we have something less than knowledge, such as opinion.50

There are three degrees of knowledge: intuitive, demonstrative, and sensitive. Intuition consists of immediately perceiving the accord or non-accord of ideas and it is a clear and certain class of knowledge.51 This class includes basic perceptions of agreement and disagreement that are obvious without any further thought, such as that one and one is equal to (agrees with) two, and that one color is not another.52 Demonstration consists of perceiving accord or non-accord of ideas with the help of other (mediating) ideas, as in a mathematical proof. Like intuition, demonstration gives us certain knowledge. However, we need mediating ideas to perceive accord or non-accord between ideas, so problems occur because of the extra steps, such as memory loss. As a practical matter, demonstration provides knowledge that is as certain but not as clear as that provided by intuition.53

Demonstrative knowledge allows us to reason from basic intuitive knowledge but does not permit us to know about the whole range of an object's qualities. To demonstrate empirically modal qualities such as color we need to show that an object's shade agrees (or does not agree) with some
standard shade. We can gauge and demonstrate the agreement of the two shades if we can show their equality or difference is produced by the object's essential constitution. But we do not have access to those essential qualities and so we can measure neither them nor the non-essential modal qualities they produce. Hence we cannot use demonstration to reason from knowledge of an object's perceived qualities to knowledge of the object's modal or dispositional qualities -- such as being more or less a particular shade or shape.

Sensitive knowledge consists of perceiving that objects exist. We base this kind of perception on our sensed ideas. This is not exactly "knowledge" for Locke since sensory information does not offer the requisite certainty we find in intuition and demonstration. Nevertheless, sensitive knowledge provides us with understanding that is as clear, if not as certain, as that provided by intuition: "We as plainly find the difference there is between any idea revived in our minds by our own memory, and actually coming into our minds by our senses, as we do between any two distinct ideas." Sensitive knowledge is not certain yet it supplements our understanding of real world objects. Locke thinks sensitive knowledge is important -- he includes it on his list of the types of knowledge even though he thinks it falls short of being true knowledge. Perhaps
sensitive knowledge is important because it allows the perception of an object's basic quality of existence and thus makes possible a wide range of (less clear and less certain) judgments about other qualities of those objects.

B. Certain knowledge and Locke's constructive skepticism

One task Locke sets for himself in the Essay is to describe the extent of our knowledge. He categorizes the ideas with which we build knowledge and examines several types of knowledge. He also develops specific views on certainty and knowledge. Locke's views on empirical knowledge guide our understanding of his views on science and scientific knowledge. He dismisses skeptical arguments against knowledge of the external world, but embraces a mitigated skeptical view of knowledge of substances. Sensitive knowledge is neither "real" nor certain because we lack information about the real essences of substances. The propositions that express our knowledge of substances do not relate more than we know about their nominal essences; these propositions are also uncertain or else uninstructive. Informative expressions of substantival knowledge are incomplete generalizations and require continuous experimental confirmation. Locke emphasizes the value of experimental inquiry and endorses probabilistic judgments as an alternative to certain knowledge of substances. He accepts a range of probabilistic evidence from direct
observation to analogy from indirect evidence. Locke's denial of access to substantival essences leads him to reject certain substantival knowledge. His view of scientific knowledge is a combination of empiricism and mild skepticism: the study of particular substances in the world is based on sensory experience and the senses yield limited though generally reliable information about those substances.


Locke entertains skeptical challenges at several points in the Essay. I consider a couple of exemplary passages to illustrate his overall stance towards the breadth and depth of our knowledge.

In his discussion of sensitive knowledge, Locke claims that sense-derived perceptions correspond to objects in the real world. He suggests one skeptical answer to this claim is that dreams as well as real world objects may produce perceptions, so there is no reason to invest faith in the existence of objects external to our minds. Locke responds with two objections: (i) truth and knowledge are "nothing" in a world merely consisting of dreams, and (ii) there is a sensory difference between dreaming of a perception and really having the same perception, and this difference can have practical effects, such the presence or avoidance of pain. The kernel of the first objection seems to be that
a world which exists in the mind alone could not tell truth from falsehood or knowledge from ignorance. Here he offers little development of this view and little argument on its behalf. In fact he may suggest the contrary view by emphasizing the certain character of demonstrative knowledge; we may demonstrate truths such as theorems without even perceiving ideas outside our minds (as in mathematical proofs). Locke's second objection is a rendering of a standard pragmatic criticism: if you doubt the reality of the world or our knowledge of it, you will have a very difficult or impossible time conducting practical affairs. The hardened skeptic is not likely swayed by this defense of sense-derived perceptions but Locke does not care to treat such recalcitrance here.

In a passage on knowledge of the existence of real world objects, Locke says we have such knowledge because our senses give us corroborating information. He notes that skeptics may claim to sense objects yet remain uncertain as to their existence. According to the skeptical argument, sensory information alone does not tell us our senses report real objects -- that would assume the reliability that needs to be proven. Locke defends the reliability of sensory information by pointing out that dependable faculties of sense are necessary to any discussion of knowledge such as that appearing in the *Essay*. The skeptic who engages in
this debate thereby admits there are dependable faculties of sense. This is a version of the incoherence criticism of skepticism: if you hold a skeptical position you will run into contradictions, sooner than a non-skeptic in a relevantly similar position. Here too an absolute skeptic might not be fazed by Locke's rebuttal, since absolute skepticism suggests there can be no criterion of knowledge. Then we do not need to worry about whether our knowledge entails contradictions since we cannot even know when we have knowledge of a true proposition, much less one that contradicts it.

Locke does not accept absolute skepticism. He views intuitive and demonstrative knowledge as sources of certain knowledge, and holds that our highly probable judgements of real world objects have a reliable sensory basis. Further, he rebuts skeptical arguments with charges of pragmatic failure and incoherence.

However, Locke also does not accept that we have complete access to knowledge with certainty. He indicates there are bounds to our knowledge and he subscribes to a mitigated skepticism concerning our knowledge of entities in the world.

2. Limits on knowledge.

Locke notes several limits on the contribution of ideas to
our knowledge. One is that we know nothing beyond our ideas. He says "...our knowledge [is] limited to our ideas, and cannot exceed them either in extent or perfection...".\(^{59}\) We build knowledge using ideas as basic materials and nothing else. Moreover, we do not understand all of our ideas; many are subject to "doubts and inquiries".\(^{60}\) We cannot even use our entire set of ideas to contribute to our knowledge.

Our knowledge is further limited by our occasional inability to grasp the relations between ideas. Perception of agreement or disagreement between ideas entails perception of four possible types of relations: identity (or diversity), relation, co-existence (or necessary connection), and real existence.\(^{61}\) Locke stresses that we know neither all the relations of ideas\(^{62}\) nor the necessity of relations between some of our ideas.\(^{63}\) We are particularly ignorant about the necessity of relations with respect to knowledge of substances.

Locke claims there is another limit on our knowledge that results from the character of our ideas. Knowledge is real only if there is agreement between ideas and reality. By "real" Locke apparently means that knowledge of our ideas does not simply concern different elements of our imagination; it is knowledge of ideas about real world objects. This agreement is additional to any agreement that
exists between ideas. So it is possible to have knowledge that is certain but not real; we could perceive agreement between ideas without perceiving agreement of those ideas with the real world.\textsuperscript{64}

It is also possible to have knowledge that is real but not certain. Notably, we rarely have certain knowledge that our ideas of substances in the world correspond to reality.\textsuperscript{65} In most cases we do not know enough about substantival essences to be certain about the co-existence relations between our ideas of substances. Though we may know the real existence relation between two ideas we are not likely to know that those two ideas are necessarily connected. We do not get this from sensitive knowledge, which tells us only that objects exist and provides no information about their real essences. In contrast, we always can have certain knowledge with respect to the reality of mathematical objects.\textsuperscript{66}


The empirical sciences advance our knowledge of material objects. Locke mainly develops his perspective on science in his views on knowledge built with ideas of self-subsisting material objects. He makes three central claims about knowledge of substances: the general propositions we use to express this knowledge are either certain or informative but not both; knowledge of the existence of
substances is reliable though not certain; and the probabilistic nature of this knowledge shapes the character of empirical research.

i. Propositional expression of knowledge of substances. Locke says our knowledge of general truths is "conceived and expressed in words" in the form of general or universal propositions. He pursues his inquiry into the nature of knowledge by studying the propositional form of knowledge. There are several types of universal propositions: trifling, instructive, and axiomatic (maxims). To show that Locke limits the expression of knowledge of substances I review his discussion of universal propositions generally and trifling and instructive propositions specifically.

Universal propositions assert that their main terms or subjects -- species of individual entities (known by nominal essences) -- have specific individual or general qualities. These propositions yield certain knowledge when we perceive the relations (agreement or disagreement) between the ideas expressed. Locke provides this example of a universal proposition (about modes): the three angles of all triangles are always equal to any two right angles. The subject of this proposition -- the three angles of all triangles -- is the species of the idea of a triangle's three angles, and the proposition asserts that this subject has the general quality of always being equal to two right
angles. We know this proposition to be certain if, as principles of geometry show, we perceive agreement between the simple ideas constituting the three angles of all triangles on the one hand and those constituting all collections of two right angles on the other.

Universal propositions about substances do not usually demonstrate the relations between their constitutive ideas. Ideas of substances refer to species with unfamiliar constitutions. Their ideas are brought together in a way that is easily sensed and grouped together as nominal essences, yet our knowledge of these propositions is in no way certain. The certainty of our knowledge depends on the perception of the co-existence relation between the simple ideas that compose the complex idea of the substance. However, we have no idea what brings together the subjects of the composite simple ideas; we do not know what constitutes the "substratum" or underlying basis of any given substance. Thus the relations we detect are only evident by experiment and lack the certainty of all the universal propositions not about substances.71

Universal propositions can be broken into two classes called "trifling" and "instructive". Trifling propositions assert something about their subjects that is "contained" in those subjects and instructive propositions assert something about their subjects that is not "contained"; these are analogous
categories to analytic and synthetic propositions. There are two types of trifling propositions: propositions of identity where "...the same term importing the same idea, is affirmed of itself...."⁷²; and propositions that define a singular quality of the object of a complex idea. In Locke's words, propositions of the second kind assert that "...a part of any complex idea is predicated of the whole..."⁷³ An example of an identity proposition is "An A is an A"⁷⁴ and an example of a singular quality definition is "Lead is a metal".⁷⁵ Each of these asserts an analytic truth about its subject. In contrast, another of Locke's examples -- "Man would be cast into sleep by opium"⁷⁶ -- shows that instructive propositions assert synthetic truths (or falsehoods) about their subjects.

Neither type of trifling proposition expresses much information about substances. Identity propositions can tell us about substances only in terms of strict identities so they are perforce empirically uninformative. Singular quality definitions are no more promising since the subjects also contain their predicates. Locke notes that trifling propositions may be certain but this is merely "verbal certainty" which is wholly uninformative.⁷⁷ However, the subjects of instructive propositions do not contain their predicates; hence they may be certain and informative. Yet Locke sees grim possibilities for expressing certain
knowledge of substances. Such knowledge is expressed far less in certain instructive propositions than in certain but trifling propositions or instructive but uncertain propositions. This is because our propositions cannot express more than our ideas of the nominal essences of substantival objects, and nominal essences do not give us certain knowledge of their relations between their constitutive simple ideas. Locke rules out expression of certain knowledge of substantival real essences since we can never reach final and certain conclusions about the real essences of substances. He accepts expression of certain knowledge where we have reached a plateau of certainty -- but this is the uninformative place of trifling propositions. His view of universal propositions concerning substances is that the informative ones will never be certain; rather, they will be subject to our renewed judgement time and again.

ii. How we know objects exist.

Locke tells us all propositions fall into two overall classes. One is the class of universal propositions. These concern species, and their certainty depends on our perception of the relations between abstract ideas. The other is the class of particular propositions. These concern individual entities and their existence, and their certainty depends on sensory information. Locke notes
that, whereas we have self-knowledge by intuition and knowledge of God by demonstration, "The knowledge of the existence of any other thing we can have only by sensation...."

Only sensory information demonstrates that real world objects exist. Ideas drawn from the imagination do not prove their existence. The senses provide information "with a certainty as great as human nature is capable of" yet this certainty falls short of that provided by intuition and demonstration. Locke gives us a series of reasons why we can rely on sensitive knowledge: (i) we are able to act and think coherently, and this requires reliable sensory information; (ii) our perceptions are produced by external sources and not by the mind so the senses cannot substitute fabricated perceptions for actual ones; (iii) ideas derived from the senses cannot be avoided like ideas from memory, so an external cause of sensory information must force us to have such perceptions; (iv) we usually recall a painful sensation without reliving the pain, so our sensations must yield richer, fuller experiences than ideas drawn from memory; and (v) the senses bear evidence for each other, as in the case of seeing a fire one also feels. These are adequate reasons for relying upon sensitive knowledge in particular propositions -- especially since those propositions are subject to review. Yet none of
these reasons truly addresses doubts about accuracy or the possibility of deception (by self or others). Locke's response (described above) is a version of the pragmatic refutation of skepticism.89

Our knowledge of an object's existence is not reliable over time. Locke notes there is no necessary connection between a thing's existing at two separate times. Our sensory information must be continuously renewed to retain its reliability from one moment to the next. Instead of trying to repeat the sensation, we usually make probabilistic judgements that our initial information is reliable.90 In sum, Locke claims we know about the existence of substances through trustworthy sensory information though our trust in the senses cannot be complete owing to their change over time.

iii. Advancing knowledge of substances: scientific knowledge and judgements.

Locke discusses principles for the conduct of scientific inquiry throughout the Essay. He tells us we generally advance knowledge by avoiding blind acceptance of maxims (axiomatic propositions) and by increasing our perceptions of relations between abstract ideas.91 However, we cannot advance knowledge of substances by consideration of abstract ideas and their relations. Rather, we increase our knowledge in this sphere by experience and experiment. As
Locke says: "Experience here must teach me what reason cannot...." He means of improving knowledge of substances -- experiment and historical study -- yield neither general nor certain knowledge. Instead, they strengthen probabilistic arguments and buttress our less-than-certain judgements. Locke retains the term "science" for the study of more general and certain knowledge such as mathematics. He says the empirical study of substances provides us with merely "advantages of ease and health".

Locke implies that studies which simply improve our "ease and health" do not deserve the name of science. Whatever his terminology, he thinks scientific research is important enough to address the methodology of gathering empirical knowledge. He discusses the use of hypotheses and the examination of regular phenomenal patterns in nature. Locke is somewhat cautious with respect to hypotheses. He suggests that we first examine individual substances and conduct experiments to ascertain the applicability of hypotheses before we adopt them as tools of explanation and discovery.

Locke says little about prediction per se in the Essay, but he explains his views on probability in some detail. In the absence of certainty, sufficiently high probability will serve to qualify our judgements in empirical studies. When we make judgements we use probabilistic evidence
because we do not have the security of intuitive and demonstrative knowledge.96 This evidence consists of statements of either direct or indirect observation and testimony97 or analogies drawn from indirect sensory information.98 A high degree of probability is assigned to testimony concerning experiments under "constant observation";99 a lower degree is assigned to conjectures we base on sensible effects of insensible causal agents.100 Nevertheless, Locke values the use of analogy:

...a wary reasoning from analogy leads us often into the discovery of truths and useful productions, which would otherwise lie concealed.101

From these approving views of analogies and other probabilistic evidence, we can gather that Locke is positively disposed towards the study of regular patterns in empirical inquiry. Our knowledge of substances is probabilistic and not certain yet we are able to judge real world phenomena and events to be part of systematic patterns. Locke’s mitigated or constructive skepticism denies the possibility of certain knowledge from our grasp of substances but grants that we can learn much from probability-based empirical studies.

Scientific knowledge is mostly a matter of probabilistic judgement, not certain knowledge. Nevertheless, scientists can use sensitive and demonstrative knowledge to build the general body of scientific knowledge. There is a skeptical
strain to this empiricism: although we use experiment to reach conclusions about real world objects and we invest some degree of belief in our ideas of those objects as being real, we do not know about substances and their qualities with certainty. Locke advises maintaining doubts about empirical studies and relying heavily on probabilistic judgements.

According to Locke's theory of knowledge the limits of our knowledge follow from limits of its constitutive ideas. Since we do not have access to ideas of substantival essences we can hope to reach only a tentative understanding of the material world. Thus his characterization of ideas and knowledge does not permit much certain knowledge of substances. In the next section, I show how Locke's view of scientific knowledge expresses his mitigated skepticism with respect to empirical inquiry.
II Aspects of Locke's Philosophy of Science

In this section I offer Lockean responses to three important questions in the philosophy of science. I show how Locke's views suggest that the objects or bodies referred to by scientific theories are real; that principles of empirical research are oriented around seventeenth century versions of probabilism and verificationism; and that theory and observation in science interactively influence one another. Locke's mitigated skeptical approach to knowledge provides the basis of support for these positions.

A. Knowledge of scientific objects and their reality.

Scientific realism is the view that the theoretical vocabulary used by scientists refers to objects in the real world, independent of our directly observing those objects. One primary opposing view says the reference of theoretical terms indeed depends on our direct observations of their objects: if we cannot see the objects then they are merely theoretical constructs. Another contending view suggests theoretical terms do not refer to any real world objects; rather they refer only to sets of our observations such as the instrument readings we stipulate to correspond with our theoretical accounts of the real world.102

Locke makes several claims that, taken together, support the scientific realist position that theories refer to entities
that are real objects. His views support a stance that is philosophically in keeping with his empiricism and scientifically in keeping with the new physical theoretical claims of his day. To wit, the new physics proposed mathematical or formal descriptions of the material world and these formal descriptions were intended to give theoretical accounts of real phenomena and objects.

Locke’s consideration of the real character of ideas and knowledge suggests a brand of scientific realism according to which we do not need to know the real essence of an object to know that the object is real. I intend the scientific realist sense of "this object is real", that is, that the object exists in the world and is not simply a theoretical construct. There are different perspectives on how to judge that an object truly exists in the world, such as judging the object’s reality from its effects, or from its accidental properties, or from its essential properties. I argue that Locke thinks we can gauge the reality of scientific objects from our ideas about the accidental properties of objects; hence I call this "non-essentialist" scientific realism.

Locke characterizes the relationship between ideas and the outside world in two ways. Ideas can be real and they can be object-conforming. He judges ideas of substances to be real if they are composed of simple ideas that are real as
individuals and as combined (cf. p 85 and note 49a). Simple ideas are real when they display distinguishing characteristics or effects that are regularly produced by real objects in the world. The regularity of those characteristics or effects must match the constant patterns of our sensory information. Simple ideas constitute real substantival ideas when they contribute to our grasp of the nominal essence of the substance and are combined in a realistic fashion. Real substantival ideas allow us to distinguish between real objects in the world on the basis of their qualities or effects, if not the whole objects themselves. Locke claims we have substantival ideas that resemble at least the parts or effects of objects in the real world, and these ideas are confirmed by regular sensory experience.

According to Locke, substantival ideas are object-conforming (a kind of accuracy) if their constitutive simple ideas agree with the material standard of real world objects and if the objects of the simple ideas combine in a physically plausible way.\(^{103}\) This standard marks Locke's belief in the accuracy of our sensory information; ideas conform to their objects when according to the senses they match their material instantiation. The match may be merely in principle: some unities of simple ideas may agree with never-realized though plausible configurations of matter.
(Contemporary examples include engineered isotopes and genes.) Substantival ideas that represent plausible real world objects qualify as object-conforming or accurate with respect to the real world.

Locke's view of object-conforming substantival ideas suggests we have ideas of whole real world objects -- not simply their parts or effects (as is the case with merely real substantival ideas). Further, we use sensory information to judge the accuracy of these ideas and we can have accurate ideas even when their objects are merely physically plausible; that is, even though their real world objects do not exist in such configurations.

The relation between knowledge and the outside world gives us a further clue about the reality of theoretical terms. According to Locke, knowledge is real if we perceive agreement between ideas and reality. That we know our knowledge to be real is established by perceiving agreement between ideas. In the case of substantival knowledge, we can perceive this agreement if the constituent ideas correspond to objects we perceive existing in nature together.104 Sensitive knowledge provides us with this perception. The perception of agreement is highly reliable because sensitive knowledge is produced by causes subject to public experience and verification. Through sensory information we detect the agreement of ideas constituting
our knowledge of substances with the outside world; thus we
detect that our knowledge is **real**. However, sensory
information does not allow us to have real substantival
knowledge with **certainty** since any knowledge derived from
changeable sensory information is similarly constantly
subject to alteration.

That Locke's views on substantival ideas and knowledge
support this non-essentialist version of scientific realism
may be argued thus:

1. Particular propositions use theoretical vocabulary to
   express the existence of real world objects.

2. Theoretical expression of the existence of objects
   (combined with Locke's view that only sensitive knowledge
   gives us knowledge of the existence of external objects)
   entails sense-derived knowledge of substances.

3. Sense-derived knowledge of substances yields knowledge of
   real world objects with a high degree of accuracy.

4. Knowledge of real world objects entails judgement of
   agreement between ideas and reality.

5. All ideas we judge to agree with reality we also judge to
   be real and object-conforming.

6. Our ideas are real and object-conforming hence we know
   they refer to real world objects.

7. Theoretical vocabularies (used in particular
   propositions) refer to real world objects (because our
   sensory knowledge does).\(^{105}\)

Nowhere does Locke explicitly conclude that theoretical
vocabularies refer to real world objects. Yet this is a
clear result of the argument's premises, which he either
suggests or directly states in the **Essay**:
1. **Particular propositions use theoretical vocabulary to express the existence of real world objects.** Propositions are expressions of knowledge; particular propositions express our knowledge of the existence of objects in the world. These propositions may utilize empirical or observational data based on simple ideas but they express knowledge of complex (usually substantival) ideas. Knowledge of such numerous and combined ideas is theoretical, not observational: even though the ideas are based on observational data, they are filtered and sorted by the relations and categories of complex ideas that we combine to constitute knowledge. Particular propositions therefore use theoretical vocabulary to express knowledge of complex ideas such as our ideas of real world objects.

2. **Theoretical expression of the existence of objects** (combined with Locke's view that only sensitive knowledge gives us knowledge of the existence of external objects) entails sense-derived knowledge of substances. Sensitive knowledge is the only means by which Locke permits us to know that external objects exist. So any expression of that knowledge must employ sense-derived knowledge of substances.

3. **Sense-derived knowledge of substances yields knowledge of real world objects with a high degree of accuracy.** Locke defines sense-derived ("sensitive") knowledge as highly
accurate though not certain knowledge of objects in the real world.\textsuperscript{105a}

4. Knowledge of real world objects entails judgement of agreement between ideas and reality. If we have ideas of objects in the real world then by Locke's definition of sensitive knowledge we can judge that there is agreement between those ideas and reality. Locke writes that "...all our complex ideas of [substances] must be such, and such only, as are made up of such simple [ideas] as have been discovered to co-exist in nature."\textsuperscript{106} Our sensitive knowledge of substantival ideas consists of judgements that those ideas conform with the objects of constitutive co-existent simple ideas. We gauge these co-existence relations by perceiving such objects in the real world: "Whatever simple ideas have been found to co-exist in any substance, these we may with confidence join together again and so make abstract ideas of substances."\textsuperscript{107}

5. All ideas we judge to agree with reality we also judge to be real and object-conforming. According to Locke, when we have real knowledge we perceive the agreement of real ideas with their real world objects.\textsuperscript{107a} Sense derived information tells us our ideas of real world objects minimally resemble the observable characteristics of such objects. Often the same information tells us those ideas resemble the objects in their entirety (that is, are object-conforming). So
these ideas are real and object-conforming.

6. Our ideas are real and object-conforming hence we know they refer to real world objects. Ideas that are real and object-conforming pick out or refer to either parts, effects, or entireties of real world objects. Thus these ideas refer to real world objects.

7. Theoretical vocabularies refer to real world objects (because sensory knowledge does). Theoretical vocabularies are used in particular propositions to express sensitive knowledge of real world objects. Such knowledge consists in perceiving agreement among real and object-conforming ideas (generally of substances). Therefore theoretical terms are used to express knowledge built with ideas of real world objects and thus those terms (like the knowledge they express and its constitutive ideas) refer to the objects themselves.

This argument appears to be valid (see note 105); its soundness depends on the interpretation of some key terms. For example, one objection says what Locke means by "particular proposition" is not what contemporary philosophers of science mean by "propositions using theoretical vocabulary". This criticism suggests Locke's particular propositions employ observational vocabulary because they express knowledge of the existence of real world objects -- which is demonstrated by observation, not theory. Yet particular propositions express knowledge
directly and ideas only indirectly, that is, as they are perceived or judged in relation to one another. Theoretical vocabulary is necessary for relating scientific understanding through particular propositions. Although we base sensitive knowledge on observational data, our knowledge consists not of observations but of judging the relations (agreement or non-agreement) between ideas produced with those observations. Hence the expression of our knowledge of the real world is an expression of our observations only as we incorporate them into the relations of simple ideas. Our understanding of the world is based on sensory observations, but we filter and re-organize our simple sensory based ideas by the (non-observational) judgements we make about relations between those ideas. For example we may observe such individual qualities -- length, hue, breadth, and sponginess -- as we might associate with Portuguese man-of-wars. Yet we will not grasp the idea (much less be able to express it) of a Portuguese man-of-war unless we judge that those qualities are related in a particular way. We make such judgements and fashion particular propositions not on the direct basis of observations, but on our relational understanding of the ideas we derive from those observations.108 So this relational understanding is rather theoretical than observational in the sense that we arrive at (and express) a judgement through a mental operation which relates our newly
acquired ideas to our background ideas, e.g. our collection of ideas or "theory" about what constitutes a Portuguese man-of-war.

Another objection says theoretical vocabulary may not refer to real world objects. If a proposition refers to ideas only indirectly (through intermediate mental categories) and the objects of those ideas even more indirectly, then its vocabulary apparently refers to those objects at great remove. Indeed, the terms apparently refer to mere theoretical constructs (namely, sensitive knowledge) that in turn may refer to objects in the world (since sensitive knowledge is not wholly certain). This brand of criticism attacks the scientific realist view that theoretical terms refer to real world entities by suggesting that they refer to theoretical entities alone. Whatever the merits of this type of criticism generally, it does not take into account Locke’s contention that our sensitive knowledge refers to real world objects via real and object-conforming ideas. The terms used to express that knowledge must also refer to objects in the world because to do otherwise would not accurately express our sensitive knowledge.

The "non-essentialist" scientific realism I outline here highlights -- and is supported by -- key aspects of Locke’s constructive skepticism. Although sensitive knowledge is not certain, it is highly reliable. Hence our knowledge of
real world objects is dependable and accurate. Ideas that form the basis of this knowledge are also accurate with respect to their objects because they are derived from sensory information which has a similarly high reliability. Our theoretical vocabularies can never be cast in stone since sense-derived ideas and knowledge are always subject to change. Yet their revisability is perfectly compatible with their referring to real world objects according to (whatever) our current sensory information. Moreover, Locke's views suggest our empirical knowledge -- though less than fully certain -- should be expressed in terms that refer to real world objects. After all, he thinks the source of that knowledge clearly refers to such external objects.

B. Gathering scientific knowledge.

Locke's views on methodology address the means, guidelines, and checks used in gathering and verifying scientific knowledge. He is reluctant to consider the natural sciences as sciences per se because they do not provide certain knowledge. Yet he outlines a view of empirical research as a reliable probabilistic means of deepening our understanding of the material world, based on our limited capacity to know about substances.

1. Primary tools: (a) sensation and reflection and (b) probabilistic judgement.

Since Locke says knowledge is the perception of agreement
or disagreement of ideas, the tools used to gather knowledge must enable us to collect ideas and to perceive agreement between them. Specifically, tools for gathering scientific knowledge must enable us to collect ideas of external objects (substances) and perceive their relations. We use some common tools -- sensation and reflection -- to further scientific knowledge. In gathering this knowledge we also employ probabilistic judgement which lets us use empirical data for cases of reliable though not certain information.

Acquisition of knowledge in science requires a different tool than knowledge acquisition generally. In science, we can never be certain of the agreement between two ideas because at least one idea incorporates sensory information, which cannot contribute to certain knowledge about substances. Scientists gather perceptions of agreement between ideas tentatively, basing their conclusions on numerous series of regular events. We use probabilistic judgements in science to mark the regularity of events where we have no certain knowledge.

2. Guiding principles
The Essay contains several themes which suggest a set of general guidelines for scientific research. Three research principles reflect Locke's constructive skepticism: the bounds and probabilistic character of empirical knowledge,
and the influence of previously-gathered ideas. According to these principles, we cannot have sensitive knowledge with certainty yet neither can we have research with unreliable data.

The uncertain nature of sensitive and scientific knowledge sets bounds on what we can possibly know. In Locke's terms, we know nothing from sensitive or scientific knowledge. The real essences of substances cannot be known with certainty hence they cannot be known at all. Knowledge of substances is limited to nominal essences, which allow us to distinguish among substances with certainty. Nominal essences, however, do not give us certain general knowledge of relations between the ideas that constitute substantival ideas. Nevertheless, knowledge of nominal essences unifies empirical data and enhances predictive power. However, since empirical studies cannot hope to uncover the substratum of matter or other essential characteristics of substance, researchers should not attempt to conclude with finality the ultimate and essential qualities of material objects in the world.

The primary aim of research is to further probabilistic judgements. Since we cannot have scientific knowledge with certainty we must direct empirical research towards characterizations of regular events with high probability. Researchers base reliable generalizations on experimental
observations. When these observations repeat frequently we can use the data to make judgements.\textsuperscript{109} Scientists substitute high probability for certainty when perceiving the agreement of ideas;\textsuperscript{110} the success of their research thereby depends on careful repetition of experiments and results.

The significance of empirical data is determined by its relation to previously gathered ideas. According to Locke we reflect on ideas we gain from empirical data just as we reflect on other ideas -- through comparison and combination with other ideas present in the imagination. To compare or combine new ideas from the senses with our pre-existing collections of substantival ideas we need to look for relevantly similar or shared characteristics. Locke claims custom plays a large role in the association of ideas: our prior ideas of nominal essences likely influence our choice of significant empirical data.\textsuperscript{111} We judge new ideas to conform with ideas we have previously gathered. We base the perception of conformity between new and old ideas largely on our wealth of previous judgements.\textsuperscript{112} For better or worse,\textsuperscript{113} our present sets of ideas and knowledge thereby impact heavily on our acceptance of information and the direction of future research.

In order to make sure judgements about material phenomena we need to renew our sensory information over and over. By
constantly verifying observational data we use experiments to strengthen judgements of phenomena we can never know with certainty; we also deepen our comprehension of the relations between our ideas concerning different phenomena.

3. Correction principles.
A Lockeian research methodology requires reliable means of re-affirming the accuracy of substantival ideas and knowledge. Locke offers two ways to systematically confirm evidence: show the coherence of new information, and show the conformity of new information with old.

The senses corroborate one another so they confirm our sensory information. Sometimes we gather information from more than one sense about the same phenomena. In such cases information from the different senses will either agree or not. If the information agrees then the senses confirm each other. Among the reasons Locke gives for trusting sensory information is the principle that each of the senses may give evidence to support information supplied by the others: "He that sees a fire, may, if he doubt whether it be anything more than a bare fancy, feel it too...." If the information does not agree then the senses cannot serve as evidence for each other. Locke does not explicitly say what role non-corroborating information should play in judging information from different senses. However, his emphasis on probabilistic judgements in the sciences suggests the view
that differing evidence should be weighed according to the frequencies of respective sensory experiences. Whatever Locke's precise view on this matter, he clearly holds that we have reliable ideas from the senses only if our sensory information yields adequate and real ideas -- and these characteristics are predicated on the agreement of information from different sensory sources. Ideas derived from various senses are thus more likely to be adequate and real when the information on which they are based is confirmed by all other relevant pieces of sensory information. If that confirmation cannot be obtained (as when the senses do not agree), then the most convincing evidence among disagreeing sensory information is the evidence with greatest observed frequency, constancy, and credibility of testimony. The ideas we base on such evidence may not be fully reliable but they will carry the cachet of highest probability.

Old ideas influence our admission of new ideas. Ideas already present in the mind help us to sort combinations of new ideas from the senses. One example is that we consider complex ideas to be real only if they are composed of real simple ideas in a plausible combination. Locke says the combination is plausible if it matches some actual cases. We use already-present ideas (of qualities we recognize in existing combinations) to judge new complex ideas as real or
not. Another example is that we judge the falsity or inadequacy of complex ideas by our current set of ideas. We may also show some simple ideas repeatedly fail to contribute to our complex ideas. The influence of old ideas indicates we cannot always use new sensory information to build empirical knowledge. Already-present ideas therefore are a means of sifting out unworkable complex ideas and setting aside infertile simple ideas.

Locke's views in the Essay suggest general methodological guidelines, specific tools of research, and means of correcting inconsistent data and inadequate ideas. These elements are significant because they suggest a coherent empirical methodology even though Locke the empiricist did not spell one out. These methodological positions argue for the reliability of sensory information yet recognize the corrective power of previously accepted ideas. His empiricism thus supports a view of scientific research where the senses play a central role. He sometimes strays from strict empiricism, as when he warns that sense-based information may fail to contribute to scientific knowledge. By withholding complete trust in knowledge built on simple sensory ideas he therefore embraces a mitigated or constructive skepticism.
C. Organizing our scientific knowledge: theoretical methodology

If Locke addresses research methodology in a largely indirect fashion, he is even less direct concerning how to build and employ scientific theories. Nevertheless, he provides some general cues in the Essay. I discern two important claims about theoretical methodology in the sciences. First, we usually use theories to guide our selection of experimental data — unless the data contradict the theory with great frequency in which case we alter or drop the theory.17 Second, theoretical descriptions of natural phenomena vary in their contribution to our certain knowledge of substances and scientists must generally settle for less than certain knowledge.

1. The influence of theories on data and of data on theories.

Influence among theories and observational data may take several forms. Scientists can select data according to currently held theories; or they can shape theories to meet newly introduced data; and there can be interplay between theories and data in selecting either. Locke does not specifically propose one of these relations but he gives us reasons to suggest that theory and data each influence the selection of the other.

We obtain basic sensory information or data about the
material world through the medium of simple ideas. Most of the time we accept experimental results and observations into the scientific canon when new ideas (data) agree with old ideas (observations and their theoretical framework). Occasionally, however, we reject old theories and their accompanying observations on the basis of consistent and conflicting new observations. Locke endorses something like this picture when he embraces probabilistic judgement as the central means of building scientific knowledge:

...when testimonies contradict common experience, and the reports of history and witnesses clash with the ordinary course of nature, or with one another; there it is, where diligence, attention, and exactness are required, to form a right judgement, and to proportion the assent to the different evidence and probability of the thing: which rises and falls, according to as those two foundations of credibility, viz. common observances in like cases, and particular testimonies in that particular instance, favour or contradict it. \(^{118}\)

Locke's basic criteria for granting assent to a probabilistic judgement are the relative frequencies of the given judgement ("particular testimonies in that particular instance") and any relevantly similar competitors ("common observances in like cases"). This view together with his rating of ideas (as adequate or inadequate, real or fantastical) and his limiting of scientific advance to probabilistic judgements yields the cross-influences of theory and observation. Our observations are theoretically adequate; when the probability of our observations consistently outstrips that of the theoretical results it is
time to reject the current theories, or in Locke's terms, give our assent to judgements against the prevailing views.

2. Types of knowledge, types of theoretical propositions, and varying degrees of certainty.

Locke holds that types of knowledge can be divided according to degrees of certainty. His division among types of knowledge suggests a similar classification of propositions used in scientific theories. We use propositions to express empirical knowledge; they give us the structure and at least part of the content of scientific theories. This parallel division of knowledge types and proposition types guides the building and judging of new scientific theories.

Locke says only probabilistic judgements further our scientific understanding of the material world. Yet all theories also employ more certain types of knowledge such as demonstration or sensitive knowledge. For example, classical Newtonian theory consists of a set of axiomatic principles of dynamics and a set of guidelines for characterizing the mechanics of the universe given the three principles or laws. This characterization is formal and so requires the use of mathematics -- which Locke includes in demonstrative knowledge. Scientists working with Newtonian theory use demonstrative knowledge in addition to probabilistic judgements they employ to describe empirical information. General principles of any theory sustain
formal structures that yield principles for the characterizations of empirical information and deductions using the theoretical language. Hence demonstration -- a type of certain knowledge -- is a necessary complement to all scientific theories.

Researchers use sensitive knowledge to assert the material relevance of empirical claims. Only sensitive knowledge informs us of the material existence of objects. Unlike demonstrative knowledge, though, sensitive knowledge is not certain -- because we gain it from the fallible senses. Nevertheless, Locke thinks sensitive knowledge is highly reliable. He even hints that it may be more certain than the "bare probability" upon which we base judgements: sensitive knowledge is perception of the relations between ideas -- not judgement of them.\textsuperscript{120} He carefully demarcates the domain of sensitive knowledge to existential claims whereas he allows all manner of descriptions under the rubric of probabilistic judgement. Sensitive knowledge does not characterize material objects other than telling us they exist. Locke may intend these differences to indicate that descriptions of an object's properties aside from the preproperty of existence are less certain and thus a matter for judgement as opposed to knowledge.\textsuperscript{121}

Probabilistic judgements are the main components of scientific understanding. We judge two ideas to agree or
disagree -- without the certainty that accompanies intuitive or demonstrative knowledge. We rely on judgements to generally describe natural phenomena because we do not have access to sure information that would form the basis of certain knowledge.

Scientists express these various types of knowledge in propositions which Locke also classifies according to their degree of certainty. Since trifling propositions are analytic statements they express certain knowledge. We can readily match elements of Locke's schema: analytic propositions can express the a priori evident truths of intuitive knowledge -- and very possibly the a priori deduced truths of demonstrative knowledge. Trifling propositions are an appropriate means of expressing (at least some forms of) certain knowledge because they cover much of the knowledge Locke calls certain.

On the other hand, instructive propositions are synthetic statements: the subjects do not include the predicates. This is fitting since we want to express a posteriori judgements with predicates that represent the novelty of experiment. If the propositions have substances for subjects then they express our current experimental grasp of substantival nominal essences. Hence instructive propositions about substances express a revisable, probabilistic knowledge. They accurately communicate an
incomplete understanding of material objects and external phenomena. Informative propositions are the adequate expression of experimental novelty and its accompanying lack of certainty.

According to Locke’s classification, different propositions serve different aims of scientific theories. We build theories with no certain knowledge of substances. Science relies mostly on sensitive knowledge and probabilistic judgements. So scientists need to use instructive propositions at least with respect to the empirical content of theories. Locke endorses the use of trifling propositions to express certain and immediate knowledge; hence their utility in the context of theoretical demonstration (though some certain truths may be instructive; cf note 122). Locke does not favor development of science through certain knowledge. He cautions that scientific theories should reflect the limits of our knowledge rather than extend beyond what we currently know or what we may hope to know in the future:

...we can go no further than particular experience informs us of matter of fact, and by analogy to guess what effects the like bodies are, upon other trials, like to produce. But as to a perfect science of natural bodies...we are, I think, so far from being capable of any such thing that I conclude it lost labour to seek after it.  

He holds a similar view of the theoretical expression of knowledge. The most informative propositions we employ in
theories are instructive and not trifling. We build theories from probabilistic judgements that we base on experimental evidence. Thus we cannot design theories that characterize natural phenomena by employing a class of knowledge that is certain but unobtainable.

Locke discusses issues of theoretical methodology when he writes about the propositional expression of knowledge and grounds for our assent to probabilistic judgement. The main claim of these discussions is that the extent of our empirical knowledge sets definite bounds on its theoretical expression yet these bounds give our theories as secure and verifiable foundations as scientists may hope for. A Lockean methodology is a firmly empiricist one.

A central goal of An Essay Concerning Human Understanding is to define the extent and limits of knowledge. Locke argues that we gain knowledge by perceiving the relations between ideas acquired through the senses. The fallibility of the senses dictates that we do not have certain knowledge concerning ideas that are strictly sense-derived. We have certain knowledge about other ideas, though, and the sensitive knowledge and probabilistic judgements we fashion from sensory information are more often reliable than not. Locke's brand of mitigated skepticism supports a broad range of claims about the conduct and character of natural science. The dependability and accuracy of sensitive
knowledge and the "real" nature of ideas about objects suggests that the theoretical vocabularies we build with such knowledge and ideas refer to real world objects. The reliability and fallibility of information from the senses indicate that empirical investigations need to balance the weights of trustworthy old experiments and fresh new evidence. Some close parallels between empirical knowledge and our theoretical expressions of the same suggest scientific theories must be empirically adequate and modest with respect to their descriptions of the material world. Locke's mitigated skeptical picture of knowledge acquisition readily yields this guarded though fertile empiricist characterization of science.
Notes


1. II viii 8, E.
2. II i 3-4, E.
3. II i 3, E.
4. II i 4, E.
5. II i 4, E.
6. II ii 1, E.
7. II ii 2, E.
8. II xii 1, E.
9. II xii 3, E.
10. II xii 6, E.
11. II xii 4, E.
12. II xii 5, E.
13. II xii 7, E.
14. II xxv 1, E.
15. II xxv 1, E.
16. III iii 15, E.
17. III vi 1, E.
18. III iii 12, E.
19. Ibid.
20. III iii 17, E.
21. III iii 16, E.
22. III iii 18, E.
23. II xxxi 6, III iii 18, E.
24. This is how real and nominal essences of modal objects coincide: The essences of modal species are created by the mind ("made by the understanding" [III v 2, E]) and so the real essence is simply "...that complex idea the mind itself has formed...." (III v 14, E) The mind, not sensory information, defines essences associated with modes. Hence the sensory properties of modal objects that constitute their nominal essences are identical to the properties that, as mentally constituted, make up the real essences of those objects.

25. III vi 3, E.
26. III vi 6, E.
27. III vi 6, E.

28. This class is at least as numerous as the number of objects in the universe if in principle we could have at least one idea about the constitutive essence of each object.

29. II xxx 1, E.
30. II xxxi 1, E.
31. II xxxi 2, E.
32. II xxxi 6,8, E.
33. II xxx 1,2, E.
33a. II xxx 2, E.
34. Ibid.
35. One exception is the case of primary qualities: our ideas of primary qualities represent those qualities and, in virtue of such representations, we take those qualities to be real. Cf II viii 24,25, E.

36. II xxx 2, E.
37. II xxx 4, E.
38. II xxx 5, E.
39. II xxxii 4,5,8, E.
40. II xxxii 12,13, E.
41. II xxxii 9, E.
42. II xxxii 10, E.
43. II xxxii 11,12, E.
44. II xxxii 13, E.
45. II xxxii 13, E.
46. II xxxii 16, E.
47. II xxxii 17, E.
48. II xxxii 18, E.
49. II xxxii 18, E.

49a. Locke says substantial ideas are collections of simple ideas which are "supposed patterns" of the qualities represented by simple ideas as they appear in the world. These conjunctions of simple ideas do not constitute accurate substantival ideas if the simple ideas are conjoined in our minds though they do not exist together in nature. For example, the shape existing in a horse, plus the size existing in a horse, plus the barking existing in a dog, yield a false idea of a horse (II xxxii 18, E). So our ideas of substances are accurate conjunctions of simple qualitative ideas if we observe such collections of qualities in the world.

50. IV ii 14, E.
51. IV ii 1, E.
52. IV ii 1, E.
53. IV ii 4,6, E.

54. IV ii 11,12,13, E. Locke thinks we can demonstrate qualities that are quantifiable (those not measured by degree or gradation) because we can show the direct relationship between essential and non-essential qualities. For example we can demonstrate knowledge of a rod's length because it is composed of a particular number of particles of a specific size.

This is a difficult claim for Locke to assert, for two reasons. First, if we know the number of individual particles and their motion, we may not know the quantifiable qualities of the object they compose because of possible interactions with combinatory results (unless the results were predictable given
relevant general laws and conditions). Second, if knowing about the component particles gives us access to the quantifiable qualities there is no reason in principle they will not tell us about other modal qualities as well. In that case Locke cannot make this claim about demonstration of quantity without changing his view about all other modal qualities.

55. IV ii 14, E.
56. IV ii 14, E.
57. Cf. also IV xi 8, E.
58. IV xi 3, E.
59. IV iii 6, E.
60. IV iii 6, E.
61. IV i 3, E.
62. IV iii 7 - 18,21, E.
63. IV iii 28, E.
64. IV iv 3, E.
65. IV iv 11,12, E.
66. IV iv 6, E.
67. IV vi 2, E.
68. IV vi 2,4, E.
69. IV vi 3, E.
70. IV vi 10, E.
71. IV vi 7, E.
72. IV viii 3, E.
73. IV viii 4, E. Woolhouse (1971) calls these propositions "partly identical". p 3.
74. IV viii 3, E.
75. IV viii 4, E.
76. IV viii 6, E.
77. IV viii 8, E.
78. IV viii 9, E.
79. IV vi 4,6, E.
80. IV vi 4,5, E.
81. IV xi 13, E.
82. IV xi 1, E.
83. IV xi 2, E.
84. IV xi 3, E.
85. IV xi 4, E.
86. IV xi 5, E.
87. IV xi 6, E.
88. IV xi 7, E.
89. IV xi 8, E.
90. IV xi 9, E.
91. IV xii 7, E.
92. IV xii 9, E.
93. IV xii 10, E.
94. IV xii 13, E.
95. IV xiv 3, E.
96. IV xv 3, E.
97. IV xvi 5, E. One example of indirect observation is viewing an object through a lens, as in a microscope.
98. IV xvi 12, E.
99. IV xvi 6, E.
100. IV xvi 12, E.
101. IV xvi 12, E.
103. II xxxii 13, E.

104. Locke's condition for judging our substantival knowledge to be real is that "...all our complex ideas of them must be such, and such only, as are made up of such simple ones as have been discovered to co-exist in nature." (IV iv 12, E)

Woozley (1977) claims that Locke thinks real knowledge consists not in perceiving agreement between ideas and the real world, but in the agreement itself. According to Woozley, Locke does not think agreement between ideas and objects can be perceived or known at all. Woozley argues that Locke does not believe this relationship can be perceived because he (Locke) never says we can know it, only that we can be sure of it (pp 143 – 145). This line of reasoning suggests that Locke thinks we can be sure about something though we do not know it. Yet Locke equates knowledge with a sure understanding of the relationship between ideas. So Woozley cannot be right because Locke holds that any understanding we have which is accompanied by assurance qualifies as knowledge.

105. This argument may be symbolized as follows:

**Predicates**

\[ Px = x \text{ is a particular proposition used in scientific discourse.} \]

\[ \Theta xy = x \text{ expresses the existence of } y \text{ in theoretical vocabulary.} \]

\[ Dx = x \text{ is a real world object.} \]

\[ Oxy = x \text{ is the only knowledge by which we know that } y \text{ exists.} \]

\[ Sx = x \text{ is sensory knowledge of substances.} \]

\[ Kxy = x \text{ is knowledge of } y \text{ with a high degree of accuracy.} \]

\[ Jxy = x \text{ is knowledge reached by judgement } y. \]

\[ Rxy = x \text{ is a judgement that } y \text{ agrees with reality.} \]

\[ Bx = x \text{ is an idea.} \]

\[ Qxy = x \text{ is a judgement based on assessment } y. \]

\[ Cxy = x \text{ is the assessment that } y \text{ is real and object-conforming.} \]

\[ Wxy = x \text{ refers to } y. \]

\[ Txyz = x \text{ is the theoretical expression of sensitive knowledge } y \text{ based on assessment } z. \]
The argument

1. (x) (u) (Px -> @xu & Du)
2. (x) (u) (y) (@xu & Oyu & Du -> Sy)
3. (y) (u) (Sy -> Kyu & Du)
4. (y) (u) (z) (v) (Kyu & Du -> Jyz & Rzv & Bv)
5. (z) (v) (w) (Rzv & Bv -> Qzw & Cwv)
6. (w) (v) (u) (Cwv & Bv -> Wvu & Bv)

7. (x) (y) (w) (v) (u) (@xu & Oyu & Bv & Du & Wvu -> Txyw & Wxu)

The conclusion (7) follows from the premises (1 - 6) with the assumptions Px, @xu, Oyu, Du, Sy, Kyu, Rzv, Bv, Cwv, and Wvu. Each step of the argument is by conditional proof. Locke’s views support each assumption and individual step though he does not explicitly express the argument I describe here.

105a. IV iii 21, E.

106. IV iv 12, E.

107. Ibid.

107a. IV iv 3, E.

108. The mental organization of empirical information raises the question of whether Locke can support purely observational vocabulary. Locke proposes that the mental operations we reflect upon are the central means of acquiring complex ideas, and that propositions are formed by assembling words standing for ideas. Since scientific propositions invariably make use of complex ideas, these mental operations are necessary steps in the expression of empirical data. Thus according to a Lockean perspective propositional expression of sensitive knowledge or probabilistic judgement remakes observational data in the image of theory.

109. Locke writes: "...what our own and other men’s constant observation has found always to be after the same manner, that we with reason conclude to be the effects of steady and regular causes, though they come not within the reach of our knowledge." IV xvi 6, E.

110. Either among two ideas or among ideas and reality.

111. II xxxiii 5,6, E.

112. IV xvi 6, E.
113. Locke warns that previous judgements of questionable value may influence new ones. IV xvi 3, E.

114. IV xi 7, E.

115. IV xv 6, IV xvi 6-9, E.

116. We use our old ideas in a similar manner to judge new complex ideas as adequate or not.

117. Contemporary theorists with relevantly similar basic views include Kuhn, who argues that theoretical paradigms "greatly direct and limit data selection (1962, passim), and Lakatos, who holds that "research programmes" which guide theoretical development exercise great control over data selection (1970, passim).

118. IV xvi 9, E.

119. Locke sees demonstration as a valid means of communicating, not acquiring, knowledge in the sciences. Yet he writes that Newton was able to discover true and certain propositions from the three laws of motion "...by finding out intermediate ideas that showed the agreement of the ideas, as expressed in the propositions he demonstrated." [my emphasis] IV vii 11, E.

120. IV ii 14, E.

121. To be sure, less-than-fully certain sensitive knowledge sounds every bit as probabilistic as judgement, yet Locke insists that sensitive knowledge is somehow more certain on the whole. Ibid.

122. As M. Kulstad indicates, Locke discusses another type of certain knowledge which he holds is not expressed by trifling propositions. Locke suggests there is a class of propositions about which we can be certain such that for any member proposition of that class, we can know something as a necessary consequence of that proposition though the consequence is not analytically "included in" the given proposition.

He gives as an example that the "...external angle of all triangles is bigger than either of the opposite internal angles...." (IV viii 8) Locke claims that this relation is not included in the complex idea of "triangle". This particular claim may not fit very well with Locke's overall view of trifling truths. He tells us that "...trifling it is to predicate any other
part of the definition of the term defined, or to affirm any of the simple ideas of a complex one, of the name of the whole complex idea...." (IV viii 5) So any proposition is a trifling truth if the proposition reports something about its subject (a complex idea) which is simply an affirmation of one of the subject's constituent ideas. The size of any external angle of a triangle, relative to the sum of the sizes of the opposing internal angles is a fact about triangles that is included in (at least) one definition of triangles, viz. figures bound by three sides the internal angles of which add up to 180 degrees. This definition says there can be no internal angle greater than or equal to 180 degrees so any external angle must be greater than 180 degrees and thus greater than the sum of any internal angles, opposing or otherwise.

Yet Locke writes that instructive propositions are those that require explanation of intermediate ideas (IV viii 3) and presumably this means that trifling propositions have no such requirement. If this is an accurate assumption then perhaps Locke would explain this triangle example as a case of instructive truth because it requires demonstration. However, Locke's view of trifling truths as predating "any other part of the definition of the term defined" leaves vague the matter of where trifling-ness ends and instructiveness begins. Simple ideas that one person may take as included in a given complex idea may be taken by another person as not included and thereby require demonstration. Moreover, another way to interpret Locke is that he did not hold the aforementioned assumption. Then he might well allow, though not require, demonstration of some (necessary) truths included in the subject terms of trifling propositions.

123. IV iii 29, E.
Chapter Three
Science and Certainty in Gassendi and Locke

Introduction
In this thesis I delineate the viewpoints of Gassendi and Locke with respect to several central questions in the philosophy of science. What are the objects of scientific inquiry? How do we go about this inquiry -- on practical and theoretical levels?

The purpose of this paper is to demonstrate how the constructive skepticism of Gassendi and Locke suggests or directly supports their views on the methodology and philosophy of science. I argue that they share the views that knowledge from the senses provides reliable though never certain information about the material world, and that the conduct and structure of the natural sciences should reflect this guarded acceptance of sensory information. Their partial skepticism suggests the development of scientific knowledge can only follow a rigorous empiricist path after which our knowledge always remains tentative.

In this chapter I explicate Gassendi and Locke's shared stances on science and their common constructive skepticists programs. I show how their close perspectives on the character of empirical knowledge is the basis for similar views on the nature and practice of science. I conclude by indicating how Gassendi and Locke converge on three general
philosophical issues: the nature of causation, our probabilistic grasp of the material world, and the hierarchical ranking of our different types of knowledge.

Whether or not Locke borrowed directly from Gassendi, there are significant parallels between their views on the acquisition and bounds of knowledge. Further, these two early empiricists share several perspectives on the conduct and character of science. However, before reviewing these parallels and shared perspectives, one may ask what -- if any -- are the historical ties between Gassendi and Locke. Gassendi's direct influence on Locke is small though detectable. Locke is known to have bought Gassendi's books. He is not known to have read them.¹

There is also indirect influence; Locke clearly read Bernier's abridgement of Gassendi's Omnia Opera.² Circumstantial evidence suggests that Locke may have fashioned his Essay on the basis of conversations with other Gassendi readers. Locke discussed the extent and limits of knowledge in conversations with prominent scientists and scholars of the day³ (he mentions such discussions in the Introduction to his Essay). Many of his conversation partners -- members of England's scientific community -- could well have taken an interest in the Provençal empiricist. For instance, it is clear from Boyle's notebooks that the English chemist widely read Gassendi's
writings. It is also clear from Locke's notebooks that
Boyle recommended Gassendi's works to him. Perhaps the
most tempting hint that Gassendi influenced Locke is their
common set of views on science, and their claims about the
limits of knowledge, which help shape their philosophies of
science.

I Aspects of philosophy of science in Gassendi and Locke.

A. Knowledge of scientific objects and their reality.
Gassendi's views (with an additional uncontroversial
assumption) support a version of scientific realism that
says theoretical vocabularies which describe appearances
refer to real objects in the world. This scientific realism
follows from his claims (1) that the senses are our surest
source of information about the material world, and (2) that
sense-based descriptions of appearances describe the
qualities of real objects that appear to us, plus the
assumption (not explicitly made by Gassendi) that there are
theoretical terms scientists use to describe those objects.
Then scientists use theoretical terms to refer to real world
objects whenever those terms are employed in descriptions of
the world. The argument is as follows: Our most certain
grasp of the material world consists of knowledge of the way
real things appear. Hence we have highly certain knowledge
of the appearances of real things. This knowledge consists
of descriptions of their various states such as their
duration and spatial and temporal position. Scientists use theoretical terms to describe these appearance parameters so the theoretical vocabularies perforce refer to the real objects described.

A Gassendian brand of scientific realism suggests we know theoretical terms refer to real objects because the terms are closely tied to reliable sensory evidence. We know the reality of described appearances because our senses assure us so. Gassendi holds that no knowledge is fully certain but he embraces the senses as our most reliable source of knowledge and he says the most reliable subset of sensory knowledge consists of minimal state or parameter descriptions of appearances. Yet these minimal descriptions are enough to assure us that the appearances -- and so the descriptions -- can refer to real objects in the world. Gassendian scientific realism is thus a consequence of a general constructive skepticist program: we can have some empirical knowledge reliably, though much of our knowledge is subject to doubt.

Lockean scientific realism also follows from a constructive skepticism, though Locke’s account of empirical knowledge takes a different form than Gassendi’s. Their scientific realisms are similar: Locke’s views likewise suggest that theoretical terms of science refer to real world entities. And like the reasoning behind the Gassendian claim, a
Lockean argument for scientific realism is based partly on the premise that sensory information yields our most certain understanding of the material world. Knowledge (or probabilistic understanding) of material substances is the perception (or "judgement") of agreement or disagreement, either between ideas of substantival appearances and other ideas, or between substantival ideas and the real world. We call ideas "real" if the qualities of objects describe cause us to have those ideas, and "object-conforming" if they accurately conform to physical standards in a materially plausible way. Knowledge of substantival ideas is therefore knowledge of ideas that highly conform to, and are caused by, real entities in the world. We fashion the theoretical expression of substantival knowledge (in propositions) with this highly accurate type of knowledge. Hence the theoretical terms scientists use also refer to real world entities.

Unlike Gassendi, Locke thinks we do not have direct knowledge of the appearances of material objects. Their scientific realisms both imply that the expression of our empirical knowledge consists of describing the appearances of real material objects. But according to Lockean scientific realism, our theoretical expression of knowledge of appearances is more indirect than the same expression given the Gassendian position. In Locke's generally more complex account of the types and relations of ideas, he
describes substantival knowledge as more remote from the objects themselves than does Gassendi. Yet Locke also says that our indirect knowledge of substances is reliable if, for example, it is object-conforming and real. Such views suggest that the propositions with which scientists describe substantival knowledge refer to real world entities.

Locke’s model of knowledge gathering is more detailed than Gassendi’s though both equally sustain a scientific realist position.

The underlying justification for Lockean scientific realism is constructive skepticism. According to Locke, we cannot know with certainty the real essences of material objects in the world yet we can tentatively construct their nominal essences on the basis of sensible qualities we detect through experiment. Our sense derived ideas are generally reliable, hence our sensitive knowledge and probabilistic judgements concerning the qualities of substances are highly accurate. Thus the objects of scientific inquiry and theory are reliably judged to be real; Locke is not a skeptic in this regard. He retains a skeptical attitude insofar as he insists that all judgements of science must be renewed since they provide no certain knowledge. Both Lockean and Gassendian scientific realism are supported by their express trust in empiricist knowledge acquisition. That trust is tempered in either case by caveats against unquestioning faith in sensory information.
B. Gathering scientific knowledge: research methodology
Gassendi and Locke share a largely common vision of basic scientific research principles. They both warn against research that relies solely on dogmatic assertions or purely rational axioms. Each argues that our understanding of the material world is limited by the ideas we gain from sensory information. According to their pictures of scientific knowledge, we cannot reach an ultimate or essential understanding of nature through empirical research, but there are no other options available to natural scientists.

Gassendi’s empiricist methodology embraces the dependability of sensory knowledge and inductive argument. Gassendi expresses a skeptical attitude by raising doubts about reasoned and sensory knowledge. Sensory information gives us far more reliable knowledge than does reasoning but neither provides total certainty. Moreover, sensory information gathering is subject to constant confirmation by experiment and observation. Thus sensory knowledge is basically trustworthy though not completely reliable. Gassendi therefore designates sensory knowledge as the primary and corrective tool of empirical research.

Hypothesis and analogy are Gassendi’s other research tools. Scientists use these tools to build on individual elements of sensory information by compiling and comparing the elements. Sensory information is also used in data
correction -- it is the standard by which we corroborate newly incoming empirical knowledge. Gassendi endorses hypotheses in scientific research, although he thinks they should be used inductively rather than deductively. We may assume hypotheses for the sake of generating proofs by drawing on experience (such that, for example, hypotheses guide our experience). Yet the hypotheses are neither taken to be true or correct nor can they be proven so. Therefore no research can begin with "unprovable" or less than certain premises, by which he means fundamental assumptions such as axioms or general laws. Hence his methodology cannot accommodate hypothetico-deductivism: the central guideline for gathering empirical knowledge is that we learn not from supposition and experiment but from experiment alone. Gassendi’s approach to empirical research is more akin to the inductivist views of Bacon, his contemporary.

Locke’s position on scientific methodology is more ambiguous. Two competing historical perspectives describe his view of hypotheses as a research tool. According to the first, Locke was a thorough Baconian inductivist who endorsed knowledge-gathering through the senses and rejected the use of hypotheses in describing natural phenomena.5 According to the second, Locke was less committed to an absolute empiricism and readily accepted hypothetical reasoning in the sciences.6
My explication of Locke's position shows that both of these perspectives are partially correct. Locke accepts the use of hypotheses but with strong reservations. Scientists must proceed with caution and ensure that any hypotheses they contemplate conform to currently available knowledge. In short, hypotheses must be theoretically and empirically adequate.⁷ Locke is pessimistic about our ability to acquire certain knowledge of substances, so he could not accept certain demonstration of hypotheses. Thus the hypothetico-deductive method affords probabilistic judgement but not certain knowledge. Scientific research can progress through theoretical conjectures though all such speculations must be constantly verified by sensory information. In sum, Locke did not trust hypotheses but he saw their value and did not rule them out. His overall view of research methodology is similar in cast: that we cannot know substances with certainty does not prevent us from pursuing a probabilistic, sensory-based research of empirical phenomena.

Gassendi and Locke base methodological principles on the view that scientific knowledge is essentially limited and tentative. We gain the most certain empirical knowledge available through experimental research which employs sensory information to produce and confirm data.
C. Organizing our scientific knowledge: theoretical methodology

The constructive skepticism of Gassendi and Locke suggests two characteristics of the theoretical organization and expression of empirical knowledge. First, a Gassendian view of theories implies they are always empirically adequate; a Lockeian view implies they are usually so. Second, both authors argue empirical knowledge provides a better guide for theoretically characterizing the material world than more certain forms of knowledge. These two characteristics indicate that, despite the fundamentally probabilistic character of theories and the need to constantly verify them by sensory information, theories have a great potential for predicting and unifying our empirical knowledge.

A Gassendian theoretical methodology suggests that scientific theories are viable only if they are empirically adequate, and that they incorporate several types of descriptive propositions that vary by degrees of certainty.

Gassendi holds that the constituent phenomenal descriptions of scientific theories must be accurate according to the standard of sensory information. Those theories are thereby empirically adequate. Further, theoretical descriptions of appearances either conform to sensory data or else they are recast. The intellect -- a mental faculty -- judges the accuracy of these descriptions on the basis of their agreement with previously acquired sensory information.
More certain sensory information is the gauge by which we measure less certain theoretical knowledge.

Empirical information is also the measure of certainty for different types of propositions. Information from the senses is more reliable than other sources of knowledge, so those propositions that describe the fundamental character of sensory appearances are very reliable. Propositions that indirectly describe phenomena on the basis of consistently related empirical data (such as its known effects) are also very reliable. On the other hand, Gassendi thinks hypothetical assumptions are usually based not on sensory information but on unproven dogma -- he has trouble separating out their unprovenness from any purported dogmatism. Thus the theoretical means of characterizing natural phenomena include various kinds of propositions that differ by greater or lesser certainty. Gassendi's characterization of theories matches his trust in sensory data and his skepticism about empirical knowledge from any other source.

A Lockean theoretical methodology suggests that new empirical observations and accepted theories each may influence the selection of the other, and that theories employ different types of propositions to express different types of knowledge, which vary by degrees of reliability.

According to Locke, scientists use theories to guide the
acceptance of new data and they may also use that data in turn to judge the viability of current theories. Locke describes the acquisition of substantival knowledge as the perception of agreement among real and adequate substantival ideas on the one hand, and ideas from experience on the other. Not all new ideas agree with the old ones, and some disagreeing new ideas provide scientists with critical tests of the defensibility of theories. The dominant direction of influence -- data on theories or vice-versa -- depends on which helps us make judgements (about substances) with greater probabilities. When we make probabilistic judgements we may accept and integrate the new ideas, reject the new ideas, or accept the new ideas and reject the old ones. Locke's probabilistic approach to new evidence balances the needs for stability and change in development and testing of scientific theories.

Locke also fashions a typology of theoretical propositions which reflects the limits on our empirical knowledge. He offers parallel distinctions among types of knowledge and among types of propositions. Types of knowledge differ according to the kind of information they represent and their degree of certainty. Scientists who follow Locke's knowledge typology would likely construct theories such that the formal structure is based on certain demonstrative knowledge, theoretical existence claims about substances are based on less-than-certain sensitive knowledge, and other
theoretical characterizations of substances are based on probabilistic judgement.

Locke similarly distinguishes among types of propositions scientists use to express empirical knowledge. Trifling propositions express knowledge of predicates analytically "included" in their subjects, whereas the predicates of instructive propositions are synthetic, that is, not included in their subjects. Demonstrative knowledge is best expressed by trifling propositions whereas sensitive knowledge and probabilistic judgements are best expressed by instructive propositions. Scientists use instructive propositions to tell us most about objects in the world, though they are the least certain and require the most constant verification. This is a purely constructive skeptic stance: we know little if anything with certainty about the material world though we can make many tentative judgements. Our scientific understanding is greater when we subject empirical knowledge to revision and do not consider it as certain truth.

Both Gassendi and Locke hold that our theoretical understanding of the material world is generally accountable to new empirical information. Moreover, both think we express this understanding with varying degrees of certainty -- and the better part of our knowledge can never be expressed in more than fairly reliable terms. They each
suggest a constructive skepticist picture of theory-building: at each step, theories must be capable of being empirically tested and they must eschew dogmatism if they are to maximize our scientific understanding given the limits on our certain knowledge.

II Conclusion: Constructive skepticism and empiricist philosophy of science

A. Gassendi, Locke, and constructive skepticism.

The central claim I try to establish is that a general epistemological stance -- constructive skepticism -- plays a formative role in shaping an empiricist philosophy of science in Gassendi and Locke. I conclude by outlining their constructive skepticist stances and highlighting the contribution of that viewpoint to key elements of empiricism. These elements include an empiricist brand of essentialism, probabilism, and ranking types of knowledge by their potential for building an empirically adequate understanding of the material world.

How do Gassendi's views represent constructive skepticism? Over the course of his career he mitigates his skepticism and brings his philosophical views in line with a less doubting scientific methodology which he and his contemporary empiricists practiced. Popkin (1979) claims that the early Gassendi was a strict Pyrrhonian concerning knowledge of the nature and reality of objects: he
suspended his judgement. This strict Pyrrhonism does not mark his later writings. The late Gassendi doubts our capacity to know the nature of objects’s essences yet he claims we know the reality and referents of appearances.

These differences between the early and late Gassendi mark his shift from Pyrrhonian to constructive skepticism. In the Disquisitio and the Syntagma, Gassendi clearly states his doubts about knowledge of essences, though he does not follow Pyrrhonian skepticism by withholding judgement about empirical knowledge. His suggestion that reality and referents of appearances can be known (albeit with some uncertainty) is consistent with the Pyrrhonian skepticist claim that we know appearances. However, Gassendi also holds that those appearances refer to objects in the world and that they are real appearances. This view tells us far more about appearances than does the traditional Pyrrhonian perspective. I suggest Gassendi’s remodeled skepticism reflects his role as an empiricist theorist of the new science. His exposition of early empiricism illuminates his constructive skepticism as a move away from a Pyrrhonian perspective to a series of positions that accommodate the novel ways of research and theory methodology in the emerging modern science.

How do Locke’s views represent constructive skepticism? As with Gassendi, the source of Locke’s constructive skepticism
is his commitment to empiricism. Unlike Gassendi, though, Locke does not start from an extreme sceptical position and increase his trust of sensory evidence. His mitigated skepticism rather consists of limits on knowledge tempered by a consistent trust in the reliability of the senses. We cannot know the real essences of substances with certainty but we can grasp their nominal essences from relevant sensory information. Many ideas of substances are not suitable for building substantival knowledge; they are either false ideas of real essences or not accurate ideas of sensed qualities. Yet the ideas that are suitable are very reliable elements of empirical knowledge. Locke catalogues several types of accessible knowledge including certain knowledge and so he is not frequently called a skeptic. However, he claims we have no access to substantival essences and therefore no knowledge of such essences. Thus he exercises sceptical doubts about our capacity to universally judge that we know something. Moreover, he argues that relations between our substantival ideas can be judged only by their probability; our empirical knowledge is never fully certain.

Locke is skeptical only about the certainty of our empirical knowledge, and he holds that there is evidence for intuitive and demonstrative knowledge. His skepticism is partial or constructive and it directly supports his effort to
delineate the particular and fallible nature of our empirical knowledge.

B. Common themes and divergences in Gassendi and Locke. The constructive skepticism and resulting perspectives on scientific theory and practice in Gassendi and Locke imply broad themes with common and divergent aspects.19 The two philosophers largely agree about the nature of scientific knowledge and its objects; they disagree slightly about degrees of skepticism and principles of hypothesizing. Their thematic commonalities reinforce my picture of two similar sets of epistemological views that each suggest a strongly empiricist philosophy of science. Their divergences do not directly concern the practice of science and are thus not as pertinent.

I discern three broad themes about which Gassendi and Locke agree: essentialism, probabilism, and knowledge-ranking. They uphold a non-traditional scientific version of essentialism according to which the arrangement of matter has a necessary cause. They share a probabilistic approach to scientific research and theory building. Finally, they agree that there are different types of knowledge and some are better than others for empirical research.

Essentialism. The traditional version of essentialism is the metaphysical view that every material object has
necessary qualities that define the object as distinct from any other. These are essential qualities and their set constitutes the essence of an object. Different conceptions of essences abound; for example, Aristotle claims the essence of an object is its form, and scholastics argued whether essences are truly qualities or things (res) and how -- or whether -- the existence of something is necessarily correlated with its essence.\textsuperscript{20} Essentialism entails the belief that objects have some necessary and definitive qualities.

This is just the kind of belief that does not seem likely to follow from a skeptic or empiricist viewpoint. Yet Gassendi and Locke subscribe to a type of essentialism which is supported by their constructive skeptic perspectives. They agree that material objects have constitutive qualities to which human beings have no access.\textsuperscript{21} Both argue that the constitution of material objects is probably defined by the arrangement and interaction of tiny constituent elements or corpuscles.\textsuperscript{22} Hence they hold that the arrangement of matter is a necessary result of hidden (corpuscularian) mechanisms.

This view combines two claims: an essentialist idea -- that the qualities of macroscopic objects are fixed by arrangement and motion of essential constituent parts, and the claim that we know little or nothing about those
Neither Gassendi nor Locke propose a classical essentialism according to which particular qualities such as Aristotelian form are essential. They suggest instead that within the limits of our empirical knowledge we can understand that objects have necessary and definitive qualities though we may never know what they are.²⁴

**Probabilism.** Probabilism is the epistemological stance that says the search for an absolute criterion for true knowledge is neither fruitful nor necessary. We can know truths on the basis of probability, not certainty. The ancient Dogmatists ruled out probable truths as not meeting an absolute criterion and the Skeptics barred probable truths because they are based on some (probabilistic) criterion. Members of the New Academy such as Carneades and Clitomachus argued that such a probabilistic criterion was possible and their proof was the practical experience of collected sensory information.²⁵

This New Academic perspective sounds a lot like constructive skepticism and the allied view of science. Gassendi and Locke share the view that we can have empirical knowledge without total certainty²⁶ and that the most prudent framework for gathering and organizing our understanding of material objects is probabilistic and never certain.²⁷ In effect they advise scientists of the revisability of data and theories. There is no absolute criterion of truth that
empirical propositions can meet and we can know; yet we do not doubt all scientific propositions because the coherence and practicality of science indicate its conceptual and material progress. Thus the probabilistic character of science at once captures our limits and aspirations for learning about the world.

Knowledge-ranking. Lastly, Gassendi and Locke share a perspective I call "knowledge-ranking". This view has two components: first, types of knowledge are ranked according to their reliability; second, scientists can judge the utility of each type by its rank. Gassendi and Locke categorize knowledge in different ways but their guiding principle in ranking knowledge is always its degree of certainty. The second component of this view -- judging the utility of different types -- also works by a shared guiding principle: the greater the certainty of our knowledge, up to but not including total certainty, the greater its utility for scientific research and theorizing. (Total certainty is not included for somewhat similar reasons: Gassendi does not think the senses give us wholly certain knowledge, and Locke thinks certain knowledge has no place in empirical studies.) Knowledge-ranking is a way to categorize different types of knowledge used in science based on the mitigated skepticist view that empirical knowledge is often available to us with probable
reliability though almost never with certainty. This approach accurately models the way scientists use different types of knowledge: theories may require the sure logical foundations of demonstration, yet research requires the lesser certainty of fallible experiment. Gassendi and Locke allot these distinct tasks of organizing and gathering empirical knowledge according to their respective levels of certainty and so they support a division of labor among knowledge-types in science.

Compared to these shared views, the differences between Gassendi and Locke are less important to their philosophy of science perspectives. They differ with respect to degree of skepticism and approach to explanation. Gassendi's skepticism is greater than Locke's. This orientation leads Gassendi to cast doubts on a possibility that Locke finds attractive: that scientific explanations account for phenomena in terms of underlying mechanisms.

Neither of these writers are complete skeptics, but Gassendi is the closer of the two. Locke thinks that true knowledge is by definition certain\textsuperscript{32} and that intuitive knowledge is known with certainty without any need for demonstration.\textsuperscript{33} Gassendi begins with a Pyrrhonian outlook and keeps it in sight: he thinks certain knowledge is not possible and even the most reliable knowledge, mathematics, is known only through partly empirical demonstration.\textsuperscript{34} However, their
views concerning empirical or scientific knowledge are each mildly skeptical and so the overall difference in their views of knowledge and certainty does not constitute a significant rift in their general philosophy of science perspectives.

Their differences are no greater with regard to the matter of scientific explanation. Locke claims phenomena can be explained by hypotheses.\textsuperscript{35} He famously suggests an appeal to hidden mechanisms: the corpuscularian hypothesis.\textsuperscript{36} On the other hand, Gassendi claims hypotheses are good explanations in limited circumstances\textsuperscript{37} and our best explanations are pure descriptions of phenomena derived from direct observations and their comparisons.\textsuperscript{38} Like Locke, he says that events in the world can be given at least a tentative explanation in terms of hidden mechanisms, that is, mechanical interactions of particles too small to be visible.\textsuperscript{39} Yet Gassendi suggests explanations appeal only to phenomena that are either apparent or consistently implied by the apparent, through indirect signs and analogy.\textsuperscript{40}

Gassendi is philosophically committed to descriptivist explanation in science, no matter his scientific accounts.\textsuperscript{41} Locke, on the other hand, clearly voices a theoretical commitment to explanation by hypothesized fundamental elements.\textsuperscript{42} The difference is purely theoretical since
Gassendi's scientific writings also approve of such hypothetical explanations. Moreover, Gassendi coherently (i) rules out explanation by hidden mechanism and (ii) sustains his version of essentialism only if (iii) he holds that objects and phenomena have definitive qualities which, though unknown, contribute to our scientific understanding. So even if scientists do not explain phenomena by overtly appealing to hypotheses of unseen mechanisms, their explanations incorporate latent appeals to those hypotheses by relying on information from indirect signs that suggest just such hidden mechanisms.

Consider this case: A Gassendian chemist reports that a particular reaction between two different molecules produces a third type of molecule altogether. She explains her claim simply by noting the evidence -- in the form of X-ray crystallography -- that such a reaction takes place and yields the suggested products. The chemist bases her findings on an auxiliary hypothesis concerning the observation of this reaction, and she never explicitly discusses the ontological commitments of the hypothesis. The relevant auxiliary hypothesis is that although we cannot detect the configuration of molecules with the naked eye, X-ray crystallography allows us to calculate that particular atoms are present in particular configurations, based on the angles of diffracted X-rays passing through the substance
presumed to be composed of molecules of a given type. In this example the diffraction patterns serve as indirect signs of molecular structure. Even though our chemist makes no explicit reference to what the diffractions represent, the theory of X-ray crystallography tells us the scattering patterns are signs of underlying molecular structures. In short, this chemist makes no overt appeal to unseen basic atomic mechanisms but explains her reports of the reaction by citing observations that are fundamentally based on a series of hypotheses about the hidden mechanisms we cannot directly observe. Thus our chemist, like Gassendi, is committed to a more positive view of the explanatory use of hypotheses then her (and his) explicit claims suggest.

C. Constructive skepticism and philosophy of science in Gassendi and Locke.

The constructive skepticist contribution to sixteenth and seventeenth century philosophy of science is the discussion of our capacity to know the ultimate physical structure of the material world. Gassendi and Locke address this matter by setting restrictions on and licenses for empirical knowledge. They thereby address questions of scientific methodology and theory guidelines. Their responses reflect claims with respect to essentialism, probabilism, and knowledge-ranking: there are underlying and necessary mechanisms that account for distinct entities in the world, we have (at best) a probabilistic notion of these
mechanisms, and we most capably reckon with the limits of our empirical understanding when we express this knowledge in experimentally verifiable terms. These are the key themes of an epistemological stance that says we have merely reliable knowledge about the world and that is all the knowledge we should hope to attain. The constructive skeptic's stance shared by Gassendi and Locke suggests scientists realize the bounds on empirical knowledge in order to progress within those confines.
Notes


7. IV xii 13, E.

8. Popkin, pp 144 - 146.

9. This passage neatly summarizes Gassendi’s views on the limits of empirical knowledge:

"...d’une certaine chose on peut dire qu’elle est ou apparaît telle en ce sens qu’elle est douée de telle masse, figure, mouvement, position; et qu’en même temps elle présente quelque analogie, par rapport à tels ou tels organes; par rapport à tel ou tel être animé ou humain; par rapport à tel ou tel tempérament ou manière d’être, [et autres] semblables [circonstances]; mais non pas qu’elle soit pour autant telle en soi ou dans
sa nature profonde...." p 70, R, p 286b, O.

10. Ibid.
11. Ibid.
12. III vi 3, 6, E.
13. II xxxi 6, 8, E.
14. II xxxii 18, E.
15. IV xi 2, E.
16. IV vi 7, E.
17. IV vi 13, E.
18. IV iii 2 - 7, E.

19. Instead of reviewing their specific common and divergent claims, I focus on general conclusions we can draw from their particular views.

20. For Aristotle, cf. for example the Metaphysics Z IV B. Two medieval views show the breadth of this debate. In Being and Essence, Thomas of Aquinas argues essence is one of two properties necessary for the actual existence of something (existence per se being the other property. The essences of physical bodies are their forms and the existence of those bodies is represented by their matter. Cf. also On Spiritual Creatures Article I 25 xiv.

William of Ockham, in his Theory of Terms, argues that essence and existence are things, not properties, and they are identical. Whatever has the property of potentiality (that is, essence) has the property of actuality (that is, existence). Hence essence and existence are one and the same thing, which can be correlated with form and matter but not one-to-one. Cf. Wippel (1982). 21 For Gassendi, cf. p 70, R, p 286b, O; for Locke, cf. IV vi 9, E.

22. For Gassendi, cf. p 280b, O, p 400, B; for Locke, cf. IV iii 24, E.

23. Is this an essentialism of kinds or of individuals? One way to interpret the fixed qualities of macroscopic objects is to say real essences demarcate the kinds or classes of those objects -- and such demarcation is useful for scientific categorization. Yet
essentialism of kinds runs counter to Locke's nominalism, according to which the only classes of objects in the world we have access to are the ones we create: "When...we quit particulars, the generals that rest are only creatures of our own making...." (III xi 11) It is far more felicitous to suggest Lockean essentialism entails that individual macroscopic objects have qualities that are fixed by the changing, shifting assembly of their essential parts.

24. Neither Gassendi nor Locke are essentialists with regard to explanation; they do not think explanations can make appeals to essential properties of objects or phenomena. This is clear from their view that the essential characteristic of objects or phenomena consists in their material arrangement and not their forms or properties.


26. For Gassendi, cf. p 532, R, p 388a, O; for Locke, cf. IV ii 14, IV iii 21, E.

27. For Gassendi, cf. p 347, B; for Locke, cf. IV xi 9, E.

28. For Gassendi, cf. p 326, B, p 347, B; for Locke, cf. IV xi 9 - 10, E.

29. Gassendi in particular holds that natural science can illuminate the glory of God's creation: cf. pp 125a - 126a, O; for Locke, cf. IV xii 10, E.

30. Gassendi asks: "...why aren't so many [of these] things considered true with equal authority though they are perceived by the mind alone and can no more appear to the senses than [those] other truths could in the past?" p 335, B; for Locke, cf. IV ii, E.

31. For Gassendi, cf. p 70, R, p 286b, O; p 265, B and p 340, B; and p 347, B; for Locke, cf. IV ii 11 - 14, IV vi 16, E.

32. IV ii 1,2, E.

33. IV ii 4 - 7, E.

34. pp 486 - 489, R, pp 378b - 379a, O.

35. IV xii 12,13, E.

36. I agree with Laudan (1967) and not Yost (1951) that
Locke approves of the use of hypotheses in science. As I note in my brief discussion of Locke's views (chapter two, p 27), Locke recommends caution with respect to the explanatory use of hypotheses, but he does not rule them out.

37. p 265, B; p 340, B.

38. p 535, B, p 388, O; and p 329, B.

39. p 280b, O, p 400, B.

40. pp 332 - 333, B.

41. In Woolhouse's terms (1971), Locke is a transcendentist and Gassendi is a sometime transcendentist and sometime descriptivist.

42. IV iii 16, IV xii 13E.

References


Osler, Margaret. (1970), "John Locke and the Changing Ideal of Scientific Knowledge", in *Journal of the History of Ideas* 31: 3 - 16.


