The philosophy of Pierre Gassendi: science and belief in seventeenth-century Paris and Provence

Thesis

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THE PHILOSOPHY OF PIERRE GASSENDI
SCIENCE AND BELIEF IN SEVENTEENTH-CENTURY PARIS AND PROVENCE

by


A thesis offered for the degree of Ph.D.
in the History of Science, at the Faculty
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'As for me, my simple explanation, 
Would be—were I adviser to creation: 
Postulate matter, give it higher powers 
(hard to conceive for any mind like ours) 
A quintessential atom—tempered light 
Even more mobile and more bright 
Than fire itself. A heat has its degrees 
So judgements differ too— 
I would not ask an ape to make this point to you.'

From La Fontaine's Fables: a discourse on the souls of animals (after Gassendi).

Teiresic preferred the music of birds above all human music, vocal or instrumental; not because he had no love of music but because he was so extremely sensitive that its after-effects troubled his mind and disturbed his dreams; its cadenzas and crescendos, sudden variations in pitch or tempo seemed to correspond with the vibrations (euntque redeuntque) of his own imagination, and consequently to excite them. But the birds, whose song cannot be imitated by art, gave delight without rousing these internal facilities.'

Quoted in G. White The Natural History of Shelbourne 1781
At the Renaissance two old themes of pagan philosophy exercised a powerful appeal on a small minority of thinkers:

1) that the differences between humans and animals were less important than the similarities;
2) that God was merely a name for the sum total of natural forces.

Despite his nominal adherence to Catholicism, Gassendi secretly subscribed to both these propositions, which were closely related to his enthusiasm for natural science. Some historians have sought to present the Renaissance pantheism—or naturalism—as the common enemy of science and Christianity. The example of Gassendi, which is by no means isolated, shows that this perspective is unacceptable. Nor should we fall into the trap of supposing, from Gassendi's carefully concealed but definite sympathy with such pagan beliefs as reincarnation, or animus mundi, that he had merely replaced Christianity with these alternative dogmas. Gassendi's attitude towards the nature of the forces behind life was one of deep agnosticism. Although we cannot be sure about his actual creed, it seems likely that his interest in the Orphic or Pythagorean theology of metempsychosis, and emanations of world spirit, rested not on literal belief, but their symbolism of still higher truths, beyond human reach. As for Christianity, he did not regard it as true in a supernatural, a historical, or even a moral sense. Unlike Pythagoreanism, even its symbolism did not inspire him. Its creeds received his assent because he accepted the authority of the Church.

The importance of Catholicism in his writings, considerable though it was, centred almost wholly on the domain of sociology.
Religion was a bond securing the obedience of the subject, a check on the exploitation of the poor by the 'tyranny' of the rich, a guarantor of the traditional constitutional balance between Church, monarchy and nobility. Once this has been clearly understood, then the reason for the careful balance between faith and reason, observed in Gassendi's public writings, becomes clear. Otherwise the student of the Syntagma wanders in a kind of fog, vainly straining to delineate the familiar landscape of fideism which modern historians of ideas—confident that thorough-going rationalism was impossible at this period—have taught him to anticipate. Ludwig Feuerbach, in the nineteenth century, got the balance right when he wrote: 'How did that tropical house-plant [religion] survive the clear wind of god-like free-thought which blows through Gassendi's writings? Because he was careful to keep the conservatory door firmly closed.' It is thanks to modern writers that the whole direction of Gassendi's philosophy has been wrongly sign-posted. Its best known feature, the debate with Descartes, reflects this. Gassendi's defence of reason in animals is usually regarded as part of a sentimental reaction to Descartes' animal machine. Modern philosophers of the animal-rights school have shown that an interest in animals need be neither sentimental nor peripheral to key philosophical questions. Yet Gassendi's anticipation of many of their arguments has been passed over in silence. Gassendi specialists have ignored his interest in animal rights altogether, or dismissed it in a footnote. Yet, historically, it was central to his philosophy. Gassendi espoused the cause long before the debate with Descartes and before his much publicised commitment to Epicurus. 'I have restored reason to the beasts', he boasted to his pupils at Aix in the 1620s. The scholastics were depicted as cattle chained to their master's stall, or as the comrades of Ulysses
changed into beasts by Circe-Aristotle and unwilling to resume their former shapes. Montaigne, an enthusiastic advocate for equality, or even superiority of animals to humans, was probably the source for this example. The key difference was that whereas Montaigne intended to shock the reader with literary paradoxes, Gassendi took the paradox seriously as an analysis of the human condition. One of his earliest convictions was that hunting and killing of animals was unnatural, and he became a vegetarian as a result. Here was no urban intellectual, but a peasant, raised in sheep and cattle country, who had to pass the slaughter houses each morning on his way to school. His passionate espousal of animal rights suggests that, even before his ordination, he had rejected the doctrine of the exclusive immortality of the human soul and the biblical promise of lordship over creation.

Gassendi's denunciations of Aristotle have been equally misunderstood and referred to his supposed passion for the sceptical Pyrrhonism of Sextus Empiricus. The truth is that Gassendi was an opponent of scholasticism, not because of any universal scepticism but because he was alienated from the dogmatic subordination of science to anthropocentric values. Pyrrhonism, or his pretended suspension of judgement between Aristotle and his critics, was no more than a convenient device to mask his real line of argument, which was anti-Christian as much as anti-Aristotelian. The question 'What is man?' lay at the real centre of his attacks on the Aristotelian doctrines of species, essences, universals. It was framed in a context of his commitment to animal rights. Again and again in his writings Gassendi returns to the difficulty of defining humanity in logical terms. If Gassendi's Pyrrhonism had been more than cosmetic, he would have set out the arguments for and against scholasticism with some pretence of balance. Instead he went straight for the jugular: the claim to ground the certainty of
logical, moral and epistemological truths on the unique **superiority** of the human race. That Gassendi was not, as is absurdly claimed, a fanatical anti-Aristotelian **per se**, is shown by his subsequent friendships with Aristotelians and his scrupulosity, even in the 1620s, to divorce the historical Aristotle from the dogmatising of his Arab and Christian disciples. Gassendi was against absolute truths, but not against objective science. This position had nothing in common with Pyrrhonism, which rejected all science. His quarrel with the Aristotelians did not extend to the anti-Christian materialistic animism of the Paduan or Averroist schools.9

Far from being a fanatical anti-Aristotelian, he gave pride of place to syllogistic logic in the Syntagma, vindicating its utility against the critique of Bacon and Descartes. But, although Gassendi accepted Aristotle's rules, he completely altered the context in which the rules were applied. The new context, or set of transformations for these rules, was supplied by Bacon's theory that ideas were not absolute definitions, based on essences, but simply packaged examples. Gassendi illustrated this from the 'universal' man.10 Drawing on the new anthropology, based on the discoveries overseas, he pointed out the different character of 'man' in 300 BC and 1600 AD. Even in Aristotle's day the Athenians had been divided into rich and poor, healthy and sick, whole and crippled. Had not the Romans used different names (vir and homo) for those used to command and those who obeyed? What idea could the mind form of man in the abstract, without sketching in such characteristics as colour? This was not entirely academic. Serious debates about the form of legislation to be applied in Spain's colonial empire had hinged on whether the Indians were fully human. We know that Gassendi, like a number of his circle, regarded Spanish colonialism as a costly blunder.11

What about outer space, he mused, where telescopic reports
indicated—rather prematurely—civilisation on the moon? Just as the New World had plant life differentiated by its environment, so intelligent life in space might produce 'rational beings' who were neither featherless nor bipeds. Cyrano de Bergerac, Gassendi's faithful but irreverent fantasist, made the inhabitants of the sun rational birds and of the moon rational quadrupeds. They put an earth-man on trial and engaged in mock scholastic debates about his definition. 12

The key to Gassendi's critique of logic was his realisation of its contingent and anthropocentric character. The rules derived their universality not from absolute truth but from the universality of human 'reasoning instinct'. Their content came, not from knowledge of essences, but from sense experience. He removed from the heart of logic—the axioms—their eternal, absolute character. They were about relationships which were relative to time and space, and hence 'speculative propositions' rather than rules or laws. Then he took the bold step of comparing the axioms—which he admitted were self-evident—to the gears and machinery of a clock. Logic was a thinking machine. 13 Perhaps he had the calculating machine invented by his young friend Pascal in mind, when he assimilated logic to mathematics. Mathematics, proceeding from self-evident axioms which overlapped with those of logic, had the same machine-like quality of compelling assent to its demonstrations. 14 In Gassendi's psychology the ability to compare similarities and differences which was for him the whole art of classification, was innate in the structure of the human brain. So was the ability to quantify comparisons through apprehending space, time, dimension, as primary relations. They formed the modulus—the inner limits on human understanding which Gassendi opposed to Descartes' insistence that mind was limited by body only. 15
Although Gassendi was too shrewd to insist on its revolutionary character, this transformed the whole nature of the logical game. Instead of trying to change the rules, like Ramus, Bacon or Herbert of Cherbury, he modified their ontological status. Mathematics was no longer a guide to the 'real entities' behind the world of appearances; and logic was no longer a key to absolute causes, substance or essence. To use a contemporary expression, which in no way betrays the spirit of Gassendi's thinking, logic and mathematics were simply a form of 'software' devised by men to programme the computing machine inside their heads. His idea that memory recorded sense-data in 'folds' or 'families', classified by association with time and place or according to similarity and difference in form (typus), has been thoroughly misunderstood. Unlike Locke, Gassendi realized that without the prior existence of a 'logical machine' such classification would be impossible. This sorted sense-data into heaps (aggeries). These were the foundation of logical 'sets', which the Aristotelians mistakenly treated as universals. In order to define Socrates in an Aristotelian sense, Gassendi argued an infinity of data would be required, differentiating Socrates from every non-Socrates in the universe. Only then would the essence of Socrates be known absolutely. The same applied to man. Since reason was itself a machine—he compared it rather crudely to a pair of scales—the antithesis between mind and measuring instruments disappeared. Our use of a criterion to make comparative judgments was indefinitely extensible by external instruments. An Aristotelian who distrusted a telescope might just as well distrust his own brain. Indeed, an awareness of the limitations of that instrument would, according to Gassendi, be rather more sensible.

The mechanism of the brain and nervous system of humanity was
interdependent. Gassendi saw the nerves as extensions of the brain and the brain itself as a giant nerve. It was not fundamentally different in humans and animals. Gassendi used the mechanism of the chameleon as a model for the operation of love and hatred in human beings. His explanation of what were then regarded as occult qualities—sympathy and aversion—was purely mechanical. Gassendi identified the chameleons' fly-catching as analogous to electricity. The same mechanism, involving invisible effluxions of minute chords or filaments, triggered impulses of love or aversion, flight or aggression. But Gassendi's idea of electricity was not limited to experiments with rubbing amber. When the cross on Aix Cathedral was struck by lightning, Gassendi discovered that it became charged with magnetic power. He noted with remarkable accuracy that those areas with the highest conductivity were copper eaten by verdigris. The iron base was least changed. These observations supported Gassendi's theory that the interior of the earth, beneath the crust, was a source of radiation (pingues) of electricity and magnetism. Gassendi guessed that these phenomena were related. They might explain the northern lights, which he was the first to describe. More boldly still he linked electricity and magnetism to gravitation, asserting that all were governed by similar laws. The same forces, Gassendi argued, which impelled a boy to pluck an apple and eat it also determined the fall of the apple to the ground, or the attraction between the planets and the sun. In a remarkable simile he compared the form of these radiations (pingues) to 'certain heated corpuscles, leaping up and extricating themselves from the pores [of the substance] like a field of wheat bursting out of the ground...whose stalks are able to reach out and compel...as if by invisible instruments.' That this was only an analogy he freely admitted, 'but however the thing is done, some such invisible mechanism is in operation.'
This account closely resembles Gassendi's theory of gravitation, in which the chameleon analogy was pressed into service again; so it is important to be clear that Gassendi is here describing a model for the operation of emotions in men and animals. Traditional accounts of the Descartes-Gassendi controversy are almost the reverse of the truth. Gassendi attacked the animal machine not out of a sentimental hostility to mechanism, but because he regarded humans as only slightly more sophisticated machinery than animals. It was the Cartesian concept of mind and its identification with the divine nature which Gassendi opposed. Gassendi and Hobbes shared the opposite view that 'man is a wolf to man'. This is the point of the elaborate atomic explanation of the aversion of sheep for wolves which, with deceptive casualness, he slips in to illustrate the existence of a 'field' wired up to the sheep's eye.

One of the the Provencal troubadours exhumed by Peiresc wrote:

"The wolf however hard he tries to learn his alphabet
Is unlikely to become the shepherd's pet
For though he recites, a, b, c, d in his sleep
The only word he's ever spelt is 'sheep', 'sheep', 'sheep'.

This exactly sums up Gassendi's view of the limitation of human science and philosophy: 'If cats could philosophize they would argue that God created rats and mice exclusively to be chased.' There were obvious reasons for arresting this critique at the hem of theology. 'Is it not enough for you humans that our Saviour became a man and shed his blood for your redemption? Must you believe that he created everything for your benefit and yours alone into the bargain?' Gassendi was said to have been an eloquent preacher, but the silences in his text speak louder than the most polished perorations. He echoes the lampoon of anthropocentric teleology in Galileo's condemned Dialogues. The scholastic Simplicio is compared to the grape who imagines that the sun shins for it alone,
sharing the presumption of all who see their own experience as a universal measure. He echoes Bruno’s confident assertion that an ant can mirror God’s infinity as well as man. If Gassendi eluded the fate of these illustrious precursors, he owed it to his immense capacity for keeping a straight face.

Speciesism is a modern term for the doctrine that humanity is a master species. Gassendi’s hostility to the concept of species linked his revision of logic to an attack on traditional taxonomy. A rejection of the absolute or essential nature of the Aristotelian classification of genus and species was implicit in his view that all logical taxonomy was a purely human instrument. But this nominalism was only a stepping-stone. By denying the existence of absolute boundaries between the species, asserting that their present state was the result of a process of evolution in time and that their variation was a product of local environmental conditions, he inflicted a slow puncture on the biblical world view. The case of Gassendi suggests that the respect shown for theology over the next two centuries reflects the deliberate restraint of such successors as Linnaeus or Buffon; not, as historians would have it, their incapacity to think outside biblical literalism. On the distinction between the species, or the boundary between organic and inorganic, Gassendi cited the example of the apple passing from one colour to another, or from ripeness into rottenness, by degrees insensible to the eye. ‘Aristotle accounts for the species in terms of their differences, but he cannot account for their resemblances.’

Ever since his days at Aix University Gassendi had been interested in dissection. He studied Galen, Harvey and other moderns and understood the techniques of comparative anatomy as practised especially at Padua. The Syntagma drew attention to many points of comparison between apes and men. Peiresc, who had studied
at Padua, was keen to know if it was possible to mate apes with women. He and Gassendi were fascinated by reports of the orang-outang. The difficulty of deciding whether it was more closely related to apes or to man was a practical illustration of the impossibility of defining man in Aristotelian terms. This is a good example of how his mind continually wove like a shuttle between the theoretical and the empirical. Peiresc had studied under Pinelli and Aquapendente in Padua and had brought back a fascination with practical botany and anatomy.

Systems of classification were somewhat anarchical in Gassendi's day, but his observations on plants were pregnant for the future. Plants had nervous systems, or 'flame-like souls', responsive to pleasure-pain stimuli like humans. Some at least have sexuality and all propagate through seeds. But how to account for the family resemblances between, say cypresses, and their differentiation round the world? The resemblances are the results of similarity in structure; similar types of corpuscles formed the seeds. The differences come from adjustment to environment: climate, salts and minerals in the soil from which they feed. Hence fossils are petrified remains of real animals whose environment changed and became unfavourable to life. Seeds can survive indefinitely without germinating, until climate or other conditions are right.

This new approach fitted Gassendi's efforts to relativise logic and turn a category universal like 'man' into a set of facts (aggeries) about a certain topic, rather than a knowledge of causes, substances or natures. This linked with Baconian scientific method and with Gassendi's view of how definitions were really forged by the machinery of the human brain. The criterion sorted heaps of sense-data into piles based on similarities and differences—much as Pascal's computing machine cranked through the numbers on
its drums in order to add and subtract. This reduction of logic
to addition and subtraction was perhaps inspired by Descartes'
*Géométrie* (1637) which reduced both geometry and arithmetic to four
operations (+, −, ×, ÷). All this remained virgin territory
to logicians until the nineteenth century and, with the sole
exception of Leibniz, Gassendi's speculations were largely ignored.
The Porphyrian tree, with which these ideas were graphically
illustrated, shows how the idea of related families of species
was linked to Gassendi's realization of the anthropocentric character
of logic. Porphyry, who was extensively quoted in Gassendi's
writings, was an anti-Christian neo-Platonist, who wrote a treatise
on vegetarianism. The neo-Platonist element in Gassendi's thinking,
which commentators have ignored, played a vital role in linking the
preoccupation with animal rights to animism. Among the books found
in Gassendi's rooms at his death were the great neo-Platonic classics;
Proclus on Plato, Marsilio Ficino, Plotinus' *Enneads*. As Professor
Wind has shown, a close link between these writers and Epicureanism
lay at the heart of Renaissance paganism.

It was from the neo-Platonic theory of emanations, on which
Gassendi based the closing chapter of his *Syntagma*, that a counter
to the Aristotelian fixity of species was derived. It was this theory
which inspired Telesio, Vanini, Patrizzi, Bruno and the Italian
naturalist tradition; whose influence on Peiresc and Gassendi was so
marked. The idea that nature—or *animus mundi*—was one; that all
forms processed from her into diversity and ultimately returned, was
evidently, destructive of the idea of fixed species. Porphyry, for
example, regarded man and animals as equally fragments of the divine;
hence his vegetarianism. The idea that natural forces, which
Gassendi calls 'quasi daemones', somehow descended into matter and
took on its identity, helped to complement Epicureanism. When Gassendi
explains that God has created and imparted innate motion to each atom
LOGICAL COMPUTING

The tree of Porphyry

LOGICA IV:
"An analogy can be drawn between logical procedure and working back to a particular person through their genealogy. This is also similar to the resolutions and compositions employed by the geometer to deduce the truth of something not known or to prove that something is impossible."

Pascal's Calculator 1645
mechanised addition and subtraction by drum and ratchet
he is speaking non-Platonically. It is not surprising to find Gassendi continually using the Hermetic term for God—Ter maximus—when describing his creative function. Gassendi's God is a thinly disguised animus mundi—a term which he unashamedly uses when describing how Pan and other 'quasi-demons' evolve out of the ocean of being into the rivers, streams and minute rivulets of the visible world. In the fulness of time, the pagan 'death of Pan', they will return again into the unity. To understand the meaning better, we should go back to the diagram of the Porphyrian tree. What is being described is a process of evolution which gives 'species' a dynamic, rather than a static, sense and makes humanity a mere boundary post in a vast cosmic cycle of emanation—existence—return. Gassendi's audacity is all the greater, in that he disarms criticism by footnoting the reference to animus mundi, so as to refer the reader back to one of his first chapters. There he quotes Lactantius—Gassendi's token Christian—who condemns the concept as 'repugnant and absurd'.

Franquis Bernier, however, was persuaded that it was an integral part of his master's philosophy.

Pan was the key to the link between animism and Epicurus. Although Lucretius lightly dismissed Pan as a rustic illusion, the god had a symbolic character as the phallus—worshipped by the Arcadians in the termi, which featured in the orgiastic revels depicted by Gassendi's fellow Epicurean Poussin. The story of the death of Pan originated with Plutarch—a keen defender of animal rights and vegetarianism—who was one of Gassendi's favourite authors. Pan stood for the pleasure-principle, at the basis of Epicurean morality, and for the fecundity of nature, which led Lucretius to describe compounds of molecules as semen. The key to neo-Platonic emanation was love, and this merged easily with
the theory that all things were generated from like atoms combining with like. Gassendi did not believe Pan was real. But then he did not believe that humanity was real, as time or space were. The set of men was a set of semina (or genes) resolvable into a set of corpuscles.

Epicureanism attacked the notion of fixed species directly, through the theory that random combinations of atoms formed 'monsters', which were then eliminated by the rigours of competing with the now established life-forms. Gassendi dismissed this as a 'myth', but only after analysing its merits at length; and it continued to play an important role into the eighteenth century in detaching La Mettrie or Buffon from full-blown creationism. Was Gassendi's rebuttal of the myth of the monsters, larded with quotation from Lactantius—who had devoted a whole treatise to refuting this aspect of Epicureanism—anything more than a theatrical device? In defending Epicurus, Gassendi made a thoughtful attack on teleology. All the arguments for design in nature were reducible to the syllogism: rain makes seeds grow, therefore rain has been exclusively intended for this purpose from the beginning. But rain falls indifferently whether seeds are to be grown or not. In any case human perspective is so limited and egotistical that it is vain to pretend to know the purpose of anything. What of the hand—which Lactantius regarded as conclusive evidence not merely of design in nature, but of a homocentric architect? Lucretius argued that use alone, over an immense time-scale, might account for the differentiation of limbs and their adaptation to function. Gassendi cited the way in which apes might be trained to use their hands like humans, or the development of muscles by exercise. Adaptation to environment was universal in nature. Deaf-mutes, of whom Gassendi had made a particular study, were able to devise elaborate systems for communication which worked
well. It was nonsense to say the tongue was created for communication, since communication was possible by other means. What about fish, who had tongues but never made a sound? What about the mule, sterile by nature, who had been endowed with complete organs of generation? It might be argued that rich and poor were different species, since the latter were able to endure hardships of hunger and exposure to weather which the former could not. But this was a matter of nurture—like the difficulties which Europeans experienced in tropical climates, or the sufferings of negroes in a European winter. They could be overcome by adaptation—as cripples soon get the knack of artificial limbs. Utility, which can generate new skills for civilised humans, as in the case of clothes or mechanical invention, might account for the present appearance of nature. The arguments which Gassendi deploys on the opposite side are exiguous: 'Our tongues were created only to praise God. The private parts of the mule are an adornment for their beauty.' If it is hard to believe that anyone was taken in by this rhetoric, it must be recalled that such feeble illustrations of design were commonplace. Only a minority of intellectuals would sense a double meaning: Cyrano de Bergerac, for example, who argued that the aristocracy on the moon displayed their private parts—considered shameful upon earth—as a chief ornament of nobility, because the phallus was the source of life. Another clue that Gassendi's defence of teleology was bogus is that he credits an all-wise Providence with a long list of disasters: monstrous births, plagues, droughts, industrial injuries. Whilst the theology is impeccable, suspicion is aroused by the fact that Gassendi has already treated monstrous births in terms of occasional misfiring in the atomic combinations within the semina. He dismissed as vain superstition the idea that they were a sign sent from heaven, comparing them to badly minted coins. The example of injuries to artisans at work shows the
unusual spread which Gassendi gives to the providential. Contemporary usage, in Provence for example, would be to regard a dramatic escape from injury—such as a boy falling from a high building, or the breaking of the noose of the condemned man—as providential; but not the loss of a limb.48

Despite all these reservations, there can be little doubt that Gassendi was sincere in rejecting Epicurean evolution as a 'myth'—not because he was convinced by the meanderings of Lactantius, but because he was already in possession of a much better evolutionary theory of his own. It should be noted that his refutation of Epicurus focused entirely on the question of Providence and design. He did not refute Epicurus by invoking the fixity of species, leaving himself free to develop variations on Epicurus' theme at greater length. It may be useful at this point to clarify a confusion among historians of thought, who tend to polarise writing about nature into those who advocate pure chance on the one hand and biblical literalism on the other. A good example of this is Westfall's comment on a defence of vegetarianism, which he ascribes to Walter Charlton. He cites it as evidence that 'the virtuoso found teleological significance in everything...an assumption of an original creation by design. It is pointless to condemn the virtuoso for not understanding evolution...they drew heavily on the medieval heritage.'49 But Charlton's defence of the natural character of vegetarianism in humans was not his own argument. It had been lifted word for word from Gassendi, who used it thirty years previously in a letter to Van Helmont. And Gassendi's argument, far from showing an inability to question the fixity of species, shows that an acceptance of evolution was fundamental to his thought. The only relationship to the 'medieval heritage' was that it furnished a convenient language to cloak a notion that many Christians still find profoundly shocking today.
There is no hint of theology in the argument that the configuration of the teeth proves that eating meat is 'unnatural' to humans. Epicurus, who was also a vegetarian, held—as we have seen—an evolutionary theory of nature and society. A later paragraph of the letter discussed the possibility of an experiment in which humans would be 're-educated' to live wild in the forest. 'They would soon develop the agility of apes, dwell in trees, gather fruits and vegetate in the shade.' This was the state of 'our ancestors', for which Gassendi sees further evidence in the fondness of small children for eating fruit and climbing. Evidently for someone who has already cast off the biblical 7,000-year time scale—as Gassendi had by the 1620s—nature does not have to be fixed from the creation in order to be contrasted with a more recently acquired vice which is 'unnatural'. Gassendi backed up the anthropology with a theory of disease, in which meat was diagnosed as an 'alien' organism. Efforts to digest it resulted in gases, vapours and bodily disorders of all kinds. It is interesting to note that this was all in the letter to Van Helmont, who later published a germ theory of disease based on similar principles. Gassendi's later writings reject the idea that disease was an imbalance of the humours and advocate a semina theory of plague. Since the two men met, in 1629, the close relationship of their theories on these, and other points, implies a mutual influence.

Exactly the same point applies to the theory that the body's natural functions can be upset by entry of an 'alien' organism, as to the principle that we are not naturally carnivorous. The idea that some things are 'alien' and others 'natural' does not presuppose a commitment to either biblical creation or fixity of species. Gassendi's idea of nature was purely relative and based on his criterion of utility. Meat-eating was wrong, not because
it violated God's design for man (an argument which he was too
shrewd not to mention in passing), but because it interfered with
the relationship between our organism and its environment. A
similar reasoning inspired Gassendi's distrust of both Galenic and
Paracelsan medicine, despite the fact that he had friends, who
were doctors, in both camps. The animals were able to treat their
ailments in the context of their natural environment, and humans
ought to be able to do the same. Although a faith-healer might
take the same attitude, Gassendi was following a pragmatic assess-
ment of human nature and the state of contemporary medicine in which
religion played no part at all. Exactly the same applies to the
argument from the shape of human teeth.

The key to Gassendi's theory of the origin of the world's
present appearance lay in his concept of the 'intestina evolutione'—
a combination of definite principles of atomic combination with
randomness, in which design was hidden. Although 'some considered
Genesis to be allegorical', Gassendi is careful not to commit
himself to this position. Rather 'we will not err if we take the
account of the six days literally', a proposition which perhaps
echoes St. Ignatius Loyola's rule for thinking with the Church:
'I am sure to avoid error if I allow that the white I see is black,
if the Church so wills it.' At any rate, it is a device for
explaining why the creation in which Gassendi literally believes
bears no relationship to the one he is about to describe. It
starts with a cloud of corpuscles, circulating in infinite space,
in a manner curiously reminiscent of the Cartesian vortex. All the
corpuscles (though not the space) have been created by God, endowed
with motion and assigned a numbered code. This code determines
both the possibilities of combination and the geometrical
patterns formed by these combinations. The great law is that laid
down by Empedocles, that like attracts like, combined with random action. The resemblance to Van Helmont's concept of a gas (which, for reasons no-one has satisfactorily explained, he claimed to be 'closely related to the chaos of the ancients') becomes even closer when Gassendi compares the atoms in space to vapour in a hermetically sealed vessel. The formation of the universe follows like the fractional distillation of oil of terebinth, alcohol, spirit of tartar and asphalt from an alchemical retort. The creation of the planets is discreetly veiled. The Syntagma resumes the description at the genesis of living creatures on earth.

But from Peiresc's notes on geology and oddly misplaced sentences in the Syntagma, it is possible to fill in some of the rest. The molten core of the earth, emitting such gases (halitus) and (pinques), as electricity, magnetism and volcanic heat, is of the same nature as the sun. The planets may originally have been 'fired' out of the sun 'like shot from a bombard', as perhaps comets still were. Peiresc envisaged the earth in some primaeval state when the crust was molten, with the rocks being drawn into something like their present shape and then solidified. Gassendi wrote of mountains being germinated by seeds rising like coral from the bed of the sea. He envisaged catastrophes in which land and sea exchanged places. The teeth of whales or elephants in the Provencal alps, the number of strata exposed by erosion or geological actions, the reports of divers about the strata laid down under the sea-bed, made it possible to make an approximate calculation of the time-scale involved. The idea of a plastic matter, shaped entirely by mechanical forces — such as the earth's rotation — and those miniature architects the seeds, similar to Helmont's alchemical archeus, shows the primordial 'gas' undergoing further stages of refinement. Beneath the earth's crust, or in the sun and distant
stars, these vapours, source of electricity, magnetism and gravity, remained in a state of heated agitation.59

How did life emerge on earth? Seeds of inorganic crystalline matters were eroded by streams from underground caves and carried, in glutinous suspension, into the open air. Peirese compared them to the nuts and fruit in the viscous cauldrons of the nougat makers of Provence. Deposited in favourable conditions, the seeds were 'cooked' by sunlight, and germination began. Gassendi pointed to a number of signs suggesting that this had actually happened. Crystalline structures were to be noted everywhere, in mineral and vegetable compounds and salt. Salt was common to organic and inorganic substances and soluble in water. Laboratory experiments showed the capacity of crystals for mathematical self-replication and reproduction. What could be more likely than that fragmentation, replication and reproduction were linked? Glass manufacture showed that intense heat could fuse sand particles into a crystal. But springs, like those at Digne, showed the amazing capacity of water for holding a variety of chemicals in solution. Once the corpuscles had fused into molecules, and the molecules into semina, a programme for structural growth and reproduction—with clearly assigned limits—followed automatically. Plants, animals, humans all evolved from these common principles. Hence the family resemblances between all life forms, which Aristotle's fixed species were unable to explain.60

In view of the astonishing boldness of these speculations it is hardly surprising that Gassendi insisted on their contingency: 'I stammer—rather than speculate. But wouldn't it be exciting to know how sentient life is generated from the insentient?'61 These passages were carefully distributed around different books of the Syntagma. There is scarcely a hint of them, for example, under these headings where they might be expected: 'On the Generation of
Animals' or 'The Anatomical Similarities and Differences of Animals and Men'. Yet his confidence is astonishingly impressive: 'If God, by a miracle were to reduce the universe back to chaos, then these certain laws would guarantee an eventual return to its present appearances — just as when a chemist inverts a glass jar, the disorder inside will eventually subside until its substances separate out again.'

We are always being cautioned against fitting modern heads on ancient shoulders, but in Gassendi's case such caution seems particularly inappropriate. The closeness of Gassendi's long-forgotten theory to one recently presented, with all the trappings of modern geology and biological experimentation by Professor Cairns-Smith, must strike even the most hardened campaigner against Whiggish anachronism. In his central idea that life is best understood as a flame-like substance, without distinct individual boundaries, Professor Cairns-Smith unconsciously echoes Gassendi.

The corpuscular soul in plants, animals or humans was again and again compared to a flame 'the flower of matter'. This explains his fascination with the idea that the earth, the sun and the stars had souls, equally material in nature, which linked Gassendi's thought with Bruno and Kepler. Gravitation, for Gassendi, was in a mathematical sense the musculature of the earth's fiery soul, holding its substance together. Here the Aristotelian, or Averroan, concept of soul as a kind of collective substance; without individual or even specifically human qualities; influenced Gassendi's animism. It was shared by La Mothe Le Vayer and Gabriel Naudé, who both published books arguing for animal intelligence. This brand of pagan Aristotelianism, which scorned the anthropocentrism of the schoolmen, was an important influence on Galileo. Aristotle had upheld a 'divine principle' common to plants, animals and stars.
Neo-Platonism was Gassendi's main source for his idea of the spiritual descending to 'ensoul' the material. A related but more shadowy connexion, lies in a Jewish mysticism, which also had a neo-Platonic basis. The diagram of the Porphyrian tree can easily be modified to represent the descent of the divine in the creative myths of the Kabbala. The theory of an equivalence of numbers with letters was traditionally Hasidic; it could be applied to conjuring, an art which Mersenne strenuously attacked in Fludd and others.

The atomism of Pythagoras had been incorporated into the Jewish writers of the Middle Ages; and the idea of correspondence between number, atoms and the Hebrew alphabet put the magic on a more scientific basis. This school was particularly strong in southern France; and in Avignon, where Gassendi took his doctorate, Peiresc was a precocious schoolboy, and Fludd was a private tutor. The idea merged naturally with Epicureanism, despite its mystical associations, through Lucretius' own analogy between composing a poem from letters and creating a universe from atoms. The letter was the atom, the word a molecule, and the sentence a material object. Gassendi's refutation of Fludd's excursions into the Kabbala has misled scholars about his attitude to this subject. It was Fludd's crude attempt to Christianise the Kabbala (by arguing that Christ was the Messiah) and his belief that biblical truths could be an assistance to serious science that Gassendi gently demolished.

At his death a Hebrew-Latin Old Testament was found in his room, but no New Testament in any language. His reliance on Hebrew to define the soul in plants, humans and animals is equally significant. His vegetarianism was not unrelated to the biblical saying 'the soul is in the blood'. The Kabbalist tradition, deeply penetrated by neo-Platonism, was essentially pantheistic; and certain schools taught transmigration of souls—a doctrine which tied in well with
vegetarianism and with which Gassendi certainly sympathised. An otherwise incomprehensible claim by Descartes, that his philosophy of the animal machine had struck a fatal blow at transmigrationists, makes sense if viewed as an oblique reference to Gassendi. Gassendi's interest in generating the sentient from the insentient, in terms of a mathematical code, is a distant echo of the Hebrew myth of the Golem, or artificial man manufactured by the rabbinic Kabbalist. 70

There has been a tendency to present mechanism and confidence in the ability of mechanists to uncover eternal truths, as the great goal to which the seventeenth century was moving. The insistence of Fr. Mersenne or Descartes on the machinery of animals contrasted with the immortal human soul and its capacity for certain knowledge, ought to be presented in a rather different light. The idea of a mechanical soul in animals is at least as old as Aristotle and had been refined and developed by such Fathers of the Church as Gregory of Nyssa or St. Thomas himself. 71 It was not original to Mersenne or Descartes and only loosely connected with science of any sort, ancient or modern. Professor Singer has argued that it was merely a mental image to justify the exploitation of animal food, labour and raw materials with impunity. As such it propped up the now threatened Christian doctrine that animals had no souls and no eternal expectations. As Gassendi put it: 'God has prepared a heaven and hell for men, since that is what they expect and to disappoint their expectations would be unjust. But since animals are tormented with no such fears he has excluded them from immortality.' 72 Descartes, who grounded human immortality on less dubious reasonings, was applauded by Cardinal Berulle for restoring the medieval world-picture in modern dress. 73 What was new was not the idea of mechanism, so much as the diminished status which Gassendi—and others—accorded to humanity.
Even Descartes had to admit that not everything in the universe was necessarily made by God for man. This is the correct perspective for understanding both Copernican revolution and the interest in comparative anatomy for disentangling the human body. It is misleading to lump Descartes' mathematics—the most important and the least examined of his achievements—with his physics and philosophy, as if all three equally personified the birth of a new world view. Both his cogito and his ontological argument were lifted directly from classical or medieval sources. Gassendi's perception that hell and heaven are a product of subjective human expectations seems far more characteristic of our secular age.74

What of the systematic efforts which Gassendi made to refine the animistic elements in his thinking? The theory of the double soul, for example, or the emphasis on design in nature? Bloch, following Borkenau, has discerned a deep and genuine conservatism here, particularly in the stress on teleology, in later writings. This Bloch regards as a reactionary element which vitiated Gassendi's claim to be one of the moderns.75 This is an enormously technical and difficult area, in which conventional ideas of what is modern or reactionary can be something of a hindrance. To take the question of teleology first: I have found no evidence that Gassendi placed any theological emphasis upon design in nature until 1645 in his inaugural lecture at the College Royal. Since the theories of the evolution of life were being worked on in the 1630s, exactly contemporaneously with the trial of Galileo, it seems likely that his efforts to show design in nature were not unconnected with the post-Tridentine emphasis on literal interpretation of scripture, or keeping man at the centre of the cosmos, which wrought Galileo's downfall.76 The sort of passages which Gassendi wrote on this theme: praise of snow-flakes, the machinery of the human body
or the flea, became legion in the writings of English virtuosi after 1660. Like Gassendi, their main aim was to signal the divorce of the new science from irreligion, in the hope of conciliating the ecclesiastical establishment and making tolerance or even patronage of scientists acceptable.\textsuperscript{77}

However, there is little in what Gassendi wrote on these themes which was incompatible with his theory of the origins of the universe and the origins of life. All animistic theories presuppose some sort of design — what Gassendi calls 'certain laws' or definite principles — on which matter may be worked. Gassendi repeatedly explained that in nature the architect and the workers were fused. There was no Aristotelian, Platonic or Mosaic distinction between mover and moved, form and matter, God and his material. At times he could be astonishingly open: 'There must be some design, God or Nature, \textit{whatever you may call it}, about this architecture', \textit{cumque nomine dicas}.\textsuperscript{78} But whether it was God or Nature 'whatever you may call it' is not merely a verbal question — even in the twentieth century. In his controversy with Descartes, Gassendi had asserted that thought was identical with language. Descartes' effort to generalise from names was unrealistic — particularly in the case of God, whose nature was totally unknown. Gassendi circumvents his own agnosticism by quoting Lactantius, whose theistic teleology covered the uncertainties of his real argument.\textsuperscript{79} But, even when Gassendi is insisting most emphatically on the order revealed by the human anatomy, he cannot allow the reader to forget that both the nature of the architect and the principles of the design are hidden. This is a long way from Paley's lost-and-found watch.\textsuperscript{80} Gassendi argued that experiment shows that if we interfere with the mechanism of an animal's body, varying the size or arrangement of the organs, or reconnecting the pipes, a change for the worse or
or the ruin of the whole organism will result. This tells us we are dealing with an isolated system running to a high degree of efficiency. But it tells us nothing about who the maker was or about final causes. It merely excites 'wonder'.

He cites the anecdote of the painter who threw a sponge at his canvas in temper, because he could not get the foam on a horse right. This matched the design perfectly: 'Does God in some way accommodate chance to his design? Does he animate like this painter?' In a letter to an obscure cleric, Gassendi made the same point again: 'Great masterpieces all began from a few rude and crude elements, which were assembled, cancelled and corrected innumerable times until they were polished into the finished work. Follow this plan and your labour will be worthy of God.' Gassendi's personal interpretation of design did not rule out a Nature (or God) which worked through some form of 'evolutione-intestina'; rather it presupposed it. But in the Syntagma he preferred to come down in favour of creationism. Another good example is his use of Plutarch's concept of pre-established harmony in matter. The elements of matter—which are not atomic in Plutarch—are compared to companies of soldiers so highly trained that they always did exactly the right thing without any word of command. Gassendi appropriated this metaphor for his semina. Such an army would need neither a strategist nor a commander. Nor would a chateau, built on such principles, require an architect or a site-manager. This argument cut the ground from under Lactantius' craftsman : planetarium; God : universe analogy. Yet Gassendi quotes Lactantius without comment, as if he settled the question, in a different chapter.

The refutation of Epicurus' theory of evolution shows a similar incongruity. Gassendi claims that to create unnecessary monsters in order to demolish them would have been a wasteful
procedure and contradict God's foreknowledge. But this argument has no force at all, if we accept Gassendi's fundamental principle that God's design is incomprehensible to the human brain. Therefore, what seems pointless or wasteful to man is not necessarily so to God; especially since, a few lines later, there is the passage crediting God with monsters, droughts, industrial injuries etc. Far from having been carelessly drafted, Gassendi's work was, we know, the result of decades of emendations and re-organization. Whatever the truth about the cosmos, it is true for Gassendi that 'chance is subsumed into the design'. Feuerbach's interpretation of the direction of the Syntagma is flamboyant but accurate:

'He has carved a niche for God, in the corner of his temple of Reason, and made him the Asylum for our ignorance or an Almshouse... By day he is on the Exchange of Knowledge, driving as hard a bargain as any atheist. By night he beats the retreat from reason and because the most credulous of Catholics and the most devout Christian. This is not all sophistry, for he honours the household gods as a pious duty, just as he does not omit to carve a niche for an anaemic devil.'

Bloch has argued that, far from reasoning like an atheist, Gassendi's obsession with design in nature led him to defend Galen and oppose Harvey on the mechanism of the heart. Bloch was drawing on Tallmadge, who seriously misrepresents Gassendi's views. His opposition to Harvey was empirical, not teleological, and centred mainly on the anatomy of the septum and the existence of the capillaries. According to Sorbière, Gassendi shortly before his death became convinced, as a result of his own experiments, that Harvey was right. A number of intimate friends, such as Gui Patin, were leading Galenists; and this may explain the abstention from judgement in the very complete discussion in the Syntagma.

Gassendi's theory of the double-soul, that a rational soul
was superimposed on the soul shared with the animals, has also been misrepresented as a pure concession to orthodoxy. As with teleology, he made every effort to conflate the double-soul with Christianity—particularly after 1644—and stole some of Descartes' arguments to eke out his own. But the double-soul was an ancient theory, long associated with animism. It was ascribed to Pythagoras and firmly held by many of the neo-Platonists. Its unorthodoxy was recognized by its condemnation at the Council of Vienna. It was closely linked to theories of reincarnation and emanation. Plutarch turned the principle into a curious science-fiction myth, in which Hades was situated on the moon and paradise on the sun. After bodily death, souls went to the moon to suffer purgation. Since their animal soul was still alive, they did not realize their own death. Gassendi likened this to the Druids' theory of the 'second death'. With the death of the animal soul, the rational soul was drawn by a kind of gravitational attraction to the sun. The wicked were reincarnated on earth. This linked with Plutarch's vegetarianism, in which a meat diet was seen as slowing the purification of the rational soul, which must become filled with light. The body was a prison for past sins. Because some souls were born as animals, rather than men, meat-eating was cannibalism.

It is possible that Gassendi—and Plutarch—attached a symbolic sense to these beliefs. On the other hand, it may well be that Gassendi took some of them seriously. The line from Virgil which he quoted on his death-bed, evokes the moment when Aeneas takes the golden bough from the Sibyl and enters the underworld. He sees the souls of the heroes awaiting reincarnation. To quote this line at such a moment implies sympathy, if not belief. The theory that the soul was composed of oscillating atoms, on wave lengths, finer than those of light and fire, but also mingled with
atoms of a denser type, provided the basis for a scientific materialism. Was mythology a convenient veil for such a socially unacceptable idea?

Bernier, the disciple who fled to India rather than face the risk of being forced to divulge Gassendi's true opinions under torture, wrote a revealing letter to Chapelle from Delhi: 'How can choice be the work of atoms or an automatic machine determine our thoughts? Though our imagination is limited by the body... nous ne sommes pas entièrement de la boue et de la fange comme ils prétendent.' Ils referred to the simpler libertins—the hedonistic Epicureans, whom Gassendi had always condemned and who were content with a crude reductionism. This was probably the view of the recipient of the letter, Chapelle himself. Bernier wrote with an eye to publication and his own impending return from a decade of exile. It is therefore misleading to quote it as proof that Bernier, or by implication Gassendi, were not libertins. This was certainly the message behind the publication of the letter. But the diary of Bernier's long stay in the East does not conceal his hostility to Christianity in general and Catholic missionaries in particular. Since this ties up with Gassendi's view that the conversion of the American Indians was 'a mistake', there is no reason to doubt that Gassendi was the source of Bernier's belief that religion did not travel well because its truth was a matter of custom and geography.

In another letter to the last surviving member of the Tetrad, La Mothe Le'Vayer, Bernier promised 'word of mouth knowledge' of how the philosophers of India agreed with Gassendi in shedding light on the problem of relationship of the soul to matter. These two letters show that Gassendi's circle was well aware of the central problem of reductionism. Theological ideas of God and the soul were useless, because they claimed to pronounce on the
'unimaginable', which of its nature was beyond explanation. Epicureanism, though comprehensible, since it reduced everything to material body, was too crude to grasp the mystery of conscious direction in nature. It is on this rock that so much commentary on Gassendi has foundered. It has been assumed that the Christian theism in his writing was a sincere acknowledgement of the failure to bridge this gap. The argument of this chapter is that Gassendi's interest in neo-Platonism, like his search for the historical Aristotle, was part of a conscious effort to 'ensoul' matter with natural forces, able to supply both the materials and the design behind the universe. Hence the excitement of Bernier when he found in the esoteric doctrines of yoga and Buddhism an atheistic and atomic world-picture, in which oriental Kabbalism and pantheism eliminated the boundaries between matter and mind, mover and moved. That is why he was willing to trust his elucidation of Gassendi's philosophy in the light of these doctrines only to 'word of mouth'. The tenor of such elucidation may be guessed from Bernier's approval, in his journal, of the doctrine held in private by 'the Brahmans' that all theistic religions existed only to keep the mob in order. 95 The implications are inescapable. Bernier's statement exactly matches the secret doctrine that 'all religions are impostures', which Morin ascribed to Gassendi and assured Mazarin had been secretly imparted to Bernier, and other disciples, by word of mouth. It is no longer possible, as scholars have in the past, to dismiss Morin as a lunatic whose accusations were, as Bernier claimed, the 'foam of a mad dog'. Gassendi's true philosophy was over the head of J. B. Morin, for whom unbelief and diabolism were closely entwined. But Morin's general charge that Gassendi was a 'hypocrita presbyteri qui se fingit Catholicum' struck home. 96 Gassendi's aims were the covert construction of a secular science. He resorted to the animistic doctrine of matter
not, as has been alleged, out of timorousness or conservatism, but because it was a model enabling him (privately) to dispense with Christian theology, scholastic metaphysics, and the need for a personal deity. 97

As for his real beliefs, even in his published writings we can discover the relationship with Eastern thought which led Bernier to translate assiduously the works of his master into Persian for use in the Moghul schools. 'If my soul is a parcel of divinity, then the world is a trick upon myself', wrote Bernier, summarising Vedic doctrine. Not only the phrase 'parcel of divinity', but the detached view, that life is an illusion, was commonplace in the writings of Gassendi. 'Do not see yourself as in the midst of a crowd in which you must actively push forward or passively be trampled. Rather contemplate events as if they were taking place in a mirror.' He regarded the 'gymnosophasts' of India, the Pythagoreans and the Druids' as part of the same secret organization, with access to mysteries of science and philosophy communicated by word of mouth alone. 98 If Gassendi employed this principle himself (and his admiration for Pythagoras implies that he did) then the incoherence of his published writings would be resolved by a more frank exposition communicated privately.

It was a long way from the Rhône to the Ganges, but it is not impossible that scraps of oriental philosophy reached Gassendi via Marseilles. 99 However, Provence itself may have been a major source of Gassendi's animism. He wrote of Prior Gaultier, who had taught the relativity of all knowledge and the importance of seeking new perspectives from India and China as 'the half of my soul'. Fr. Gafferel, a lifelong friend of Gassendi, with whom we have already seen him discussing the age of the earth, was a sceptic in matters of Christian dogma, but steeped in the traditions of Italian naturalism and the Kabbala. 100
PROVENCE: geology / relief

Cassendi's field trips in Provence, and speculations about its geological formation, were closely connected with his astronomy, his new idea of time and his attitude to the scientific claims made for the Bible.

Peiresc regarded the alignment (dip/strike) of the mountains as determined by the earth's rotation when the rocks were molten.
Scipion du Périer (1588-1667), one of the most eminent presidents in the parlement, and a minor poet, illustrates the extent to which Gassendi articulated attitudes which were already commonplace among the educated jurists of Aix:

'Au lieu d'une vain lecture
Ou mon esprit va se gênant
J'étudie en me promenant
Sur les œuvres de la nature
Je n'y vois ni plante ni fleur
Je n'y sens ni froid ni chaleur
En qui l'Ouvrier ne paroisse
Et ne vois pas mouvoir des vers
Que mon ame ne reconnaïse
Cette main qui meut l'univers
etc ridiculc souci.
De vivre encore après la vie
Ne vient point me troubler ici.'

Written during the plague of 1629 when Du Périer, like the rest of the parlement deserted Aix for rural retreat, the Deistic sentiments are evident. The argument from design is here being used in a recognizably non-Christian context, since the author denies immortality explicitly and the value of the Bible implicitly.

The quietist Francois Malaval, who expressed similar pantheistic sentiments, rejected the Bible for the great book of nature. The reference to 'studying while you walk' recalls the naturalistic excursions of Gassendi and Gaultier, where so much of the geological and botanical signa for the semina theory of evolution was collected.

Du Périer's incredulity is still more evident in other poems where he speaks of himself frankly as 'un esprit fort' (or atheist), whose task is to follow destiny alone and whose sole consolation is the company of friends. One of his closest friends was Peiresc, who affirmed that if Du Périer's head were to be split open it would disclose a sun—sentiments which recall the naturalistic identification of the rational soul with fire and its home in the sun. Invited to send for a confessor on his deathbed he replied: 101 'I have been too busy to have offended God.' His poetry, like
Gassendi's philosophy, is a warning of the dangers of confusing belief in design in nature with belief in Christianity. Although it was often convenient to the 'esprit fort' for the distinction to be blurred; and Du Périer outwardly conformed to Catholicism; the reality is that they were historically distinct.

This question is also relevant for the Compagnie du Saint Sacrement, that ultra-Catholic society which was so powerful in Provence and whose links with Gassendi have been traced elsewhere. Not only was this a secret society, but its members frequently mentioned le secret—a specific secret which none of them ever divulged. At the heart of the company was the worship of the Holy Sacrament. Could this have had some connexion with le secret? Bishop Godeau, its Provencal organizer, described the essence of the Holy Sacrament as the helplessness of God. He is truly present, but stripped of all his supernatural powers, 'without any trace of sense—en état de mort', like Christ in the tomb. Is this a clue to the strange mix of piety and scepticism which we find in those associated with the Company? Was 'le secret' that God in the Holy Sacrament was an image of God's presence in his universe? Just as the Holy Sacrament could be abused, trampled on by troops, fed to dogs, with impunity, so God 'en état de mort' in the universe never intervenes in any way. This Epicureanisation of the fundamental image of sacramental Christianity would mean that the true teaching of the Company was not very far from that of the pantheistic Malaval. It is not therefore without interest that one of the secret rendezvous for the meetings of the directors of the Marseilles sector was the garden of Malaval's father, who was himself a member. 'He doesn't believe in God, that's all his secret', wrote Dostoevsky of his Grand Inquisitor. Was this 'the secret' of the Company?
In this respect it is instructive to turn from the Gassendi of the *Syntagma* to the Cassander of La Motte le Voyer's dialogues. Since these were privately printed, for a small circle of friends, in miniscule editions with fake publishing dates: they are surprisingly frank. No-one has ever questioned the identity of Cassander with Gassendi, and this has now been thoroughly investigated by M. Pintard. In these dialogues Gassendi expressed opinions which would be unusual even from the lips of our more avant-garde priests. The Brahmins, for example, are 'les plus sages hommes de la terre'. Socrates is 'the richest and most perfect model we could ever find'. We should never pretend to infallible certainty in this life but leave it to the supernatural powers of the popes or those ridiculous mullahs. Death by plague is relatively merciful because the priests and doctors leave the patient to expire quickly without their 'nemeries'. Public execution is not so bad, and Christ had an easy death.

Most striking of all is Gassendi's anticipation of Malthus: The pressure of growing population on fixed resources is endemic in nature. The 'great legislators of the past', like the Druids and the Incas, took sensible measures to control it. So do the present oriental rulers. Abortion, exposure of infants, human sacrifice, widow burning, and euthanasia for the elderly are indispensable if this problem is to be checked. The wise customs, which Christians have foolishly abandoned, are preferable to the haphazard slaughter in wars and plagues, which are the inevitable result of neglecting these prudent policies. If this were not a private conversation we might expect Providence to be introduced at this point. This was another of those eloquent silences of which Gassendi was such a master. Apart from a coarse jest about 'le vrai Dieu de Moise' not being fixed in his opinions, as Jonah at
Nineveh discovered, God is not so much hidden as passed over. Even Malthus thought it necessary to 'vindicate the ways of God to man', in order to save the Deity from the charge of improvidence or malice.

This population principle did not find its way into Gassendi's published treatises. How much more of his true philosophy was suppressed solely because it completely ignored Christianity? And how different would Gassendi's discussion of the origin of life or the principles of similarity and difference between species have been, if he had felt able to make the godless principles implied by his population policies explicit? Evidently, Gassendi saw no difference between animal and human life, or the behaviour of animals and humans. Perhaps his discussion of Norwegian experiments on the habits of lemmings, mentioned twice in the Syntagma, and his description of the way the citizens of Digne responded to the plague, gives some clue as to how his argument might have developed.

Gassendi has often been accused of ambiguity. A modern advocate of animal rights, like Professor Singer, who is also a utilitarian and an enthusiast for contraception, abortion, and euthanasia, shows impeccable logic in developing his principles. He has the good fortune to live in a secular society and may say what he likes on such issues. Had this been Gassendi's case, there is little doubt that his ambiguities, which I do not deny, would have been much reduced. St. Vincent de Paul, a key figure in the Compagnie du Saint Sacrement, wrote of meeting Gassendi in 1654, shortly before his death. He misspelt his name 'Cassandieux'—a distortion particularly gross, even by mid-seventeenth-century standards. Casser—to break—was also a technical term used when the king cancelled a decree or revoked the powers of a tribunal. Literally, the name meant 'breaking the gods'. This was not an inappropriate way of summarising Gassendi's cautious but systematic efforts to exclude
the supernatural from our enquiries into nature. There is reason to think that, when he coined this spelling, Vincent knew Gassendi's mind as intimately as anyone ever did.\textsuperscript{110}

Gassendi's vegetarianism was not merely an intellectual influence, derived from anti-Christian neo-Platonists like Porphyry or Julian the Apostate. It was closely linked to the economic and social problems of his own time.

Modern historians have vindicated Gassendi's analysis of plagues and their relation to population and food supply in early modern France. To describe this 'operation of the Malthusian scissors', a wealth of tables, graphs and statistical analyses have been assembled for both Languedoc and Provence.

A transformation in peasant diet occurred between about 1560 and 1600. Whereas Renaissance peasants, like their late-medieval counterparts, ate white bread and meat, those of Gassendi's day were reduced to coarse bread, and not always enough of that. They had become vegetarians through the principle of supply and demand. The growing prosperity of the urban markets, such as Aix, Arles and Marseilles, sucked in meat to glut the appetites of the townsman. Not only were many peasant families worse fed in absolute terms than their medieval ancestors, but the gulf between rich and poor had increased. The innumerable meat courses at the sort of banquets Gassendi was accustomed to attend in the houses of his aristocratic patrons fuelled a calorie intake twice that of modern Europeans.\textsuperscript{111} In this context Gassendi's insistence on parboiled vegetables and herbs, with almost no wine, had a whiff of social revolution. It was naturally regarded as a sign of saintly austerity.

One of the reasons why the disappearance of meat from the French peasant's diet was more rapid than elsewhere was the sharp rise in salt tax. Gassendi's attitude can be gauged from a letter
he wrote to Peiresc describing how the salt commissioners mounted guard on a newly found deposit until the weather eroded it, whilst the peasants watched helplessly. Matters were made worse by the enthusiasm of the parlement, and by the wealthy oligarchies in the towns, continually raising local taxes on wine and basic foodstuffs. 'It is not for my sake, but a matter of equity', Gassendi wrote to De Valois, enlisting aid for 'his' candidate in a local election, 'For I cannot abandon our weak and exhausted country, impoverished to make certain powerful men still richer.' One aspect of this process was the widespread practice of seizing cattle to satisfy arrears of interest to a rich creditor. This meant the total number of beasts fell sharply. In his Syntagma Gassendi denounced the ease with which the fat 'kine' always shifted the weight of taxation onto the 'lean kine', who were less able to bear it. De Valois was toppled from power in Provence, because he had been endeavouring to apportion the tax more equitably. Gassendi's use of animal metaphor may deliberately echo Richelieu's cynical remark: 'The peasant is a beast of burden, who must be well laden if he is to remain docile.' La Bruyère made a dramatic literary point by writing a naturalist's description of some strange animals in a den and concluding "c'etaient des hommes". Gassendi's sympathy with social justice may seem inconsistent with his utilitarian principles. But, as with the question of whether meat-eating was 'natural' or not, the inconsistency is more apparent than real. Since he saw animals and humans as morally related, there was no inconsistency in defending the need for equity in the dealings of the privileged classes with the peasants, just as humans ought to be equitable in their dealings with animals. On the other hand, perhaps Gassendi saw in religion a much more powerful psychological check on acquisitiveness than Epicurean humanism. It was in the name of Christ that
the Compaongie were able to raise enormous sums for the relief of
the poor from the pockets of the rich.\textsuperscript{118}

The decline of Digne, and its range war with the graziers
of Arles, has been described in chapter one. It was a natural
economic consequence of a shift in purchasing power to the towns
of Basse Provence, which then sought to monopolise the flocks'
pastures and the tanneries as well. In this conflict Gassendi and
De Valois stood up for the local village communities against the
powerful sheep syndicates, financed by members of the parlement.
Since Digne Cathedral was frequently involved in lawsuits over
grazing, Gassendi was scarcely an impartial spectator in this conflict
Gassendi's bitter comment that men, not wolves, were the shepherd's
real enemy, was inspired by events; as when Digne was cut off from
its pastures and food supply by the plague-guards set by the
parlement, and a third of its inhabitants died. In this struggle
the old seigneurial families backed Gassendi and De Valois; the
richer peasants, the parlement. The outcome was a triumph for the
parlement and the more objective approach to economic problems which
Roman Law based attitudes fostered.\textsuperscript{119}

The problems of Digne were just one of a hundred minor conflicts
which were drawn into the vortex of what modern historians see as
random disorder, but which in the view of informed contemporaries
amounted to a 'class war'; whose roots lay in the pressure of mount-
ing population and increasing government taxation on static, or
diminishing, resources.\textsuperscript{120} In the statistical sense, Gassendi was
right. Plagues solved the problem. But his Epicureanism, based on
the principle that only a minimum was necessary to happiness, and
that each should be contented with that, suggested a social solution.
So did his efforts to promote vegetarianism, which would not only
reduce the demand on a dwindling meat supply, but would, so he
claimed, reduce fertility as well. Whatever the reason, fertility did drop sharply in France once chronic under-nourishment set in, from the 1630s. Gassendi ignored the possibility for creating new wealth through the newly fashionable mercantilism, and evidently felt distaste for the nascent consumerism and creative enterprise of his day; attacking both courtiers and financiers for failing to realize that the pleasures of natural sufficiency were preferable to the senseless display or accumulation of wealth. Nor did he advocate any major redistribution of wealth, except through an increase of voluntary charity and self-limitation. His attitude therefore reflects an essential conservatism, coupled with a realistic desire to guarantee a sufficiency of bread per mouth, and was probably held by many less articulate peasants of the day. It was the ruthless and dehumanising policies of French governments which turned such demands into a manifesto for rebellion.

Efforts have been made recently to show that a native pantheistic tradition—separate from the intellectual discussed so far—flourished among some European peasantry. Certainly, there is evidence that shepherds in Provence were popularly seen as magicians and herbalists. Mistral showed that they still addressed their sheep in Greek in the nineteenth century. The priest-wizard Gaufridi, executed in 1611, was from a shepherd family in the Haute Alpes. Morin accused Gassendi of sharing his demoniacal beliefs. Gassendi insisted that the language of the Druid mysteries was Greek, and that there were still traces of this influence in modern French. Marseilles was supposed to have played a key role in the Druid assimilation of the Pythagoreans; and the grotto of Mary Magdalene had been a sacred Druid site. What matters is not so much the historical truth of these connexions, but Gassendi's keenness to uphold their plausibility. The extent of de-Christianisation, or
decline of religious practice, which Vovelle found among the peasant communities of Gassendi's Basse Alpes, may be a pointer here. 126 Gassendi himself wrote of the mob at Digne throwing stones at religious processions. This latent paganism should evidently be distinguished from the 'abominations, superstitions and ignorant clergy' uncovered by the agents of the Compagnie du Saint Sacrement in the big towns of the Basse Provence. 127 The distinction is sufficiently marked for some to write of a 'superstitious' plain and a 'rational' mountain. That is taking it too far, for the failure to practise Christianity may have no connexion with 'reason' in the eighteenth-century sense at all.

Did Gassendi's animism co-exist with dogmatic Christianity in his mind, as they are juxtaposed on the pages of the Syntagma? Or did he experience a well concealed but dramatic conversion to Deism and Naturalism through contact with sceptical upper-class society in Aix and Paris? My impression is that he never was an orthodox Christian at all. Despite the spiral of erudition which grew almost impenetrable, his pantheism remained a refinement of an attitude acquired in childhood spent among mountains and outdoors with shepherds, gossiping about werewolves and predicting weather 'signs'. In this society animal life was often more valuable than human life, in economic terms. Epicurus' maxim that 'the beast is a mirror of nature', or 'the philosopher tracks his quarry like the hunting dog', struck a chord in his existing attitudes. Sceptics from a rentier background like Montaigne or the poet Theophile du Viau emphasised that the imitation of the beasts was the way to wisdom for humanity, out of civilised distaste for the scholastic preoccupation with God and angels. 128 Gassendi adopted this intellectual position, because it corresponded to his experience.
GASSENDI ON LIFE AND SOULS
CLASSIFICATION, ORIGINS AND EVOLUTION

1. G. Boas The Happy Beast 1933 and above all the works of H. Busson, such as Les Sources et le Developpement du Rationalisme dans la Litterature 1533-1601 1922; for a less literary and more philosophical approach there is J. Spink French Free Thought from Gassendi to Voltaire 1960.

2. First argued by Fr. Lenoble in his Mersenne-Naissance du Mechanisme 1943. I define as a pantheist anyone who accepts propositions 1) and 2) in this section.


4. e.g. L. Rosenfield From Beast to Beast Machine 1941 p.265.


'Quand je joue avec ma chatte qui sait si elle passe son temps de moi plus que je ne fais d'elle? ... La présomption est notre maladie.'

8. O.O. II pp.301-2; V p.33a; VI pp. 19-24, 251b, 271b-2a.

9. The distinction between Cassendi's probabilistic epistemology and Renaissance Pyrrhonism is clearly made in the masterful study by C. Schmitt Gianfrancesco Pico della Mirandola and his Critique of Aristotle 1967. The myth that all anti-scholastics were also bigoted anti-Aristotelians is nailed by G. Tullio in a recent study of 'the Aristotle of the Libertins' reprinted in Studi su Aristote e Venezia 1983.

10. O.O. I pp.72-6, 97-8; III pp.157-75; II pp.413-4.

11. O.O. II pp.194b and 227b. See L. Hanke Aristotle and the American Indians 1959 p.15; 'Are these Indians men? Do they have rational souls?" Cassendi condemned Aristotle's racial distinction between Greek and barbarian as 'a parish pump morality' and the European annexation of America; Deux Dialogues d'Orasius Tubero La Motte le Voyer ed. Tisserand 1922 pp.184-5. Since they had 'natural virtue', converting them to Catholicism was 'a mistake'.

12. O.O.V pp.332-3. Cyrano de Bergerac Voyage dans la Lune ... ed. De Spens pp.60 and 138. The debates among these creatures about whether Cyrano is a man or a monkey are directly taken from Cassendi's logic. 'I am tempted to write a satire', Cassendi himself had written in 1624, but he always resisted the temptation.

13. O.O. I pp.121-2 Ut in arithmetica fit dum additionem subtractione et subractionem additiones probamus. Pari enim modo progressus...et methodus duplex idem Ariadnes fillum est... Sic enim Machine (vc Horologii) recte-ne se habeat, probatur sum ipsius partes aut resolutae recte se habere.
14 Pascal Oeuvres ed. du Seuil pp.187-193 The machine was dedicated to Chancellor Séguier, a patron of Gassendi, in 1645 and sales were in the hands of Roberval, Gassendi's friend and colleague at the College Royal. This reference to the brain as an addition/subtraction machine was not in the Carpentras MS of the 'Logica' written before Pascal's invention. The idea of geometrical demonstration as mechanical may have been suggested by Descartes' Géométrie (1637)—a book which Gassendi praised as 'excellent'. It contained a number of hinged mechanical devices for constructing curves and extracting square roots. The definition of a geometrical demonstration as something which 'compels belief by force' came from Gassendi's correspondent Fermat.

15 0.0. II pp.342ab Gassendi's idea is always ascribed to Kant and called a 'Copernican Revolution'—compare Critique of Pure Reason ed. N. Kemp Smith pp.84-91 and passim.

16 0.0. p.406a Gassendi does cite Aristotle's example of the blank wax tablet and the seal, but specifically repudiates it for his own image of mental 'origami'—three-dimensional foldings in parchment. Dr Chapman has suggested to me that the idea came from the convoluted appearance of the cerebral cortex after dissection, which is literally folded into channels.

17 0.0. II pp.413-4. Gassendi is using non-monotonic reasoning: assume (a) is universally true: research finds a(not-a) which is(b); then the definition of (a) will be adjusted to take account of (b)'s existence. Set theory was not developed by logicians until the nineteenth century.

18 0.0. II p.824; I p.91a 'Artem Canonican quemadmodum Regulam Faber qua opus suum dirigat.' In I p.122 experiment and the chemical analysis of metals are described as 'logical instruments', since their results can modify the content of universals. 0.0. II 310a nerves = counterpoise or spring of our machinery. 0.0. II pp.622b, 714b; see P. Pendzig Die Ethik Gassendis und ihre Quellen (II) 1910 pp.8-11.

19 0.0. II pp.134-5, II pp.93-4.

20 0.0. I p.346b.

21 0.0. I p.450'...huiuscemodi res electricae pingues sunt...ut dum perfrictioni poruli laxuntur libertasque aliqua corporusculis caloris sese extricandi exsiliendique fit, ea illorum seges cooportun...tum corpuscula versus rem, e qua prodierint, reprimat, tum occurrentes festuculas, caeteraque id genus eodem compellat. Quomodocunque autem res fiat, intercedant necesse est invisibilia organula, quorum opera ipsa seu attractio, seu compulsio fiat.'

22 G. Brett Philosophy of Gassendi p.80 is the only writer to have seen any significance in his description of an electrical field as a set of chameleon's tongues. In fact, if not in name, Gassendi is advancing a unified field theory. How else explain the deliberate inclusion of the boy-apple analogy in both the section on gravitation and immediately following the quote in n.21 describing the nervous system?
23 Lynn Thorndyke *History of Magic* VI 1959 pp.426-65 was entirely deceived by this section and tried to argue that it showed the absurd credulity of a 'supposed rationalist' like Gassendi, apparently accepting occult influences in everyday events.

24 'Col lop quan vol de letra apprendre
E anch nul temps poch hors fer entendre
Ne A, B, ne D ne L
Mays solament 'anyell anyell anyell.' Peire Vidal (circa 1200).

25 0.0. I p.151 This is one of his very rare explicit references to the central doctrine of Christianity. Even his popular sermons were based on pagan moral treatises.

26 Galileo *Dialogues Concerning Two Chief World Systems* pp.368 and 61.

27 'A man is not closer to an image of infinity than an ant', quoted in Lovejoy *The Great Chain of Being* 1936 p.120. Bruno's atomism was inseparable from animism.

28 0.0. II p.474a 'Canem et equum nihilio posse minus conscri' distingu essentia. Cum cuiusque essentia consistat in certa Principiorum contempotanone, quae in diversis, diversa est.'

29 0.0. III pp.238-9 printed separately as: Elegans de septo cordis brevis observatio. He wrote that he frequently attended dissections in Aix from 1618-24, 0.0. II pp.314-18.

30 Correspondants de Peiresc ed. Tamizay de Larroque (20) 1895 p.117. The Dutch naturalist Bontius (d.1631) had written on the Orang Outang. Gassendi linked his discussion of it with more fabulous couplings such as Tritons (0.0. II 196a).

31 Rather maliciously. Gassendi described Descartes' logic as 'a direct imitation of Verulamus', 0.0. I 65b.

32 0.0. II p.146a he claims the Hebrew for vegetation implies a soul and gives the example of Peiresc's experiments with the sensitive plant p.146a; pp.173b-174a for sex in plants. Soul and seed were co-terminous.

33 0.0. II pp.171-2.

34 0.0. II p.116b. His account ignores scripture (a token mention of a deluge) and quotes the classical theories of Ovid and Seneca. According to A. Norton *History of Botanical Science* 1931 'this interpretation was ignored till revived by Steno and Ray', p.289. Both studied in Montpellier in the 1660s. Gassendi's real views were even more daring than the *Syntagma*, as Peiresc's geological notebooks show.

35 0.0. II pp.413-4.

36 Discourse on Method, Optics, Geometry ed. P. Oolscamp 1965 p.177. This statement made possible the assimilation of arithmetic to geometry and is the key to the Cartesian revolution.

37 0.0. I p.488a. Porphyry had an evolutionary theory of his own, which Gassendi quotes, 0.0. I p.219a. The English poet Cowley, exiled in France, knew Cassendi's work well enough to give an accurate versification of a rather complex idea. See his poem Knowledge: 'That right Porphyrian tree which did true logic show
Each leaf did learned notions give,
And th'apples were demonstrative.'

Cowley contrasts true knowledge, based on scepticism, with the the scholastic claim to know essences and substances.
38 See Gassendi's 'Inventaire après Décès in the Archives Nationales. It has been published several times, e.g.: Tricentaire 1955 pp.46-7.
40 0.0. II pp. 84-9 He uses a double metaphor: an ocean which becomes a tree. 0.0. I p.161b.
41 B. Rochot Les Travaux de Gassendi ... 1944 p.200; see MS Tours 709 f.253-4.
42 Poussin Friedlander 1966 pp.104, 130, 190, 140 etc.
43 0.0. II p.851.
44 0.0. II pp.227a-9b quotes Lucretius's theory; p.253 dismisses it. Op cit. n.34 p.291; Lactantius De Opifici Dei circa 310 AD; see vol. XXII Anti-Nicene Christian Library.
45 See Carpentras MS 'livre de raison' of deaf-mute of Remoules 0.0. II pp.227b-288a. The mule was of great significance to Buffon as showing a genetic boundary point between horses and donkeys.
46 See the very popular work Les Merveilles de la Nature 1621 by Fr. Binet S.J.
47 Cyrano Voyage dans la Lune ... ed. Spens p.86. 0.0. II p.236.
48 e.g. H. Bouche Histoire et Chorographie de Provence II p.921 cites a Protestant struck blind who became a Catholic; blindness was therefore providential.
49 R. Westfall Science and Religion in Seventeenth Century England 1958 pp.51-2. Charlton, who translated much of Gassendi's work, was being reported by Samuel Pepys Everyman II p.72
50 0.0. VI p.23.
51 In a letter written to Gafferel the same year: Cedo vero quaedam haec es qua nos miselli homunculi evehi gestimus audacia uti ex aliquot perspectis hominum aetatis decarpanus aeternatam. Non condono solum 5 aut 6 annorum millia, quae iuxta sacros Codices a condito orbe deducuntur. 0.0. VI p.13a.
52 Gassendi was developing an idea in Plutarch Moralia XIII 994-5; Helmont Ortus Medicinae ... 1648 p.550a, his idea of an alien visitor or archeus infecting the semina parallels Gassendi 0.0. II 569ab and II 61 as germ theory.
53 0.0. VI 251b and 271a.
54 0.0. I p.494.
56 0.0. I p.475b, II pp.171-2 or pp.255-6: sometimes he writes of the 'proportions', or ratios of combination, as fixed by God; sometimes of the anima mundi.
57 Helmont Ortus Medicinae 1648 p.74:
Deum ter gloriosum in principi creat coelum et terram et abyssam.
Nil ibi legitur de creatione aeris...Nunc vero halitus historiam aggregiar qui vaporem simul et Gas continet.
Gassendi uses halitus and vaporem to mean much the same as Helmont's gas. 0.0. I p.485b
58 0.0. II pp.42b-43 Carpentras MS 1801, 1821 and T. de Larroque Notes Inédite de Peiresc sur l'Histoire Naturelle. Peiresc was convinced that the alignment of dip in the world's mountains confirmed Galileo's theory of the tides. This was geologically dubious, but it shows his total emancipation from a biblical, geocentric world-view. See Vita Peireskii V p.306

59 0.0. II p.116b, I p.167a; in I pp.164-5 he argued that fossils proved the immense age of the world, just as the civilized state of humanity was relatively recent—as the invention of galleys and gun-powder showed.

60 0.0. II pp.114b-118b. Op cit n.58 p.13, 0.0. II pp.347-50.

61 0.0. II pp.347, 624-6.

62 0.0. I p.494.

63 A. Cairns Smith Genetic Take-Over 1982 p.1 'Life on earth evolved through natural selection from inorganic crystals.' Semina = genes, the paste containing the seeds = colloids, crystals act like a jig to structure genes. The genes store mathematical information to be replicated. Even the comparison with alchemical distillation: 'the basic glass-ware, the chemist's flask' is drawn on. Salt and photosynthesis have an important part to play and their mineralogical examples are often identical. He writes (p.263) of the ancient idea that life is a kind of fire, the central theme of this book, a fire alight through millions of years'. See especially pp. 270, 284, 294, 299, 304-5.

64 0.0. II pp.48-9.

65 Naudé edited an Italian work arguing that beasts are more reasonable than men in 1648 and La Mothe Le Vayer's Politique du Prince 1654 is based on the principle that human societies should be analysed in terms of animal behaviour. The work had a modest influence, since he was tutor to Louis XIV at the time, who used it as his primer in statecraft. For the impact of pagan Aristotelianism on science see J. Randall The School of Padua and the Emergence of Modern Science 1961 pp.83-4 and passim.

66 R. Lenoble Naissance du Mécanisme p.27 seq. Mersenne, like Gassendi, had a good knowledge of Hebrew. It was he who persuaded Gassendi to write against Fludd. In 1618 Mersenne himself had been advised 'to introduce the discussion of magical and forbidden notions into your books by way of refuting them', pp.103-8 Fr. Lenoble was shocked at how deeply Mersenne himself was affected by Kabbalah.

67 G. Scholem On the Kabbalah and its Symbolism 1965 pp.169-70, 170-2 cf. Lucretius II 1.685-700 Dr Scholem shows the influence of these ideas on Paracelsus, whose 'invisible workmen' influenced both Helmont's archeus and Gassendi's semina.

68 Tricentaire p.47.

69 0.0. II pp.145a and 245b. It was also a key text for mortalists.


72 0.0. II p.633.

73 Baillet Vie de Descartes 1660 pp.160-6. The scholastic element in Descartes is indisputable. See E. Gilson especially the Index Scholastico-Cartesian 1913.

74 Compare the dogmatic and crude reductionism of Descartes on animals e.g. his letters to the Marquis of Newcastle Oeuvres 5 pp.275-9 and 573-7, or the Discours de la Methode part V with the sceptical and limited mechanism of Gassendi 0.0. I p.261 or II p.234.

75 0. Bloch Philosophie de Gassendi pp.440-3, 492.

76 0.0. IV pp.66-73 This is confirmed by the fact that the names of Galileo and Kepler were excluded from the lectures, the case for Copernicanism was deliberately weakened, and the avowed aim of the course was to 'uphold decorum and the old religion (antiqua fide) to show the legitimacy of retaining a sincere and pristine pietà and drown the armour of these new Alcibiades, so that they may not be suffered to profane religion with impunity'. The new Alcibiades were the libertins—or rather those libertins who used science to mock the faith openly.

77 R. Westfall Science and Religion in Seventeenth Century England 1958 p.219 'The scepticism of the enlightenment was present in embryo in their own minds. The virtuosi nourished the atheist within.' M. C. Jacob The Newtonians and the English Revolution 1976 'Preservation of society and government' was a powerful motive for defending a 'providential theology' pp.56-7.

78 0.0. II p.231b He also makes a shrewd methodological point. Democritus' indifference to final causes had 'led us' [as Christians] to a truer knowledge of design and nature because he followed a proper Baconian method. Those who assumed they knew God's plan would never get any closer to finding out what it really was. Hence science ought always to be independent of theology.

79 Lactantius was an Arian, somewhat pagan and unorthodox. He was much admired by Milton and was the most quoted Church Father among unorthodox Renaissance thinkers. See C. Hill Milton 1977 p.285 and H. Von Campenhausen Fathers of the Church 1964 p.86.

80 Natural Theology p.12 Lactantius used the same argument with Archimedes' model planetarium.

81 0.0. II p.234a nulla pars sit in qua ubi molem substantiam formam connexionam situm ac simul officium usumve consideravimus, esse captos sente oporteat nisi agnoscemus nihil esse fortuitum, nihil non provisum, nihil non a solertissima, sapientissima causa destinatum...stuporem!

82 Loc cit 234b.

83 0.0. VI p.331b Nihil initio perfectum est...

84 Moralia XII Loeb ed. 925 0.0. I p.336.
85 L. Feuerbach Geschichte der Neuem Philosophie Leipzig 1847 p.130.

86 Bulletin of History of Medicine VII May 1939 (5) 'Gassendi and the Septum'. He bases his argument on a tiny extract from the work against Fludd (see n.28), which was somehow published separately with some treatises on virginity.

87 O.O. I Praefatio, II 310-319. Evidently Gassendi did not object to vivisection. It is very easy to misrepresent 'reactionary' attitudes. Even Gui Patin was not so much concerned to 'refute' Harvey or Pecquet scientifically as to deny the value of abstract research to practical medicine. See J. Roger Les Sciences de la Vie ... 1971 p.13.

88 W. Guthrie A History of Greek Philosophy 1962 pp.306-19 Gassendi was familiar with all the sources cited.

89 Fr. Sortais S.J. La Philosophie Moderne II 1922 p.256. At this Council (1312) Pope Clement dissolved the Templars: see Pelican History of Medieval Europe M. Keen p.217.

90 Moralia II 941-5, 993B-995, Lucan Pharsalia I lines 449-51: cited by Gassendi.

91 Plutarch writes of demons descending from the moon, such as the demon of Socrates. In writing of the possibility of lunar travel, Gassendi seems to take this seriously. But in writing of his own demon or genius, he interprets it symbolically to mean 'higher consciousness'.

92 See GASSENDI AND THE CHURCH (n.94 and n.95)

93 Van Helmont's son propagated a theory of reincarnation on other universes as an alternative to hell or purgatory. See Walker The Decline of Hell 1964.

94 Gassendi was the first to see in the oscillation of a particle on a quantified wave-length the clue to the nature of matter. B. Rochot Les Travaux de Gassendi ... 1944 p.186 and O.O. I p.279a. This made sense of the Greek term for soul: harmony.


96 V. Fanurndi Epistola de Tribus Impostoribus 1654 pp.4-34.

97 For Gassendi's supposed 'timidity' see J. Roger Les Sciences de la Vie dans La Pensee Francaise du XVIIIe siécle 1971 p.159, who fails to see the audacious pantheistic implications of the soul as 'the flower of matter'. For his supposed failure to become a 'real mechanist', see W. Shea and M. Bonelli Reason, Experiment and Mysticism in the Scientific Revolution 1975, introduction.

98 Op cit n.95 pp.171-201, 0.0. II p.719a, VI p.133b, I. p.13.

99 The similarities are striking. See M. Gangopadhyaya Indian Atomism 1980 passim, or compare 0.0. II pp.718-9; his ideal of equal-minded contemplation in the midst of action with the Bhagavad-Gita.

100 J. Gaffare Curiositez Inouyes 1629. Because he rejects the flood, he finds it incredible that the mountains of Europe were ever under water and attributes fossils to spontaneous generation pp.166-81. He praises star worship among the Persians as a form of natural religion.

101 Bougerel Histoires des Hommes Illustres de Provence Paris 1752 p.185 seq. Du Perier was the advocate who won Gassendi's long dispute to become Provost of Digne in 1634.
102 La Compagnie du Trés Saint Sacrement de l'Autel à Marseilles  
R. Allier 1909 p.146.

103 Op cit p.16. 'Il faut que tout genou fléchisse devant ce Dieu anéanti.' (Directive from Paris) The company was urged to conceal its activities from men in order to imitate God in the world.

104 Op cit p.224. Malaval's works were dedicated to Clapiers de Colongue, who was also a member of the Compagnie p.260.  
See MENTALITIES ii Religion.

105 R. Pintard Thèse Complémentaire 1943 pp.13-24 I venture to disagree with his view that the plague which they are discussing is the one of 1631 in Paris. Rather it was that of 1629 in Provence. Cassand Lettres de Peiresc IV p.472.


107 Malthus Principles of Population 1830 conclusion.

108 O.0. II pp. 200 and 264-6. The Danish naturalist Olaus had refuted the myth that lemmings were generated in the clouds and fell out of the sky, by examining the contents of their stomachs. Unless corn grew in the clouds, the myth was refuted. But why did the lemmings leap from high places? Cassendi reserved judgement, but did point out that they were so ravenous that their impact on their environment was not unlike that of a plague of locusts. O.0. V p.673a: To escape the bad air they crowded on top of high buildings. They then flung each other down, or jumped down themselves, imagining they were birds or could fly.


The use of Dieux was often used to camouflage blasphemy as in Cyrano de Bergerac's Mort d'Artipline:

Ces Dieux que l'homme a faits et qui n'ont point fait l'homme
Dans plus fersmes états ce fantasaque soutien,
Qui les craint, ne craint rien.

St. Vincent wrote his letter in September and Cyrano's play had its one (and only) performance four months previously. The play was broken up to cries of 'l'athée' and "il insulte le saint sacrement". Cyrano had been fatally injured when a beam fell on his head three days before. Some asserted that this accident had been arranged by the Compagnie.


112 Impressions de Pierre Gassendi dans la Provence Alpestre 1887 ed. T. de Larroque. This excursion was in January 1635. In another letter written at this time Peiresc complained: "L'on [the government]; cache de nous l'étendu de la misère dans la campagne, qui est le vrai cause de ces soulèvements."

The salt tax paid the salary of administrators; the parlement and university lecturers. Salt was vital to preserve fish and meat,
An account of the election in which Gassendi was interested is given in Pillorget Les Mouvements Insurrectionnels...1975 pp.539-42 and 683. De Valois wished to widen the municipal franchise and secure regular cheap food supplies. The faction supporting the parlement wished to dis-enfranchise the peasants, secure the payment of the town's debts and minimise taxation on land-owners. See MENTALITIES: iv A Sense of Community; Les Paysans de Languedoc p.116 for seizure of cattle.

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The 'Livre de Raison' of Leon de Trimond, a councillor in De Valois' semestre, whose family features in Gassendi's history of medieval Digne, is a most revealing document. Trimond describes a running battle with his coqs de village on the one hand and the parlement on the other. But by 1659 his son had married the daughter of a councillor and bought an office in the parlement. By 1662 his outstanding lawsuits were settled and his creditors had to pay up. He was even able to commute all those tedious feudal tenures into profitable share-cropping agreements (métayage) as most of the large landlords already had by that time. Aix MJanes MS 1140. For his relations with Gassendi see R. Pintard Lib.Erud. I p.384. G. Chavernac Origines du Métayage en Provence 1899.

This was the view of an enlightened descendant of an Aix parlement family (writing in the 1690s). L. Thomassin Traité de Negoce 1697 argued that the Roman Law in Provence had always tolerated usury—in contrast to the rest of France. 'Subject to correction by the Church' he defended the legalisation of usury—'without which society cannot subsist'. But he also condemns 'the cunning and duplicitous methods, used by the rich in the past, who wage increasing war on the poor, which ends only when they have been stripped of the last sod of what God gave them.' pp.119 and 503.

'Poverty is a great argument for chastity.' II 695b, 696a and 704a Gassendi's attitude on the question of wealth is markedly more conservative than other libertins: Montaigne and Monchrietien argued that avarice was a virtue, creating public prosperity, and both Naudé and La Mothe Le Vayer insisted on the distinction between private vice and public benefits. N. Keohane Philosophy and the State in France 1980 pp.150-71.

There are numerous flaws in his argument.

Guide de la Provence Mystérieuse pp.XXII-XXX, De Tribus Impostribis 1654 pp.80, 97. 111.

Op cit n.106, p.158. This was the subject of a controversy with Vaugelas.
125 Lucan Pharsalia III lines 355-433. The Provencal Honoré D'Urfé, who was a member of the Compagnie du Saint Sacrement, wrote a long novel about the Druids, L'Astrée.

126 G. Vovelle Piété Baroque et Dechristianisation en Provence 1973

127 'La Compagnie du Saint Sacrement et les écoles populaires à Marseilles'

128 C. Boas The Happy Beast pp.55-70 shows the importance of the idea for libertin magistrates: E. Pasquier, who claimed his aim was 'not to cause atheism but to banish our pride'. Charron in his Sagesse, La Mothe Le Vayer in Politique du Prince, all use the idea to escape scholasticism in science and morality. Theophile de Viau, who was a pure pantheist, had a direct connexion with Gassendi through Luillier, Revue d'Histoire et de la Philosophie 1933
A. Adam 'Libertinisme et Theophile de Viau'.
THE GALLEY EXPERIMENT

Marseilles, October 1640

This labouring vast, Tellurian galleon,
Riding at anchor off the Orient sun,
Had broken its cable and stood out to space
Down some frore arctic of the aerial ways:
And now, back warping from the inclement main,
Its vaprous shroudage drenched with icy rain,
It swung into its azure roads again.

Francis Thompson

The fundamental-seeming philosophical question - How much of our science is merely contributed by language and how much is a genuine reflection of reality? - is perhaps a spurious question.

Yet we must not leap to the fatalistic conclusion that we are stuck with the conceptual scheme we grow up in. We can change it, bit by bit, plank by plank, though meanwhile there is nothing to carry us along but the evolving conceptual scheme itself. The philosopher's task was well compared, by Neurath, to that of a mariner who must rebuild his ship on the open sea.

W. Quine From a Logical Point of View 1953

At Genoa one can see written on the walls of the slave-barracks and engraved on the irons of the oarsmen the word Libertas. This is excellent and just. In all states it is only the criminals who prevent all citizens being free. If they were one and all confined to the galleys it would be possible to enjoy true freedom.

Rousseau Social Contract

As, when many a great shipwreck has come to pass, the vast sea spews hither and thither rowing benches, ribs, yards, prow, masts, oars, swimming along the coasts where floating stern-pieces warn all mortals to shun the perils of the sea; nor trust it at any time, when the wiles of the windless waves smile treacherously; even so, if you suppose the primordial atoms to be limited, scattered through all time they will be tossed hither and thither by the tides of matter, so that they can never come together in union, or take increase and grow ... It is manifest therefore, that the primordial atoms are infinite, from whence all things draw supplies.

Lucretius Rerum Natura II
The Galley Experiment: some social and philosophical aspects of the reconstruction of Physics

It was on a calm October morning in the year 1640 that one of the swiftest vessels of France's newly reconstructed Mediterranean fleet, designed to wrest from Spain control of the vital sea-passages to Italy, was rowed out into the Marseilles roads. The galley, its poop swarming with gilded baroque statuary, its mastheads fluttering with pennants, powered by two banks of twenty-eight oars, five men chained to each oar, mirrored the contrasting pomp and squalor of the age. A knot of figures gathered on the poop deck; the predominantly corpulent Louis de Valois, governor of Provence, sponsoring the day's operations, was conspicuous; whilst beside him the short and ascetic silhouette of a priest in soutane and skull cap, Pierre Gassendi, contrasted with the ceremonial sashes and breastplates of the military. In addition to the purely naval aspect of the manoeuvre testing just how far at a maximum speed the warship could travel, there was an ulterior motive, proposed by Gassendi and carried into execution by De Valois, of vindicating in a spectacular and public manner the hypotheses of Copernicus, Giordano Bruno and Galileo, touching the relativity of all observed motions.

'If the body we are on is in motion, everything we do and all the things we move will actually and apparently take place as if they were at rest.'

A common argument of the time, against Copernicanism, was that objects on a moving earth would be visibly affected by its rotation: objects 'separate' from earth, such as clouds, birds, projectiles, falling bodies, arrows or cannon balls ought to reveal a visible drift, as they lagged behind. These arguments were as old as Ptolemy, but had been refurbished by contemporaries of the calibre of Tycho Brahe, and the Jesuit order.

In defence of this school it was argued that an arrow, or a bullet,
fired vertically above the stern of an ongoing ship would fall into the sea; or that a stone dropped from the mast-head would land at the same distance from the foot of the mast that the ship had travelled during the interval of its fall. This argument made sense in the context of the Aristotelian view that the unity of a physical object was impressed by its form on the material and that causal connection between two physical objects was only possible through direct contact. As he saw it, the passengers and cargo of a ship were being moved in a very different way from the masts, planks and rigging. The latter belonged to the form of the ship and were therefore moved directly; whereas the former were separate objects and were moved directly only if crossing from one side of the ship to the other; for the purposes of the voyage being in 'accidental' motion only. This argument was ingeniously adopted to explain the relationship of the planets to the motion of the sphere of fixed stars; the fact that all planets were carried in twenty-four hours from East to West corresponded to the 'accidental' motion, communicated by the ship to the passengers; the idiosyncratic wandering of the planets along the ecliptic was equivalent to the passengers wandering across the deck. Galileo contradicted this mode of thought in an eloquent passage:

'Shut yourself up with some friend on the lower deck in the cabin of some large ship and have with you there some flies, butterflies and other small flying animals. Have a large bowl of water with some fish in it; hang up a bottle drop by drop emptying into some large vessel beneath. With the vessel standing still observe carefully how the little animals fly with equal speed to all sides of the cabin. The fish swim indifferently in all directions; the drops fall into the vessel beneath; and, in throwing something to your friend, you need throw it no more strongly in one direction than another, the distances being equal; jumping with your feet together, you pass equal spaces in every direction. When you have observed all these things carefully (though there is no doubt that when the ship is standing still everything must happen in this way) have the ship proceed with any speed you like, so long as the motion is uniform .... you will not discover the least change in all the effects named .... The cause of all these correspondences is the fact that the ship's motion is common to all the things contained in it.'
Maximum speed of ship: 10 German miles per hour
Time of descent: 3 secs.

MAST: 108 feet height
We are now so familiar with the concept of relativity (and Galileo's starting point is remarkably close to Einstein's) that Gassendi's experiment to vindicate these physical principles appears needlessly elaborate. It did not seem so to the spectators, many of them distinguished members of the judiciary, officers in the governor's regiment, or local nobles who were genuinely surprised when the stone dropped repeatedly to the same spot at the foot of the mast-head, or was thrown up and caught from the crow's nest without difficulty, even when the galley was at full speed. Streamlined to catch up with any enemy, so that her five chaser guns could be fired at point-blank range into the waterline, such ships were capable of cruising at around eight knots with a fresh crew. If Gassendi's figures are correct she covered the six kilometers to Cap Croisette in only fifteen minutes; a considerable improvement on the maximum speeds calculated by Guilmartin for Spanish warships forty years earlier. The spectators on shore were diverted by a variety of activities, such as tennis balls struck back and forth over the heads of the oarsmen, and parallel experiments on land. It was also noted, which particularly pleased Gassendi, that the ball in falling from the mast of the ship at speed seemed to follow a parabolic, or quasi-parabolic, trajectory; whereas to those on ship-board it appeared a vertical descent. This reinforced the fundamental perspective of Copernican dynamics, that motions appeared different according to the state of motion of the observer's 'view-point'. Although to an observer on earth bodies might seem to fall vertically, an observer in outer space would see the fall as a curve, compounded of the earth's motion and gravitational attraction. Gassendi referred to the results of the experiment as 'paradoxical', perhaps recalling his earlier unfinished 'paradoxes' against the Aristotelians. It is doubtful if Gassendi, long since a convinced Copernican, was sincere when he claimed to share the astonishment of the spectators and other
learned men at the result. 13

The truth was that the galley experiment was as much a propaganda exercise as an impartial observation; and a peculiarly audacious one, using a royal warship at a time when Richelieu had assumed personal charge of all naval matters 14 and was rumoured to be encouraging the Sorbonne to enact the Inquisition decrees against Copernicanism in France. 15 It seems that Gassendi was not the first to perform this experiment and although Galileo had announced that he did not need to, because he could predict the result in advance, it is possible that he had seen something of the sort done much earlier in Venice. 16 Gassendi was too cautious to assert that the experiment vindicated Copernicus or Galileo; but he was too committed to the new world system to let slip the opportunity, in his account of the experiment, of using their failure to distinguish between systems at rest and systems in motion as a point of entry for arguments designed to show the inadequacy of the physics put forward by the Aristotelians, both celestial and terrestrial. This was not, as in the Paradoxes, purely destructive. There was a concerted attempt to show the potential links between the new animistic physics of the heavens, propounded by Gilbert and Kepler, and the experimental approach to the motion of bodies in general advocated in Galileo's Discorsi due nuove Scienze, with the thinly disguised objective of magnifying the probability of Copernicanism in the mind of the educated public. 17 Gassendi's bland assertion that 'I do not blush to hold my intellect captive' to the judgement of the Church, at the conclusion of the treatise, recalls the contemporary painting by Rubens of reason prostrated before the mystery of transubstantiation. 18 But in Gassendi's case fideism, or his public expression of it, furnished a secure bastion from which his intellect was free to launch the most audacious assaults on the biblical-Aristotelian world-picture.

Although he pretended not to know the precise reasons for the
condemnation of heliocentrism, which he held could not in any case be an article of faith, it is unlikely that he was unaware that the principal reservation, as expressed by Cardinal Bellarmine, was that astronomy as a science was kinematic and mathematical in its nature. Copernicus, understood in this sense, was acceptable; but when Galileo and others attempted to establish astronomy as the science of a definite physical system, in which the earth formed a component, and regarded this as a sufficiently established basis from which to reinterpret the Bible and the Fathers, they strayed not merely into error, but heresy. Gassendi's efforts to establish gravitation as a physical force, analogous to magnetism — accounting for the behaviour of falling bodies, pendulums, hypothetical physical systems isolated in empty space, the elliptical path of the planets round the sun—have been termed crude and eclectic. It is easy to point to errors in his formulation, such as the introduction of a form of 'turbine' effect from air-pressure, to account for arithmetical progression in Galileo's law of falling bodies, or his partial acceptance of Galileo's argument that the tides were the resultant force of annual and diurnal motion of the earth. But such errors significantly testify to the zeal and commitment with which he flung himself into the quest for a physical basis for the Copernican system. Even if it could not be demonstrated in absolute terms, evidence of its ever increasing superiority in the conciseness and generality of its interpretations, would leave the Aristotelians high and dry and force the theologians to allow the scientific community that autonomy which Gassendi thought indispensable to its virility.

Despite attempts to belittle the De Motu it is undeniable that it took a firm step in the direction of Newtonian synthesis, and not merely through gropings which can be identified with hindsight. Using Galileo's treatise as a starting point (which Bloch and Koyré agree Gassendi 'profoundly understood') it puts forward all three of Newton's laws of motion; though not quite as crisply as in the early pages of Principia.
The first law, that everybody continues in a state of rest or uniform motion unless changed by an impressed force, appears Newtonian in both statement and intention. It is perhaps remarkable that being in possession of the law of inertia, which he had acquired ten years earlier in Holland as a result of conversations with Isaac Beckmann, and to which he evidently attached great importance, his contribution to physics remained so limited. The same might be said of Descartes, who also derived this law from conversations with Beckmann. In his case the scholastic dualism between rest and motion dominated his thinking so that, although his language sounds Newtonian, the context in which it was formulated was not. There is no such excuse for Gassendi, who clearly equated rest with uniform motion as states and repeatedly stressed, against Aristotle, that any change in state must be brought about by an external, impressed force; and that motion was not an internal principle. Unlike Newton he specified (correctly) that the motion of individual atoms was explained by laws (2) and (3); but the rule of inertia applied only to molecular composites. Gassendi's dictum that 'action and reaction in nature are always reciprocal' is otherwise Newton's third law, though unlike Newton he did not relate it to specific collision experiments. The second law emerges from a thought-experiment in which the reader is invited to imagine that, at the precise instant when the stone was released from the top of the mast, the galley, the earth, the universe and everything except the stone were annihilated by an omnipotent deity: 'In whatever direction the stone is thrown ... it will move eternally in, as imparted to it by the hand.' Only the idea that speed will be proportional to force is missing. And this is explained, in his later Syntagma, rather more thoroughly than by Newton.

It has been said that Gassendi lacked the mathematical base necessary to follow up these themes; recent research has shown the numerous blockages and false starts which delayed Newton's own marriage of new
 mathematical skills to correct dynamical formulations between 1666 and the composition of the Principia. But Gassendi's appreciation of the importance of mathematics, in the formulation of a physics able to challenge the Jesuits and neo-scholastics with success, is evident from the pains he took, between the publication of De Motu and the composition of his De Proporzione qua gravia decidentia accelerantur in 1645, to rectify the gross errors in his interpretation of Galileo's law of fall. He consulted Carcavi, the mathematical lawyer in the parlement of Paris, and Pierre de Fermat, the prodigy, also a lawyer in the parlement of Toulouse whose area of jurisdiction bordered on Provence. Although there is a paucity of geometrical diagrams in Gassendi's own work, and when they appear they are often crude, as in the illustration that the path of a stone falling down the ship's mast is really a parabola, or in the explanation of the law of fall in the De Motu of 1642, it is evident that he could not have been such an accomplished practical astronomer without being at least competent as a mathematician. If his position as lecturer in mathematics at the College Royal from 1645-8 owed more to the patronage of influential aristocrats, such as the Archbishop of Lyons (rather than his mathematical flair), it must not be forgotten that he was on close terms with mathematicians of the calibre of Roberval, also at the College Royal, the young Pascal and another priest-astronomer Isaac Boulliau. He could not have read the works of Kepler and Galileo; mastering their message so adroitly, without a degree of mathematical understanding and it would be unwise to assume, from his evident lack of any spark of mathematical creativity, that he was unaware of the importance of the new developments in algebra and geometry, in which France and Italy at this time predominated.

The importance of De Motu for the history of science is that it made the first published effort to integrate Kepler and Galileo, on a dynamic and a physical basis, at a time when the writings of both were prohibited.
in Rome, in order to underpin the probability of a Copernican world-picture. What, to the Church, appeared Copernicus' great virtue, making possible the re-issue of his book with minimal erasures, was the absence of any clear physical basis for his theory. This, for Gassendi, was his chief defect. The existence of imaginary point centres in space, whether in the equants of Ptolemy or the epicycles of Copernicus, seemed to him to reduce astronomy 'to cloudy fictions and hypotheses'. The importance of Kepler's ellipse, perhaps accepted by Gassendi as early as 1630, was that it translated astronomy from a kinematic to a physical basis, though he blandly assumed that eccentrics and epicycles, would still be used for calculation. A good example of this bizarre combination of conceptual sophistication with mathematical conservatism was Boulliau's use of an equant at the foci of Keplerian ellipses in his Astronomia Philolaica (1644). But it was really Kepler's theories of cosmic magnetism which appealed most strongly to Gassendi. Two months before the galley experiment he wrote to Athanasius Kircher: 'On the causes [of magnetic di] ... I have nothing ad hoc to communicate which might satisfy but I might settle this debt by feigning variously from the guesses of Copernicus, the vortices of Gilbert, the [planetary] nuclei of Kepler, the hooks and chains of Democritus and a multitude of other [hypotheses] as excessive as they are numerous.' This was a satirical dig at the excesses into which early mechanists could fall. But it was, to a certain extent, a shrewd self-parody; an apparently unthinking eclecticism being the first point which modern critics seize on in his work. The De Motu exploits an equally broad range of magnetic theories of planetary and gravitational attraction, drawing on Gilbert, Kepler and Greek atomism, whose accuracy Gassendi was in no position to determine experimentally, for no other reason than to supply a physical basis for Copernicanism and an alternative to Aristotle.

This raises the particular question, to what extent the galley
experiment can be regarded as a 'proof' of Copernicanism, and the more
general, and recently hotly debated problem, of how far 'rational' or
'experimental' criteria motivated Aristotle's post-Renaissance enemies.
On the former question there are a diversity of views ranging from the
positive assessment of Debus: 'They did definitely remove one obstacle
that had hitherto opposed the general acceptance of Copernicanism' and
the reservations of Brush, who doubted whether observers really would have
seen the stone's path as a parabola, to the scepticism of Feyerabend:
'The problem did not readily lend itself to an experimental solution.
Experiments were made but their results were far from conclusive.'

Attitudes to the importance of the experiment will generally be a
function of a wider philosophy of science and it is here that the post-
empiricism, or post-Whig, antipathies, which have profoundly coloured
the history and philosophy of science in the twentieth century, have
helped to obscure the importance of Gassendi. Here the views of arch-
conservatives and new-science radicals converge; for both are happy to
discover metaphysical dimensions behind any programme of observation and
experiment and to reduce the 'facts' of scientific enquiry to pawns in
rival epistemological establishments. Hence scholars with opinions as
diverse as Duhem, Koyré, Crombie and Feyerabend, can agree, with Cardinal
Bellermine, that Galileo did not have enough evidence to turn Copernicus
into a convincing physical system. These moderns, like their scholastic-
predecessors, tend to confuse the search for truth in the natural sciences
with dogmatism, and project back onto the seventeenth century a Euclidean
ideal of proof which really became normative only from the early nine-
teenth century onwards. In Gassendi's circle, logical or geometrical
proof-structures were valid only within the boundaries delimited by
linguistic or mathematical syntax. The natural sciences, even when
admixed with mathematics, relied on conjectures from probabilities
and it was the accumulation down the ages of a variety of observations
and experiments, and the application of minds with very different
perspectives and experiences to the same problem, which gradually unveiled truths through time. This philosophy of science, which might be termed Paduan Baconianism, was common to Gassendi and Peiresc, who had known Sarpi and Galileo at Padua, and a variety of their European correspondents such as Wendelin, in Liège, or Cassiano del Pozzo in Rome. It was this epistemology, not merely caution over the 1633 decree, which led Gassendi to describe the galley experiment in modest terms; as merely setting up an analogy between the motion impressed by the boat upon the stone and the way in which a uniformly rotating earth might impress motion upon the boat, the stone and anything within its sphere of attraction. This made the paradoxes urged by Ptolemy, Tycho and others 'less wonderful' and 'to imagine its motion less absurd'. It explains the importance to Gassendi of the parallel experiments made on shore the same day with coaches, galloping horsemen and runners imparting their own motion to projectiles, and the little experiment which Gassendi urged Pierre Dupuy to perform himself with a child's ball from the gallery of his own library.

Gassendi’s philosophical ambitions lay in the direction of disen-tangling science as a body of cumulative propositions, certain or uncertain, from the primacy of metaphysics, whether Aristotelian or Cartesian, and theology, whether biblical or scholastic. This programme was faithful to the original spirit of Epicurus and Lucretius, for whom empirical science, underpinned by atomic reductionism, was a means of emancipating the human spirit from popular paganism, on the one hand, and the metaphysics of immaterial forms and souls, shared by Platonists and Aristotelians, on the other. Some of the constraints on the realisation of this potential for scepticism have already been discussed. They led Gassendi to adopt, as far as was possible, an attitude of neutrality towards dogmatic religion, avoiding any hint of Lucretius’ passionate crusade against it. Although Lucretius was quoted so often by Gassendi
that he could almost be reconstructed from his works, if the manuscript were lost, the famous hymns on the elimination of superstition were suppressed. But there was a rather surprising reference in the letter which Gassendi wrote to Galileo after publication of the *Two Worlds Systems* and before it was suppressed. There Galileo was addressed in the terms which Lucretius reserved for Epicurus on having penetrated the forbidden mysteries of the universe; but the powerful and evocative lines which immediately precede and follow the section quoted by Gassendi, about religion having previously dominated puny man from the sky, but was now being thrown down at his feet, were prudently omitted. Perhaps Gassendi felt that even this was going too far, as he later declined to write to Galileo at all, 'things being rather ticklish in that quarter'. Galileo would certainly have known his Lucretius well enough to have filled in the missing lines for himself.

The tendency of twentieth-century historians and philosophers of science, on the other hand, has been to 'theologise' their subject. The desire of Duhem to assimilate the indifference of scholastic writers to the details of scientific theory to philosophical positivism, the passionate zeal of Burtt, Koyre or Macguire to minimize experiment as a motor of scientific change and set up Platonism instead, Koestler's emphasis on the irrationality of the scientist, Butterfield's insistence that it is 'the new thinking-cap ... not new observations or additional evidence'; which matters were valuable correctives to the epistemology of Comte or J. S. Mill. But although the above would rather claim to be rediscovering the past as it really happened, liberating it from a mid-nineteenth-century perspective, the example of Gassendi shows that the new obsession with the role of metaphysics, and more recently of magic or astrology in history, can be equally distorting. The climax of the effort to theologise science came with the emergence of Kuhn and his disciples. The interpretation of scientific change in terms of
consensus or paradigms is, it has been pointed out, merely a transposition of the theories put forward by Cardinal Newman in his *Development of Christian Doctrine* and *Grammar of Assent* to explain how the Catholic Church down the ages has reconciled authority with evolution of doctrine. Kuhn's position would have been quite incomprehensible to Gassendi (and incidentally to Newman) as for both there was a real antithesis between faith, which led the believer to accept on authority, and science, which was a matter for evidence, individual judgement and freedom in the choice of hypotheses. Kuhn's interpretation has led directly to the emergence of a school which sees science as an ideology, or to the arguments that there is no distinction between science and magic, science and myth or the cosmologies uncovered by anthropologists. Western science since the seventeenth century is portrayed as a conspiracy, rather than a consensus, advancing capitalism, imperialism and, more recently, anti-feminism.

This transition from a 'metaphysical' to a social interpretation of science, however much Koyré or Koestler might dislike the idea, has a certain logic. Once suppose that the choice of hypotheses is dictated not solely by evidence but that sub-conscious or aesthetic criteria apply, the question naturally arises whether or not the scientist's own society, or ideal of society, may influence his selection; for an example of this we need go no further than Plato. Another would be the climate in which science and Puritanism flourished amidst the ruins of the Elizabethan world-picture. Even if we allow that truly great minds in science—a Galileo, a Kepler or even a Gassendi—were Copernican because of their understanding the implications of certain observations and experiments, what about their passionate public among amateur nobles, gentry, lawyers, doctors? Even if Stillman Drake is right in supposing that Galileo's career can be adequately justified in empiricist terms, without the need to invoke Platonist theologising or subconscious irrationalism, it takes more than a handful of penetrating minds to make a scientific revolution.
The fate of the Epicureans and Stoics in the late Roman world, the isolation of Philoponous in Byzantium or the so-called Merton school in late medieval Europe is evidence of this. It was the existence of a republic of letters and beyond that, of an enlightened lay culture, which turned the work of Copernicus and Galileo into a catalyst for permanent change. But what were the grounds on which enthusiastic amateurs like Peiresc, whom Bayle styled the procureur general of the republic of letters, or Louis de Valois, rested their Copernicanism? It was with the hope of enlarging this section of supporters that the galley experiment, and the measurement of air pressure, were dramatised. For this reason Gassendi addressed his letters to Pierre Dupuy, the doyen of Parisian lawyers and the leader of an informal academy of gentlemen scholars. There were also members of the Provençal parlement, like Gaultier; the De Cormis family; or Gaufridi, first president of De Valois' semestre. There was the anonymous officer of the watch on the galley; who told Gassendi he had already discharged his pistol at the mast-head several times on a previous voyage and observed the shot fall to the base. All the above had performed experiments for themselves. But it is not likely that, as busy public men, they had the leisure to master all the complex mathematical and physical arguments involved in the verification of Copernicus.

Indeed in Peiresc's case, it is clear from the arguments he painstakingly developed to vindicate the physical character of Galileo's system in the years between 1633 and his death in 1637, that he confounded such disparate problems as those of the so-called perpetual motion machine of Drebbel, the water-clock of Fr. Linus, the botanical sun-clock of Athanasius Kircher, the rotation of stones in the gall bladder, and the behaviour of a 'floating stone' (pumice) armed with a magnet, into a single illustration of the physical principles contested in Galileo's theory of the tides and the moving earth. As for De Valois, his approach was more literary, arguing the necessity of the earth's motion
from the upheavals and public disorders of the 1640s in France and Europe. For Gaufridi, on the other hand, defending the introduction of a new Court of Requests in Provence in 1641, which was held to be an innovation infringing local privilege, Copernicanism had overthrown the idea that law was simply time-honoured tradition: 'Today's innovation is tomorrow's precedent .... and, if we are to believe the philosophers, even the universe is now governed by new laws.' In accounting for the reception of Copernican ideas outside the ranks of a handful of trained astronomers or mathematicians we are justified in considering the social component which, joined with such evidence as the telescopic discoveries or the galley experiment, transformed old ideas like heliocentrism or atomism into instruments of change. Without endorsing Feyerabend's view that the Copernican revolution was a triumph for propaganda and blind faith, rather than science, it is possible to agree that:

'In this context the rise of a new secular class with a new outlook and a considerable contempt for the science of the schools, for its methods its results and even for its language, becomes important. The barbaric Latin .... the intellectual squalor of academic science, its otherworldliness which is soon interpreted as uselessness, its connection with the Church — all these elements are now lumped together with the Aristotelian cosmology and the contempt one feels for them is transferred to every single Aristotelian argument. This guilt-by-association does not make the arguments less rational or conclusive but it reduces their influence on the minds of those who are willing to follow Copernicus. For Copernicus now stands for progress in other areas as well, he is a symbol for the ideals of a new class that looks back to the classical times of Plato and Cicero and forward to a free and pluralistic society.'

If we substitute Epicurus and Lucretius for Plato and Cicero, this was exactly the case of Gassendi and those whom he influenced. Molière, who felt Gassendi's influence early in life, translating Lucretius, used his skill as a playwright to lampoon the logic, language and science of the schools and even the Church, not by reasoning but by 'guilt by association' with absurd venality or wickedness. If by the 1650s, Gassendi managed to prune the contempt from his discussion of Aristotelianism, or toned down his demands for the independence of knowledge
from theology, it is notable that at the same time he wavered from Copernicanism towards Tycho Brahe and sought to reinforce his ties with the higher clergy and nobility.

As Poincaré claimed, there was no empirical basis for Newton's first law of motion, which Gassendi derived in De Motu from a thought-experiment using infinite Epicurean space and Galileo's experimentally derived concept of inertia. According to J. Lindsay:

'The Galilean and Newtonian concepts need as their social correlative a system in which each individual is conceived as living on atomic existence, apart from all others, impacting and being impacted on, but revealing in the last resort an egoist entity. The ideal conditions with which classical mechanics was concerned were the conditions of the free atomistic bourgeois soul. Thus Newtonian mechanics asserted that a point mass left to itself moved with uniform velocity in a straight line.'

In relating this principle to Gassendi's thinking on inertia it is to be remembered that the idea was originally acquired on a visit to Holland in 1630, at the height of its successful commercial revolution. In a famous passage Descartes commented on the extreme individualism of the Dutch at that time, which he attributed to their commercial spirit:

'Amongst a teeming and great people, very active and careful each of their own affairs rather than curious of their neighbour's ... I have dwelt in the most populous towns more solitary and withdrawn than in the most distant deserts.'

But even before Gassendi visited Holland he had attached himself to Epicureanism; though it was the moral, rather than the physical aspect, that had attracted his interest. Epicurean morality, flourishing at periods of social unrest and political decay, such as Athens between the Peloponnesian wars and Alexander the Great, or Rome between Republic and Empire, was essentially an ethic of isolation. Apart from the cultivation of personal friendships, the individual was advised to imitate the Epicurean gods and withdraw from politics, society and the world as far as possible. It was this pleasure of solitude, as a detached spectator of the disasters of others,
that Epicurus urged as the supreme good. The doctrine that societies were formed of individuals, bound by contracts, which could be dissolved, paralleled the physical theory that the most solid objects were merely bonded atoms and molecules, in perpetual flux. It was only when he discovered that Epicurus' atomic theory agreed with Galileo's prediction about light and heavy objects falling at the same speed in a vacuum and that an infinite, empty space was a pre-condition for Beckmann's rule of inertia that he saw Epicurus as an appropriate vehicle for a new science as well as a morality. In the end it was the morality which was neglected; largely because the essentially selfish and this-worldly precepts of Epicureanism ultimately resisted Christianisation in the ethical section of the Syntagma. But the true nature of Gassendi's thoughts about morality was not far removed from that of Hobbes; the account of the origin of political societies in the Syntagma is a thinly veiled adaptation of Hobbes, except that the sovereignty of the prince is limited by the existence of three separate contracts instead of one. The idea of the solitary individual was deeply rooted in libertin thought; it is celebrated, for example, in the poetry of Theophile de Viau or Saint Amant—the latter an intermediary between Peiresc and Galileo and a strong Epicurean. But the social roots of this individualism should probably be sought in the nature of French political society rather than, as in Holland, in the pace of commercial expansion and urbanisation. Although Marseilles, scene of the galley experiment, was a major port with a substantial bourgeoisie, it could not at this period compare with Amsterdam. On the other hand, in Provence, as elsewhere in France, this was a period of acute social readjustment as the provincial feudalism of medieval France reached the last stages of its evolution into the corporate feudalism of the absolute state. In the period of unexampled violence which accompanied these changes, as groups or individuals struggled to maintain their privileges,
the grim maxim which Hobbes formulated in the *De Cive*, that every individual fears death as certainly as a stone falls towards the earth, was a conscious effort to assimilate the new laws of motion to a science of society.\textsuperscript{77}

It was during the key period from 1610 to around 1660, when feudalism was already something of a legal and economic fossil but absolutism had not yet embedded its tubers firmly in the roots of provincial life, that the climate for individualism was most propitious. A leading literary historian has significantly entitled a survey of this period of French history *Studies in Self-Interest*; and a Dutch historian has described the *Fronde* of 1648-53 'an epidemic of egotism'.\textsuperscript{78} Perhaps the most striking form, from the standpoint of social unrest, was the institutionalised selfishness which has been so shrewdly analysed by Mousnier in numerous books and articles.\textsuperscript{79} This was exhibited not merely by towns, villages, guilds and provinces, which rebelled only when their own local privileges were threatened and whose mutual jealousies prevented any collective action against royal encroachment, but by those bodies created by the Crown in order to extend its own authority— notably the *parlements*— who initiated the *Fronde* and actively stimulated a number of 'popular' revolts, the *tresoriers*, responsible for tax collection, the *élus*, responsible for its assessment, the royal provincial governors and provincial estates.\textsuperscript{80} It was fear of these centrifugal tendencies within the State which led the Crown to avoid summoning a States General, after the unseemly spectacle of communal rivalries between nobles and civil servants, civil servants and clergy, which had marred the assembly of 1614.\textsuperscript{81} Even the nobility, who have been accused of irresponsible selfishness by historians of the *Fronde*, were operating corporately; rather than as individuals in the modern sense, as they saw themselves to be defending the privileges attached to an ancient family name and the interests of their clients and tenants, rather than furthering
personal ambition. In this respect the preoccupation of De Valois with family honor and those who depended on his fortunes must be allowed to be as typical as what looks like pure opportunism in De Retz, Archbishop of Paris. The Provencal nobility showed themselves capable of a remarkable degree of corporate action in defense of what they saw as their rightful privileges from 1637-55.

If we attempt the delicate task of translating Gassendi's physics into social terms, Lindsay's analogy between the atom/individual in inertial motion breaks down. Firstly because in Gassendi's system inertial motion is attributed not to the atom, but to their agglomeration in molecules, the res concretae or corporate object; secondly because seventeenth-century France was for social and political purposes corporate, rather than individual, in its responses—although, as we have seen, a somewhat escapist individualism was evident in libertin poetry or Gassendi's brand of Epicurean withdrawal from politics and society. But these two qualifications cancel, so that it is possible to present a parallel between the res concretae, with its capacity for inertial motion towards an infinite horizon, and the corporate egotism displayed by French institutions during this period which imperilled the stability of the State. A similar notion may have been in Kepler's mind when he bound the configuration of his elliptical orbits to 'sun-seeking' and 'sun-repellent' magnetic poles located on the corporate 'soul' of his planets. Kepler followed Copernicanism, Rheticus and others in equating the sun with the Emperor or, or ruling principle, and the planets with his subjects. This would help to explain why he believed that his third law, expounded in the Harmonice Mundi (1619), would resolve not merely the secret of planetary harmonics but the problem of creating political stability in Europe and Germany. It was an analogy which struck Dr. Johnson in the mid-eighteenth century:
'The reigning philosophy informs us that the vast bodies which constitute the universe are regulated in their progress through the aetherial spaces by the perpetual agency of contrary forces; by one of which they are restrained from deserting their orbits, and losing themselves in the immensity; and held off by the other from rushing together, and clustering around the centre with everlasting cohesion.

The same contrariety of impulse may be perhaps discovered in the motions of men. We are formed for society, not for combination; we are equally unqualified to live in a close connexion with our fellow beings and in total separation from them; we are attracted towards each other by general sympathy, but kept back from contact by private interests.'

Although Johnson was evidently musing on Newton, the logic of his comparison is closer to Kepler's magnetism than to gravitation.

How far was the discovery of the inadequacy of Aristotelian physics a concomitant of the break-down of Aristotelian political theory? The concept of man as a social animal seemed inadequate to explain the violence and turmoil of the period 1560 to 1660, described by modern historians as one of 'general crisis'. The idolization of small city states, praise of leisured gentility, condemnation of usury, trade or manufactures, or the assumption of an organic tie between slave and master, seemed increasingly irrelevant to the politics of western Europe. One of Gassendi's targets in the De Motu was the distinction between natural and violent motion; and he propounded the maxim that action and reaction were always reciprocal in order to show that violence, far from being unnatural, was central to the interactions of material bodies. Perhaps this new attitude was not unconnected with the way in which violence had been institutionalised as an instrument of policy, by successive German Emperors from 1618-48 and by Cardinals Richelieu and Mazarin during the same period, especially through their intendants who were everywhere after 1637. The increasing tendency of political relations to depend on force was deplored by Archbishop Montchal, Gassendi's spiritual adviser, during the debate on the taxation of the clergy. It is an interesting commentary on the ambiguity of Gassendi's position that the De Motu took the form of letters addressed to Pierre Dupuy, one of Richelieu's
foremost Gallican propagandists, whereas his resignation of his Agency, at Montchal's suggestion, implies that he had been won over by Richelieu's clerical opponents. It was Montchal who feared that Richelieu's government rested too blatantly on military force. Lindsay's suggestion that Newton's laws are modelled on a concept of force which grew out of the cannon has been dismissed by historians who point out the abstraction of Newton's laws. But Gassendi made no secret that the cannon was a vehicle whose operation illustrated the interaction of all three laws: from the firing of the powder, through to the emission of the shot and the recoil of the carriage. 93

If Gassendi wanted an example of the increasing violence of social relations under absolutism he need look no further than the motive force of the galley. In the later Middle Ages, as at the height of the Athenian Empire, the war galleys were powered by free-wage labour. But, as alterations in design brought about the transition from galleys with several banks and one man to each oar, to a single rowing deck with five or seven to an oar, the proportion of free labour declined. 94 The French began to use convicts and by the time J. J. Bouchard visited the galleys at Marseilles, in 1629, he was sceptical of their military value and described them as little more than 'a hell in which to torment wretched malefactors'. When he inquired their crimes he was surprised to find that they came from all ranks of society, including clergy who had quarrelled with their bishops, duellists, and young nobles who had disputed precedence with their betters. 95 The galleys formed a means of checking that spirit of divisive egotism, mentioned earlier, which menaced the stability of a hierarchical society. This was even more evident as Richelieu expanded the fleet into a viable fighting force in the 1630s. A galley might require from 150 to 300 oarsmen. Poor diet, mostly biscuit, constant exposure to all weathers chained on deck, and prison fever in the crowded slave-barracks on shore, meant mortality was
high. The fleet required an army of about 6,000 slaves together with a constant stream of recruits. Other Mediterranean powers, like Spain and Venice, had recruiting problems. But thanks to the almost uninterrupted series of peasant rebellions from 1629 to 1646, renewed in the 1650s, Richelieu had as many oarsmen as he could handle. In 1640, for example, following the suppression of a major revolt in Normandy against taxation, hundreds of chained convicts were escorted south.

Mlle. de Scudéry, the romantic novelist, wrote to a friend: 'There are over 4,000 convicts in the Bagne at Marseilles. Everyone calls them slaves but I can assure you there is nothing romanesque about them.'

There is no hint in Gassendi's life or writings of that sympathy with the plight of the galley slaves which is one of the jewels in the crown of the Catholic revival in France and attracted the energies of St. Vincent de Paul between 1619 and 1623, and of the saintly Bishop of Marseilles, J. B. Gault, who established a prison hospital; showing such zeal for their spiritual and material welfare that he died of gaol fever contracted in the galleys in 1643. It is arguable whether or not this lack of interest indicates a lack of Christian commitment on Gassendi's part, but references to the galleys and the slave-barracks, or bagne, a familiar sight in Marseilles and later Toulon, in his writings are strangely unsympathetic. In the Exercitationes, lectures delivered at Aix when the agitation about the conditions of the slaves was at its height, he compared the disciples of Aristotle to those companions of Ulysses who wished to remain beasts even when Circe offered to release them 'and also to the galley slaves or vagabonds for whom wounds and ulcers have grown sweet by custom and preferable to any honest sort of life'. He again identified them with the Aristotelians when he compared the liberty of the medieval philosopher to choose Scotus, or Aquinas, or Ockham, as being equivalent to that of a slave transferred from one chamber of his barracks to another. And the same image of
the slave-barracks (*ergastulum*) appeared in 1640 when he condemned Descartes for choosing the *ergastulum* of metaphysics in preference to the bright 'theatre of nature'. There was therefore a private irony for Gassendi in the choice of a craft powered by chained convicts to discomfort the Aristotelian doctrine of motion. It is also possible that he saw an analogy between the subservience to authority, which both he and Galileo saw as the hallmark of the Aristotelians, and the hierarchical dependence of one man on another, regarded as natural by servile and feudal societies.

This suggestion is supported by Gassendi's hostility to those features of Aristotelian metaphysics which relate most closely to the theory that certain relationships naturally involve a response of command/obedience which became assimilated to the hierarchical arrangement of society and the state. They include: form/matter, the unmoved mover and the moved, the soul as the source of motion, the absolute nature of the distinction between up/down, rectilinear/curved, as directions and forms of motion. Aristotle's concept of matter as passive, until activated by forms, so that an object became an essential whole by virtue of form, was evidently contrary to the older atomic theory, revived by Gassendi, that life and motion was innate in the material atoms. It was not inconceivable to Gassendi that matter should think, hence his hostility to Descartes. The confusion which led Aristoteleans to argue that the stone should be left behind by the ship originated in the reasoning that, since the ship and the stone functioned as separate wholes, with a distinct form, motion could only be transferred from one to the other by direct contact. Gassendi specifically repudiated in *De Motu* the theory that motion implied a chain of movers or an unmoved mover, which had been traditionally regarded as an argument for the existence of God. It is interesting to note that this argument was losing its authority as early as 1597 when it was repudiated by the otherwise Thomist
Spanish scholastic Suarez. He suggested, perhaps influenced by the new cosmology, that the motion of the heavens might be inertial and independent of intelligences or first mover; and argued that God's priority as absolute being was a less disputable proof of His existence so that all other beings derived existence from him.\textsuperscript{108} Descartes' arguments for God's existence, based on the existence of the soul and the necessity of a cause for the soul's existence, evidently owed something to Suarez. In both cases the motivation was to disentangle theology from a physical principle that stood in danger of being discredited. Gassendi, typically, repudiated these ontological arguments as being no less metaphysical than those based on motion.\textsuperscript{109}

Aristotle's theory of the soul followed directly from his idea of form, since the soul was the form of the body. It is interesting that the quotation distinguishing between accidental and direct motion in terms of a ship (see p.301) had as its original context the soul's power to move the body, directly, and that which the body carries, indirectly. As God moved the Aristotelian universe, so the unmoved movers did the planets and the soul the body, even in animals.\textsuperscript{110} For Gassendi the example of the self-moving pendulum or inertial motion in a vacuum removed the need for the soul or any internal principle of motion.\textsuperscript{111} The theory of atomism, in which objects were themselves a collection of objects, removed the necessity for forms or souls to endow them with an essential individuality which they no longer possessed. It is possible that in the case of the galley the method of storing the boats 'in winter quarters' and releasing them quickly for campaigns was an influence here. Venice had pioneered the method, which France adopted, of constructing the galleys as far as possible in kit-form so that the bare hulls could easily be stacked away in the arsenals — the very dockyard in which Galileo set his Discorsi a due Nuove Scienze (1638). The warships were then reassembled and provisioned by a process which has been described
as 'an amazing standardisation of production methods', comparable with the modern assembly line. In these circumstances it must have been easier for Bruno, Galileo and Gassendi to view the ship as an assemblage of components, rather than a whole, and to see the oarsmen, cargo and passengers as additional components, rather than as separate forms. The idea of the falling stone participating dynamically in the ship's motion would seem no more strange than the participation of an ear. It is also interesting to note other methods of mass-production initiated during the first half of the seventeenth century: the boring and casting of cannon, cannon balls, grenades and bombs, screw-cutting on lathes, coin production by screw press, iron-production on the blast-furnace. Gassendi's theory of the semina rerum, assemblages of atoms into a definite structure able to programme the germination of mineral, plant or animal life, into their known forms; not qualitatively distinct like those of Aristotle; owed something to the model of industrial production. He continually referred to them as analogous to 'workmen' or 'skilled artisans' and their methods as a form of mass-production—beyond most human craftsmen.

The analytical method behind the origins of modern science involved the construction of isolated systems, real like the pendulum or impacting balls suspended from frames; or imaginary like the stone at rest or in motion in empty, infinite space. For the purpose of the galley experiment Gassendi's stone and mast was an example of the first type; Galileo's ship in uniform and perpetual navigation of an ideal planet submerged by an ever tranquil sea, of the second. Kepler's calculations were based on the assumption that the sun and planets formed an isolated system in which their forces, like the unknowns in an equation, could be assumed to balance. This was the importance of the method; once the components of the system had been analysed, and the laws relating them established, a complete description had been achieved.
Galileo's rule of fall or Mersenne's law of the pendulum were products of this method. Apparent failures in logic, such as the neglect of friction, air resistance, or indivisible quantities, were its side-effects. Lindsay and Feyerabend rightly argue that the elimination of a humanoid observer, or at any rate his anthropocentrism, was another feature. Hence Gassendi criticised the introduction of absolute concepts like 'up' and 'down'; 'heavy' and 'light', into Aristotle's account of motion because their frame of reference is the head, feet and lifting capacity of the human body. Similarly both Galileo and Gassendi dismissed the visual experience of the sun going round the earth, or the sensory experience of objects in general, because these sensations were fundamentally subjective. It was the atoms, below our level of perception, even with the microscope, which were conceived as primary and whose configurations determined our world-experience.

Aristotle saw the cosmos as a whole, and he analysed it on the principle that human experience was the touchstone of its operations. Everything was linked through hierarchies yet qualitatively differentiated; for example, motion could be both circular and straight; but the former, being celestial, was hierarchically superior to the latter, which was the direction of falling bodies reuniting with the corruptible earth. For Gassendi, Galileo, Torricelli or Roberval the composition of motions, in which a body might describe a curve which was a resultant of forces applied in two different directions simultaneously, was a commonplace of mathematical mechanics. This was the method by which Gassendi resolved the horizontal motion of the boat and the vertical motion of the stone into a common parabolic curve. For the same reason there was no hesitation in replacing circular with elliptical orbits. Gassendi realised that Aristotelian logic might not be unrelated to the problems of his disciples in accepting this new and relativistic perspective. The proposition that (a) is (b) simultaneously unites
and disjoins. It implies an identity between (ab) yet also implies a distinction (a)+(b). In the same way Aristotle regarded a slave as an organic part of his master, like an arm or leg, yet at that same time insisted on an absolute distinction between 'slaveness' and 'masterness'.

Gassendi, for this reason, disliked formal logic, which he included in his *Syntagma* with certain criticisms attached, though here the definitive version of the 1650s was more cautious than that he had started in the 1630s. Gassendi regarded such relations as that of master and slave as accidental rather than natural, because they could be severed by the departure of the slave.

It now remains to consider the associations with the new philosophy which shipping had in the mind of Gassendi and many of his erudite audience. The disproportionate space in Galileo's *Two World Systems* devoted to illustrating Copernicanism with nautical examples is scarcely accounted for by its nominal reason: that one of the principal speakers, Sagredo, was a leading Venetian expert on commercial relations. Venice's principal market, the Levant, was also of the greatest importance to Marseilles; and De Valois found himself involved in an increasingly embarrassing wrangle when he tried to mediate between rival groups of merchants with conflicting financial interests (1639-43). Either Galileo was keen that Italian merchants would read his book or the ship had a symbolic value in itself. In both the *De Motu* and the *Syntagma* Gassendi compared the earth to a ship navigating an immense sea of aether; and Kepler, in an extended analogy of some importance to his physics, compared the sun's rays to an aether river and the planets to great space-ships, navigated by 'souls' and steered by a magnetic rudder.

There is a passage in Lucretius in which it is suggested that the sun's light and heat are transmitted to the earth with great velocity through 'waves in the aether'; and Copernicus asked, somewhat enigmatically: 'What is the difference between waves in the air and
waves on the sea?' Lucretius has a long passage on the visual relativity of motion in which the argument is developed far more explicitly than in the little quote from Virgil about the shore receding from Aeneas' ship, cited by Copernicus.\textsuperscript{124}

There was a psychological affinity between the philosopher and the new voyages of discovery. America appeared at the opening of \textit{De Revolutionibus} and the circumnavigation of a sphere was the first form in which inertial motion suggested itself to both Galileo and Gassendi.\textsuperscript{125} Newton used a ship to illustrate the distinction between absolute and relative space at the outset of the \textit{Principia}, a concept which was itself derived from Gassendi.\textsuperscript{126} The expansion of world trade outside the Mediterranean, which would turn the galley from a warship into a prison ship, led Galileo to exclaim: 'If other nations have navigated more we have not theorised less.'\textsuperscript{127} For Gassendi those chemists who believed there were no more than four elements resembled 'those who thought the pillars of Hercules the limits to all discovery'.\textsuperscript{128}

Writing on Galileo's \textit{Sidereus Nuntius} Kepler compared the astronomer not merely to the explorer but the cartographer and looked forward to the day when ships would sail to the moon and use Galileo's observations as maps.\textsuperscript{129} In the 1630s Gassendi made and engraved the first maps of the moon, a project financed by Peiresc, and later continued by Gassendi's correspondent Hevelius.\textsuperscript{130} Science-fiction fantasies inspired the work of Cyrano de Bergerac, who may possibly have been a spectator of the galley experiment. His early play, \textit{Le Pédant Joué}, contained the line, 'Que le diable allait il faire dans cet galère?', subsequently incorporated into Molière's more famous comedy \textit{Les Fourberies de Scapin}. The model for Cyrano's satire was the work of Lucian, the Greek satirist from the twilight of paganism, and a favourite of Gassendi. Gassendi wrote, in the preface to his \textit{Exercitationes}, of 'launching my book into the heavens like the Icaro-Menippus', a reference to the satire in which
Menippus travels to the moon, converses with the gods, and observes the absurdities of the distant earth. The story had been incorporated into Erasmus' *In Praise of Folly*:

> 'In sum Menippus if you could look down from the moon on the innumerable agitations of the earth you would think you saw a swarm of flies or mosquitos, fighting, quarrelling or setting traps, flying, playing, strutting, falling, dying, so that you would be unable to believe what tragedies could be enacted by a miserable creepy crawly destined to die so soon.'

That Gassendi himself adopted this position—as a spectator of human folly in a cosmos in which man had lost his privileged position—is evident from a number of passages in his work; his comparison of a human army with a column of ants for example. It was a perspective reinforced, but not created, by the telescope and microscope, with their images of the plurality of possible worlds between the infinitely great and the infinitely small—an argument which Pascal, incidentally, borrowed from Gassendi. It was part of the repudiation of an anthropomorphic universe which was basic to the critique of Aristotle's physics.

For Cyrano, as for Lucian, science fiction was essentially a means of acquiring a new frame of reference from which to lampoon contemporary society and religion. Intellectually the technique had affinities with the dilemma of Copernicanism which could not study the earth's motion without a fixed frame of reference in absolute space outside it. Kepler's calculation of the earth's orbit as viewed by an astronomer from Mars employed a similar method; and indeed Kepler composed his own science-fiction story—the unpublished *Somnium*. It is likely that Gassendi, sympathetic towards the non-interventionist deities of Epicurus, who were wholly indifferent to human activities, was diverted by Lucian's critique of Olympus. Much of it was applicable to the anthropomorphic aspects of Christianity, such as the satire on petitionary prayer in which Jupiter explained to Menippus how he coped with
contradictory supplications from two, equally worthy, votaries.\textsuperscript{138} There was a local antiquarian interest in Lucian's account of the adventures of a ship which sailed beyond the pillars of Hercules, in quest of Thule, and was sucked up into outer space by a water-spout.\textsuperscript{139} This story was inspired by Lucian's contemporary Pytheas, the Marseilles' astronomer, about whom little is known, who brought back stories of civilisations beyond the seas which all respectable Greek writers rejected.\textsuperscript{140} Gassendi had been involved in an attempt to reconstruct his determination of the longitude of Marseilles, from the use of an enormous gnomon to determine the elevation of the sun, which attracted international interest.\textsuperscript{141} The account of civilisations in outer space, and the war between the sun and moon, would have appealed to Gassendi as illustrating the Epicurean theory of a plurality of worlds.\textsuperscript{142} The idea of an orbiting ship was part of the discussions of the question of escape velocity, carried on in Mersenne's circle at this time, as the notion of gravitation as a finite force field took hold.\textsuperscript{143} Lucian is a good example of how the Greeks provided ammunition for a critique of religion and society, much as Epicurus' physics furnished a lever against Aristotelean scholastics.

The problem of the calculation of longitude, central to contemporary oceanic navigation, attracted the interest of numerous astronomers. Gassendi's arch-enemy, J. B. Morin, against whose anti-Copernican arguments the galley experiment was principally directed, devised a system using the moon.\textsuperscript{144} Peiresc and Galileo realised, independently, the potentiality of Jupiter's satellites as a navigational clock; though it was to require a navigator of Cook's calibre to rely on them with confidence. In the 1630s Gassendi and Peiresc were active in coordinating the observation of eclipses, across the Mediterranean and worldwide, in the interests of a more precise geography. Their efforts were rewarded by rectification of a considerable error on the Cyprus-Aleppo route, a matter of some importance to merchants from Marseilles.
and Venice. Péiresc had close contacts with merchants and missionaries and made good use of both in these experiments; whilst Gassendi supplied a handbook to enable laymen to take observations. But the importance of such activities goes beyond the practical. There was a real affinity between the mentality of the cartographer, or even the navigator, and the methodology of the new science. The debate about the motion of the earth, by virtue of its manifest incapacity for solution by some absolute demonstration, such as Bellarmine demanded, implied that no certain reliance could be placed on such fundamental Aristotelian principles as the nature of motion or the nature of vision. If the human race was indeed located on a moving 'view-point', then its position was not dissimilar to that of a ship's navigator, in unknown seas, struggling with an inadequate mathematical and instrumental back-up to pin-point his true location from the stars. That is why Gassendi, sceptical of the possibility of perceiving the absolute truth about nature, urged the importance of accumulating observations from different periods, or alien cultures, and the possibilities of knowledge which the perfection of instruments of observation, like clocks and telescopes, or the discovery of new ones, might bring. As Kepler put it:

\['Man must make an annual journey on the good ship earth to perform his observations. So surveyors in measuring inaccessible objects move from place to place for the purpose of obtaining from the distance between their positions an accurate base-line for triangulations.\]'

If we compare Newton's distinction between absolute motion, illustrated by a boat moving relative to the surface of the sea, and relative motion, such as behaviour of the passengers or an object falling from the mast, with Aristotle's analysis of the same two kinds of motion into direct and accidental, we are not dealing merely with a translation from one form of words to another. For Aristotle the emphasis is on the mover which establishes a qualitative difference between two kinds of motion. This is why the motion of the stone down the mast would be natural, directed to the centre of the
earth and unconnected dynamically with the ship. For Newton, on the other hand, there was no objective distinction to be drawn between motion of different kinds. The frame of reference chosen to describe it was the critical matter. Galileo made the same point when he contrasted the squiggly line drawn by a pen in relation to the Mediterranean with the decipherable characters of the letter read in the context of the writer's cabin. 147

This rediscovery of the relativity of perspectives was by no means exclusively a scientific question. It was the raison d'être of humanism to restore the lost perspectives of classical culture. Hence the importance for Gassendi of recovering the essential spirit of Epicureanism; rather than Epicurus seen through the eyes of Stoic or Christian moralists. It was never his intention to set up Epicurus in order to supplant Aristotle, as Descartes consciously aspired to do with his new philosophy; but rather to expose the limitations inherent in upholding one philosophical method as a monopoly. It was for this reason that he compared 'the pleasure of the Aristotelians in their slavery to the master', to galley slaves chained to the bench under the eye of their overseer. The relativity of moralities was an important issue in the essais of Montaigne at the end of the sixteenth century and in the work of a fellow member of Gassendi's Tetrad, La Mothe Le Vayer. The dangers of observing the world from the perspective of one idée fixe is the theme of nearly all Molière's comedies and the ease with which illusion may be confused with reality was particularly popular with French dramatists at the time of the galley experiment. 148

De Valois was a prominent patron of literary as well as scientific circles and an habitué of the salons associated with the Hotel Rambouillet, as well as of the Galilean academy of Mersenne. In the plays of George Scudéry, a decayed Provencal noble who held the post of military governor in Marseilles in the 1640s, thanks to De Valois' patronage, there is a
preoccupation with the boundaries of the imagination, the play within a play, which can also be found in Corneille's contemporary *Illusion Comique*. George and his novelist daughter, Madeleine Scudéry, were both, like Antoine Godeau for whom De Valois obtained the bishopric of Grasse, members of the Rambouillet circle. The absurd practical jokes which they were accustomed to play on each other—Godeau arriving with his friends disguised as army quarter-masters, pretending to requisition the chateau; Mlle Scudéry and her companions disguising themselves as rocks on which a guest was invited to picnic; De Valois' gourmand father-in-law being served an enormous meal, after which his buttons were cut off and resewn during his sleep, so that he awoke persuaded that he had swelled up from eating too many mushrooms—appear scarcely worth the elaborate preparation involved. But there is a certain resemblance with Gassendi's attempt to explain what he called the 'hallucination' of geocentrism in terms of a man unfamiliar with boats, who falls asleep on the deck of a ship, not realising it is about to sail; next morning he will wake on the open sea but because his surroundings are unchanged he will not realise he is in motion. Descartes, in enquiring into how far our interpretation of everyday experiences may be trusted, brought up the example of 'those whose brains are so disordered and clouded by dark and bilious vapours that they obstinately insist that they are monarchs, though in dire poverty ... or that their head is made of clay, their body of glass or that they are gourds'. He even goes so far as to imagine that God is an omnipotent demon whose only end is to deceive. These Meditations, completed about the same time as the galley experiment, reflect the depth of the challenge which scepticism, by 1640, posed for the European mind.

Just as Descartes proposed an extreme scepticism, in order to overthrow it with a triumphant re-statement of the traditional certainties of God and the soul, couched in up-dated philosophical language; so
Gassendi's counter-insistence that the extreme cases of insanity, dreams or demons, did not invalidate all the information accessible to our waking senses, was designed to establish limits for scepticism in order to preserve doubt as a weapon against dogmatism. Gassendi looked back to the humanistic critique of Aristotelianism of the late fifteenth and sixteenth century; to the satirical tradition of the 'ship of fools', with its weird cargo of blinkered experts in science, philosophy and theology, whose absurdly restricted viewpoint became evident the moment an alternative frame of reference was introduced, in the shape of Erasmian humanism. For Gassendi, as for Claude Bernard in the nineteenth century, doubt was the great experimental principle. But, along with Bernard, he also realised that the sceptic who really believed in nothing had no criterion to distinguish the trivial from the significant and was doomed to impotence in science. The behaviour of the stone on the galley, or the tennis ball bounced by the rider, was for Gassendi one of those 'signa', or significant pointers, which enable the philosopher to accumulate probabilities so that he can know nature indirectly; as a dog hunts its quarry, or as sun-spots are best studied through a camera-obscura. Whether or not Copernicus was 'right' in absolute terms, he had no doubts that, whereas the geocentrist was shackled to the oar of Aristotle, the heliocentrist was free to steer towards an unlimited horizon.

As well as a love of signs Gassendi also shared the love of symbols of the neo-Platonists — still the natural stepping-stones for thought during this period. Gassendi was of the opinion that 'there is no outstanding truth, in physics or ethics, which has not been transmitted under the wrappings of fable, in Homer especially': He and Peiresc played a significant role in the revival of Homeric scholarship in France; but their primary interest in the manuscripts was not so much the text as the neo-Platonic glosses, attributed to Proclus or Porphyry, elucidating the true philosophy. In this perspective, which has been
revived in the twentieth century in the *Ulysses* of James Joyce, Polyphemus' cavern became Plato's cave, the slaughter of the sun's cattle an allegory of heliocentrism, Circe's witchcraft, the transmigration of souls and so on. *Ulysses*' peregrinations themselves could be interpreted as an allegory of the earth's annual circuit round the sun.¹⁶¹ The Argonauts were subjected to a similar metamorphosis; one of their number, Linceus, gave the name to the academy which Della Porta, Prince Cesi and Galileo established at Rome.¹⁶² In his introduction to the Dutch edition of Copernicus, published provocatively in 1617, the year after the Papacy had ordered that it should be 'corrected', Müller of Groningen argued that the Dutch were 'the true Argonauts', peculiarly fitted to acquire the golden fleece of wisdom, because their ships already travelled the four quarters of the world amassing real gold for their owners.¹⁶³ The paranoid inquisitor, who thought that the emblem of the fishes which appeared under the galleon sailing out of harbour between the bodies of Copernicus and Ptolemy was the sign of a secret society, may have been guilty of error but he did not essentially misjudge the mentality of the age.¹⁶⁴

Gassendi was impressed by the number of Dutch intellectuals who were Copernicans.¹⁶⁵ In 1606 Peiresc had travelled to the low countries and Gassendi's account of his trip on the sands of Scheveling, in Stevinus' newly designed 'wind-chariot', suggests that the idea that visual relations were a function of the motion of the observer's frame of reference had occurred to Peiresc then.¹⁶⁶ In 1655, right at the end of Gassendi's life, the Dutch physicist Huygens visited him in Paris. Huygens came from the sceptical, humanist circles fostered by the Arminian regent class in Holland, and adjusted so comfortably to Parisian life that he remained there nearly thirty years, even for the duration of a French war with the United Provinces.¹⁶⁷ However brief his encounter with Gassendi may have been, the influence of the older man
is evident in the enthusiasm with which Huygens turned to the analysis of Saturn's varying appearances and a thought experiment, involving bodies in collision on a moving ship, which he worked out in 1656, the year after Gassendi's death. The elements were an observer on the bank, a moving ship and an experimenter on board ship observing the collision of perfectly elastic bodies on strings. Huygens concluded three propositions, central to a new mechanics, from this work:

1) in any collision, even between a large object and a small one, the exchange of force was reciprocal;

2) in any collision of multiple bodies they would act as if they formed a single body with a common centre of gravity, following the same straight line;

3) the observer on the bank and the observer in the boat will interpret the exchange of energies between the bodies differently according to the state of their frames of reference.

These notions, not published till later, discredited Descartes' laws of motion and provided a bridge between the physics of Gassendi's *De Motu* and that of Newton.

Gassendi's most important contribution in this context was the idea that objects which we perceive as natural wholes, in terms of commonsense as elucidated by Aristotelian theory, are related dynamically along invisible mechanical lines which divide the world quite differently. This was a rather more sophisticated mechanism than the Cartesian variety; which can perhaps be usefully compared with that of the experiment in which De Bono invites an audience to invent a mechanical explanation for the apparently inexplicable collapse of a solid black cylinder in the course of one of his lectures. Cartesian physics is essentially the crude reductionism of the theatrical spectator who explains to the rest of the audience how "it's all done by mirrors". Gassendi, on the other hand, whilst admitting that our brains may well be too limited, or our historical period defective in the necessary equipment, to uncover the actual mechanisms, asks simply that as a first step the limitations
on our framework for perceiving the world are recognised. The next step, which is to reconstruct our experience from the dynamic interaction of invisible particles, and the combination of those particles into material objects, could not have been made without ancient atomism. The third step, the use of experiment and observation to test out what the rules for the configurations of this invisible world are, represents a massive development of techniques from the late medieval and early modern period from a classical base.

This process, which 'combines schemas and concepts drawn from Greek and Latin antiquity, scholastic traditions and Renaissance humanism with theses and themes which inaugurate the science, gnoseology and even political thought of modern times', may be not unfairly regarded as the intellectual counterpart of Richelieu's new warships. The design of the galley, modified by the addition of a rudder, heavy cannon and the superstructure of a poop designed to accommodate soldiers and officers, retained the essential mode of propulsion of the war-fleets of Byzantium or republican Athens. If it is possible to write of Gassendi's synthesis of the antique with the scientific revolution as a 'privileged transitional moment'; the same applies to the galleass which emerged only in the late sixteenth century and was a floating fossil by the eighteenth century. It is possible to extend this analogy to other areas as well; the education in Roman Law which provided such a powerful weapon to the administrators of French absolutism of the sixteenth and seventeenth centuries; or the way in which mathematicians equipped the principles, supplied by Euclid or Archimedes, with techniques alien to antiquity such as algebra or indivisibles.

P. Anderson has described this process as 'a specific historical precession of the classical over the medieval worlds' which distinguished early modern Europe by its critical dynamism from other contemporary cultures.
knowledge of science in classical antiquity, or in any alien culture from Persia, China, Arabia to medieval Jewry, would advance present learning. The rapidity with which European science accelerated between 1700 and 1900 meant that this theory became rapidly outmoded; though there are signs of its revival today. But as a historical analysis of the development of science it has much to commend it. Each society tends to be bounded by prejudices arising from its existing social structure and is limited by the techniques which its economic development has made available; these limits are reflected in its science. These points were shrewdly made by Gassendi in his restrained but mordant critique of biblical cosmology. They were to be corrected only by cultivating a multiplicity of perspectives; a principle which taken to extremes led to cultural anthropology and eclecticism, but which, at its best, united humanism and Copernicanism in their advocacy of a plurality of frames of preference to modify a hitherto monolithic biblical-Aristotelian world-picture.
THE GALLEY EXPERIMENT

FOOTNOTES

1 0.0. III De Motore Impresso a Motore. Translato letter to Pierre Dupuy written in November and December of 1640 and published 1642. p. 478

Histoire de Provence ed. Privat, 1969, p. 274; naval construction was from 1636–42; by 1642 there were 25 galleys at a naval review in Toulon (as against 13 in 1636).

2 Locke Travels in France ed. J. Lough 1953 p. 76.

3 Aix Mémones MS. 43 f. 75. On one occasion, after a hot skirmish with some rioters, De Valois required assistance in sheathing his sword on account of his size and breathlessness.

4 N. Copernicus De Revolutionibus Orbium Caelestium (1543) I, v and viii: ‘Between objects which move equally in the same direction no motion is perceived.’ G. Bruno: ‘He who finds himself on a moving boat in the middle of a river will not be aware of the movement of the boat unless he knows the direction of the water or can see both banks.’ quoted in P. H. Michel The Cosmology of Giordano Bruno 1973 p. 191; and also: ‘If someone on the ship throws a stone straight upwards towards the top of the mast or towards the crow’s nest, the stone will fall down again along the same path no matter how fast the ship is moving so long as it is not rolling.’ quoted in A. Koyré Galilean Studies 1978 p. 137. Although neither Galileo nor Gassendi quote Bruno, probably on account of his unorthodox associations, it is likely that this passage suggested this mode of attack on Aristotelianism. See pages 223–4.

5 0.0. III p. 478

6 J. Dreyer A History of Astronomy from Thales to Kepler 1906 p. 356

‘Tycho Brahe maintained that this argument about the falling stone was unanswerable. It is very curious that not even he ... thought of making the simple experiment of dropping a pebble from the top of the mast of a swiftly moving vessel.’ Galileo and his followers debated this subject with Italian Jesuits like Grassi and Ingoli; see S. Drake Galileo at Work 1978 pp. 292–4.

7 Aristotle De Anima 406a 5–10.

8 0.0. I p. 600 Gassendi attributes this view to Cleomedes and Hyginus


10 Understanding Space and Time O.U. S554 unit 3.2 and 10.2.

11 Guillemart Galleys and Gunpowder in the sixteenth century 1974 pp. 74, 292

0.0. III 478b. He estimated that the oarsmen could not keep up a speed of more than 200 yards a minute over four miles. Gassendi does not actually tell us whether the distance was rowed or sailed, but from the point of view of the experiments it would obviously be convenient to keep the sails out of the way.

12 Copernicus op cit I viii ed. A. Duncan 1976 p. 45 0.0. III 483–7

‘We have to admit that the motion of rising and falling bodies is a dual motion in comparison with the universe and is no less a compound of straight and circular motion.’

13 0.0. III p. 478.

14 For Richelieu and the navy see H. Méthivier ‘Richelieu et le front de mer de Provence’ Revue Historique (185) 1939. He dismantled the feudal command structure and abolished the posts of Admiral of France, Admiral of the Levantine Seas, and Commander of the Galleys, reserving control of maritime strategy to himself and its execution to his nominees, pp. 123–41.
I have not been able to clarify the details of this episode which is reported by G. Gusdorf 'La Révolution Galiléenne' 1969 I p.123, A. C. Crombie Augustine to Galileo 1969 2 p.223, neither cites a primary source, but the affair is mentioned by N. Poisson in his Commentaire sur le Discours de la Méthode 1670 (introduction). In fact, Richelieu's only practical measure was to authorize the publication of the 1633 decree in Renaudot's official Gazette de France. Although this aroused the fears of pro-Copernicans (such as Peiresc) they were not realized.

A. Debus 'Pierre Gassendi and his Scientific Expedition of 1640' Archives Internationales d'Histoire des Sciences (13) 1963 pp.130-4
S. Drake Galileo at Work pp.292, 404.

0.0. III pp.491-4 suggests that objects can interact by 'magnetic rays' of tenuous invisible particles, like those conveying smell. He gives the example of a mite under a microscope to show, by analogy, that such an unseen world exists. It is a good example of his caution that Kepler is not mentioned in connection with the theory that the earth is a magnet (although Gilbert is). Ellipses are not mentioned until p.515. Similarly in the Syntagma I pp.622-3, 639-40, the physical and kinematic aspects of Kepler are separated.

0.0. III p.519 Rubens was a correspondent and friend of Peiresc; and a sympathy with Epicureanism is evident in many of his non-religious works.

Neither of Gassendi's proposed reasons: (1) the decree refers to the scriptures as understood by the common man, not by mathematicians; or (2) the earth, like the impression of a signet on wax, may be reversed in space without changing the relation of its parts, appears to approach the real sense of the Cardinals. His true feelings: surface briefly in a letter to the Calvinist Hortensius, in which he refers contemptuously to the 'so-called Holy Office'. VI p.64 1633; for Bellarmine's position, Brodick Life and Work of Robert Bellarmine 1928 II pp.333-51.

There has been some debate recently about the scientific value of Galileo's argument from tides in terms of the knowledge available at that date. Contrast A. Koestler Sleepwalkers p.460 '... it contradicted Galileo's own researches ... was a crude relapse into Aristotelianism...in such glaring contradiction to fact...so absurd...its conception can only be explained in psychological terms.' With S. Drake Galileo at Work p.44 'it accounted coherently for the phenomena known to him about tides round the Mediterranean'. For Gassendi's support: 0.0. III pp.646-50. For the 'turbine effect' see J. Clark 'Pierre Gassendi and the Physics of Galileo' Isis 1963 pp.356-60.

The Aristotelians had abandoned this liberty; for various passages where Gassendi appears to assume that science ought to be disengaged from religion see Bloch La Philosophie de Gassendi p.320 and R. Tack Untersuchungen zum Philosophie und Wissenschafts Begriff bei Gassendi 1974 pp.155-60.
THE LAWS OF MOTION

Corpus omne perseverare in statu suo quiescendi vel movendi uniformiter in directum nisi quatenus illud a viribus impressis cogitetur statum sumum mutare.

(1) Existimare motum horizontalem, a quacunque causa fiat, ex sua natura perpetum fore nisi causa aliqua intervenerit, quae mobile abducat, motumque exturbet.

It has been suggested that Gassendi, because he goes on to give an example of inertial circular motion on a frictionless globe, did not really understand inertia. But Gassendi makes it clear that the example of the globe is merely a visual aid.

'Id ut minus absurdum habeas, concipiendum' for those for whom infinite horizontal motion was inconceivable. Gassendi's critics in this matter have evidently not read Newton either, because following the above definition he gives the example of a Trochus in a state of inertial circular motion and the inertial circular motion of the planets. Like Gassendi's example these are offered as visual aids to elucidate the definition.

Gassendi's critics ignore the obvious point that, in the limit, as the frictionless globe becomes infinite, circular becomes indistinguishable from horizontal uniform motion.

(1) and (ii), like the two halves of an indenture, make up Newton's first law of motion.

But, in between, Gassendi has given us, as Newton did not, the line of thought which led to his propositions. The horizontal inertia was an abstraction of the 'vector' imparted to the stone by the boat's motion from the 'vector' of gravitational acceleration. The stationary inertia resulted from an abstraction of all matter from the universe on the hypothesis that matter was the source of all external force.

Mutationem motus proportionalem esse ut vi motrici impressae et fieri secundam lineam rectam qua vis illa imprimitur.

(11) Qualem movens habet, donec mobil est ipsi conjunctum et qualis continuandus esset futurus-que perpetuus nisi a moto aliquo adverso labefactatur ...

Ex hoc enim sit, ut manu vel sursum vel transversum, vel quoquesursum vales, nota, lapis in eandem partem movetur; et quia tamen manus a corpore retente, ipsive innixa sese interim subduxit a lapide, sit ut lapis manus non cohaerens, ac solum contiguis peragt caepTamque cum manu non deferat viam. Quod is perpetuo viam non teneat, si cogatur deflectare, si postremo quiescere, dicta iam est causa non semel ... quod dico de manu de quodlibet allo physico moventi intellegi potest.
(iv) Gassendi explains why Galileo's free fall involves continuo cleritatis incremento (0.0.1 349-50). Imagine:
   a) Stone moving uniformly in imaginary space.
   b) It receives a series of blows.
   c) Quod prior impetu perseverante, neque destructo, alius superaddetur, ex quo adjuncto necessarium esset ferrir velocius lapidem. Heinc nimium est cur facile sit rem motam movere, velocitatenque motui addere. Finge imprimi motu tertium; tum moveretur adhuc velocius; finge quartum; adhuc velocius; atque ita de caeteris.

This formulation of the second law strikes me as good as, or better than, Newton's, because he mentions velocity and increments of velocity, where Newton talks only of 'change of motion'.

Actioni contrariam semper et aequalem esse reactionem; sive corporum duorum actiones in se mutuo semper esse aequales et in partes contrarias dirigii.

(v) Cum constet nihil alterari, nihil interire, nihil exoriri, absque motu reciproco, sive actione et reactione, qua unaquaeque res vim patiatur. 0.0. III 488a

Quantum una Atomus in aliam impacta ipsam impellit, tantum ab ipsa repellitur sicque impetus neque increscit, neque decrescit; sed ob factam compensaciones, idem semper manet, et motus idem perseverat...eapropter res quaque concretae, dum se invicem pellunt ac repellunt, intelligi possint a se invicem pati, ut seu paribus viribus occurrant parem utrinque motum retineant; seu imparibus ea sit compensatio, qua in silum acceptis tantundem motus perseveret. 0.0. I 342(b)

(v) and (vi) lack the vectorial clarity of 3, but are much closer to Newton than the Cartesian concept of collision and highlighted the need for research on collision (see p. 334). The emphasis (v) on reciprocity of motion in collisions—qualifying the 'action and reaction' (which suggests a cause effect relation) is actually closer to modern physics than that of Newton.
Koyré admits (Galileo Studies 1978 p.251) 'The deliberate elimination of the idea of impetus, the possession of a theory of gravity and the definitive geometrisation of space enabled Gassendi to break through the barriers which had held back those two great intellects [Galileo/Kepler].'

Koyré op cit p.244. O. Bloch La Philosophie de Gassendi pp.194-9

B. Rochot 'Beckman, Gassendi et le Principe d’Inertie' Archives Internationales d’Histoire des Sciences 1952 pp.252-9

A Gabbey 'Force and inertia in seventeenth century dynamics' Studies in the History and Philosophy of Science 2/1 1971 p.56

O. III pp.488b, 497b

O. I 343b makes the distinction clear, although it is left obscure in the De Motu because atomism is not discussed. R. Tack, P. Pav and Koyré are therefore wrong to accuse Gassendi of confusion on this point. Pav 'Gassendi...Inertia' Isis 1966 pp.29-30; Koyré in Pierre Gassendi: 'Centre International de Synthèse' 1955 p.109 Tack op cit (22) p.189.

O. III p.488a, I 343b

O. III p.496ab, I 349-50


O. III pp.621-4

O. III p.570 refers to his appeal to Carcavi and mentions also Torricelli’s book De Motu Gravium 1644, a highly technical treatise using the new ‘indivisibles’.


See Mahoney Mathematical Career of Pierre de Fermat 1973

0.0 IV passim. There has been no appraisal of Gassendi as astronomer since P. Humbert Philosophes et Savants 1953 pp.79-107

0.0. I p.204 Pascal, p.635 Roberval and his correspondence with Boulliau (Bullialdus) in VI. All three were convinced Copernicans obliged to camouflage this fact in their published work.

0.0. IV p.81 to Mersenne 1635 he argued that the use of mathematical fictions on both sides made it impossible to decide between Copernicans and Ptolemaics.

0.0. III p.515 De Motu Kepler’s magnetic theory of ellipses used to confute Tycho; as early as February 1630 ... he wrote a long eulogy of Kepler and his Rudolphine tables to the Dutch orientalist Golius (0.0. VI p.29) 'Experiundo comprobare posset illae-ne Tabularum suarum supputationi congruent ... Si congruent; Deum Immortalem, quae exultatio! 'One congruence’ was Gassendi’s observation of the transit of Mercury in November 1631: Mercurius in Sole Visus 0.0. IV pp.499-504 sent to Kepler and Schickard at Tübingen. In 1632 Kepler’s elliptical orbits were being taught by Schickard.

See O. Neugebauer A History of Ancient Mathematical Astronomy 1975

0.0. VI 99a

Pierre Gassendi (1955) C.I.S. B. Rochot p.72 'Il procède par sélectisme: c’est un interprétant autrui qu’il se fait comprendre lui-même; mais c’est là une voie détournée.' See also additional notes on pp.339-340
ADDITIONS TO NOTES 51 AND 52

Human ante oculos foedum vita iaceret
in terris oppressa gravi sub religione
quaer caput a caeli regionibus ostendebat
horribili super aspectu mortalibus instans.
Primum Graius homo mortalis tollere contra
est oculos ausus primusque obistere contra
quam neque fama deum nec fulmina nec minitandi
murmure compressit caelum, sed eo magis acer
irritat animi virtutem, effringere ut arta
naturae primus portarum claustra cupiret.

ergo vivida vis animi pervicit et extra
processit longe flammantia moenia mundi
atque omne immensum peragrit mente animoque
unde referat nobis victor quid possit oriri,
quid nequeat, finita potestas denique cuique
quanam sit ratione atque alta. terminus haerans.
quara religio pedibus subjiciat vicissim
obteritur, nos exaequat victoria caelo

The next twenty lines give the account of Iphigenea's sacrifice by
her father and end with the immortal conclusion:

tantum religio potuit suadere malorum

When human life lay grovelling in all men's sight
Crushed to the earth under the dead weight of superstition
Whose grim features loured menacingly on mortals from the four
quarters of the sky,
A man of Greece was first to raise mortal eyes in defiance
First to stand erect and brave the challenge.
Fables of the gods did not crush him, nor the lightning flash
And growling menace of the sky
Rather they quickened his manhood so that he first of all men
Longed to smash the constraining locks of nature's doors.
The vital vigour of his mind prevailed... He ventured far out beyond
the flaming ramparts of the world and voyaged in mind through infinity.
Returning victorious he proclaimed to us what can be and what cannot.
How a limit is fixed to the power of everything and an immovable frontier
post.
Therefore superstition, in its turn lies crushed beneath his feet,
And we by his triumph are lifted level with the skies.

(Penguin Classics translation)

It is evident that by quoting the passage underlined to Galileo at such
time Gassendi, on the very 'weakest' interpretation of his scepticism,
was celebrating the fact that the author of Two World Systems had
refused to be intimidated by those theologians who subordinated
science's rights to make laws for the universe to theological authority. But it is hard to see, granted the extraordinary venom of Lucretius' language and the notoriety of the passage recounting the sacrifice of Iphigenea, quite how Gassendi's use of the passage on this historic occasion can be squared with the view of those historians who regard his attempt to Christianise Epicurus as a serious intellectual exercise. It seems more natural to take a 'strong' interpretation and equate 'limit fixed to the power of everything' with the elimination of miracle by science, as in the case of Joshua; the 'flaming ramparts of the world' with the primum mobile and traditional location of heaven; 'infinity' with the Copernican expansion of the universe into a possible plurality of universes; and the 'lifting level with the skies' as the adoption of a literal interpretation of Copernicus. The 'fables of the gods' and 'lightning flash' which did not intimidate would refer to the decree of 1616 and the scholastic theologians. 'Superstition' was commonly used in the circles of Gassendi and Peiresc to refer to 'monkish' attitudes of mind or belief in relics, miracles etc. An objection to this interpretation is that it turns Galileo into a tacit accomplice, and his orthodox Catholicism has been unquestioned in the twentieth century. Dr Carrugo has proposed to me, as a solution to this difficulty, that Galileo's Latin was not good enough for him to grasp Gassendi's meaning. Sancta Simplicitas?
A. Debus 'Pierre Gassendi...expedition of 1640' Archives Internationales d'Histoire des Sciences 1963 13 p.140
C. B. Brush Selected Works of Pierre Gassendi 1972
P. Feyerabend Against Method 1975 p.92.


This situation has been analysed in mathematics e.g. I. Lakatos Proofs and Refutations 1976 pp.136-42 or Philosophie et Calcul de l'Infini 1976 ed. P. Raymond p.86.
D. T. Whiteside 'Patterns of Mathematical Thought in the Later Seventeenth Century' Archives for the History of Exact Sciences 1960 p.184

0.0. III p.571 '... in scientiis, ac demonstrationibus attinentibus ad Mathesin puran, mera evidentia, non solo suspicio, aut verisimilitudo, admitterenda est: in scientiis tamen Physicus, ac mista Mathesi, quacumque quae Physica, hoc est caligo humane mentis in rebus naturalis investigandis, ingerit; foelices simus, si non evidentiam sed verisimilitudinem assequamur.'

Rizza Peiresc e Italia 1967 pp.188-207.

0.0. III 499b-500a.
0.0. III 471-81

T. Gregory Scetticismo ed Empirismo 1961 pp.70-77 0.0. III 412-3, I 122-3
Gassendi believed that 'descriptive or experimental' knowledge, in which nature was reconstructed from the smallest known element, was the only possible science. Any system which started from an over-view of the cosmos, or its principles, was suspect.

The Epicurean conception of nature, which saw it as the theatre of law and removed it from miracle, from the arbitrary interference of deity, helped the seventeenth century to clear the path for the new birth of science.'

Such as Lucretius I 62-80 or VI 1-100.

Galileo's debt to Lucretius is evident in his distinction of primary from secondary qualities and his concept of parti non quanti and vacua. It has only recently been pointed out: S. Drake Galileo at Work p.285.

E. Burtt Metaphysical Foundations of Modern Science 1925.

A. Koyré Galileo Studies 1978 (French version 1939)
A. Koestler Sleepwalkers 1959 H. Butterfield Origins of Modern Science
Koyré is particularly nasty about Gassendi's empiricism: 1959 'épistemologie qui n'a fait que vicier et stériliser sa pensée' Pierre Gassendi C.I.S. (1955) p.67 and describing him as 'not a very good physicist, a bad mathematician and a second-rate philosopher'. Newtonian Studies 1965 p.176.

The Essential Tension 1977.

Published in 1845 and 1870 respectively.

* See also pp.342 and 343 for additional notes
Writers such as P. Rattansi—see his essay in Reason, Experiment and Mysticism in the Scientific Revolution ed. W. Shea 1975—or F. Yates The Rosicrucian Enlightenment 1975 celebrate the contribution to science of what Gassendi and many of his circle would have regarded as obvious blind alleys.


C. Webster The Great Instauration 1975 suggests that the hankering for a political Utopia formed a key-link between puritanism and the desire for scientific innovation. The translation of Gassendi's Vita Peireskii (1641) by W. Rand in 1657 (op cit. p.305-6) and the spread of Epicureanism in England after 1642 can be seen as part of this process. Extreme puritanism was hostile to independent thought; as is evident from the example of Lucy Hutchinson who ripped the pages dealing with her discussion of Epicurean ideas and translation of Lucretius out of her diary; later published as the Life of Col. Hutchinson. But she kept the ms. of her translation secretly intact. Mayo Epicurus in England p.121 Memoirs of Col. Hutchinson Everyman p.15 'Here the story of herself abruptly ends....... many leaves being torn out.'


Bibliothèque Nationale MS. F.Fr. 9531 f.150 Peiresc to Diodati and also O. O. V Vita Peireskii 321ab MS. F.Fr. 12772 f.146 Peiresc to Gassendi.

O. O. VI p.362b 'To my mind the whole Cosmos is engaged in a ritual cycle of purification, nothing fixed; not even, as I am able to perceive, the earth; a continual motion of things, like the image of an inconstant goddess, there is war everywhere, peace nowhere, rulers in want, the poor raised up, I see all things subverted.' Feb. 1646 to Gassendi.

Bibliothèque Méjanes MS. 1685 f.233-238 'Histoire du Gouvernement du Comte d'Alet'.


A lot of erudite energy has been expended trying to show that the old tradition that Molière was Gassendi's pupil was incompatible with Molière's laundry lists. But, as R. Jasinski Molière 1969 p.4 points out, the influence is incontestable and the milieu through which it was transmitted—Luillier and his illegitimate son Chapelle—known. It is likely that Molière (aged 19) met Gassendi in Paris in 1641 and possible that he met Louis de Valois when he accompanied the court to Tarascon in 1642 (June). Only the timing is in doubt.

H. Poincaré La Science et l'Hypothèse 1968 pp.113-7

J. Lindsay Blast Power and Ballistics 1974 p.89

Descartes Discours de la Méthode ed. Flammarion III p.57


J. Brun L'Epicurisme 1966 pp.9-10, C. Bailey De Rerum Natura 1947 I pp.3-4

J. P. Faye Épicure: Doctrines et Maximes 1965 p.22
In 1646 Gassendi had written enthusiastically of Hobbes De Cive: 'I know of no-one among philosophers more free from prejudice, who has seen more closely into the interior of things'—praise indeed from Gassendi, who generally held that 'the interior of things' was the one part philosophers could never reach.

Marseilles expanded rapidly in the second half of the sixteenth century but from 1610 to 1660 both government reports and merchants complain of decline. The term 'bourgeois' in 17th-century Marseilles meant 'citizen-merchant'. Pillorget Mouvemens Insurrectionels pp. 220-2.


J. Salmon Society in Crisis: France in the Sixteenth Century 1975 pp.19-20


The uniformly high moral tone adopted by English historians towards the opponents of Mazarin is so general it would be invidious to give a single example. French writers, often favourable to absolutism, do not always avoid it. But contrast the neutral account of the Fronde in H. Méthivier's Siècle de Louis XIII 1967 with that in any English textbook. Perhaps Dickens' Marquis de Saint Evremond is to blame for this national consensus that the nobility was the most selfish section of French society.


90 These themes are treated at length in Aristotle, Politics, Book I.

91 O. O. III p.488a 'It should not seem absurd that there should be continual violence in nature, since that very violence may be termed natural; it was instituted by the author of nature to serve the generation of natural things. For nothing exchanges places, declines or rises without reciprocal motion, or action and reaction in which one or other experiences force.' p.490b cites the example of recoil in a cannon.

92 Il est entré dans la pensée du peuple que tout leur ministère (the intendants) estolent violent' quoted in R. Bonney France under Richelieu and Mazarin p.214. See GASSENDI AND ABSOLUTE MONARCHY p.175

93 See GASSENDI AND ABSOLUTE MONARCHY p.175

94 Gasquet Guillemins et Gunpowder 1974 pp.64-72

95 Bibliothèque Nationale MS 4236 'Mémoires et un Voyage' f.59. He noted with relief that the nobility had to row with the ranks for only a short period; after which they were allowed lighter duties. See GASSENDI AND CHURCH for analogies between hell and prisons.


97 M. Foisil La Révolte des Nu Pieds 1970 pp.300-11. The judicial inquiry and sentencing lasted from November 1639 to May 1640 and was presided over by Lord Chancellor Séguier; to whom Gassendi dedicated his Diogenis Laertii Liber X in 1649. The courts were often advised of the pressing need for oarsmen. See art. gal; res in M. Marion Dictionnaire des Institutions de la Fiance au XVII et XVIII siècles 1923

98 A. d'Arnaud 'Mlle. de Scudéry et Marseille' Revue du Musée du Vieux Marseille 1959 p.15. For the Scudéry family see p.331.

99 I do not know of any recent scholarly study dealing with St. Vincent's work. There is a CTS pamphlet (B164) by Fr. Martindale S.J., nor is there much on Bishop Gault, although the impression he made at the time is evident from the intendant's letter to Ségui er on his death; A. Lublinskaya Lettres et Mémoires adressées au Chancelier Pierre Séguier (1633-49) 1966 de Vautorte No. 22 1643

100 The point was first made by R. Pintari 'Modernisme, Humanisme, Libertinage' Revue d'Histoire Littéraire de France 48/1 1948 p.35 and taken up by O. Bloch Philosophie de Gassendi p.293

101 O. O. III p.114b

102 O. O. III p.112a

103 O. O. III p.382a Disquisitio Metaphysica published 1643 to Sorbsère.
The title of the chapter from which quotes 123/124 comes is: 'That the Aristotelians have groundlessly surrendered the liberty to philosophise' and has sub-sections such as 'They are unable to shake off the tyrannous yoke of Aristotle.' O.O. III index.

F. Solmsen Aristotle's System of the Physical World 1960 passim.

0.0. (III) 368-9: this is one of the many points of connexion between Gassendi and Locke. Compare An Essay Concerning Human Understanding 1690 IV iii 6.

0.0. (III) p.487b.


0.0. (III) pp.315-57.

Aristotle On the Heavens (II) xii.

0.0.(II) pp.495-6 There were no pendulum clocks, but it was used to time experiments.

Guilmartin Galleys and Gunpowder 1974 p.146; not that it was on the same scale, but it used the same principle.

Fontana Economic History of Europe (2) ed. C. Cipolla pp.212-3, 191-2 and 395-7. Earlier historians have greatly underrated the development of this production in the 17th century.

0.0.(II)p.263b. Brett The Philosophy of Gassendi 1908 pp.129-30 realised the importance of the idea, as does A.G. Morton History of Botanical Science 1981 p.224, who described it as 'exactly fitted to provide a basis for the new chemistry and physiology'.

Feyerabend Against Method pp.86-7 Lindsay Blast-Power p.405.

0.0. (III)p.507b spatial directions p.509 heavy and light.

As a companion to De Motu Gassendi wrote a treatise on the limitations of our finite visual horizon De Apparente Magnitudine published in the same volume in 1642.


0.0. (III)p.175-7 He also pointed out the ambiguity of 'is' as a logical 'signum' and a term asserting existence - e.g. in propositions about God.

Aristotle resolved this problem by the theory that every natural whole contains a ruling and a ruled part Politics 1252b-54b. This was in turn related to the theory that the motions of the heavenly bodies are different in principle to those on earth. Physics 261a: Earthly objects are identified with slaves; heavenly with masters.

0.0. (I) 98a 99b Significantly he identifies the master/slave relation with those of spatial direction, which Aristotle treats as absolutes, Gassendi as relative.

R. Pillorget Les Mouvements Insurrectionels de Provence 1975 pp.541-64 The problem was the liquidation of the debts of the French merchants in Alexandria and Aleppo.


Lucretius Rerum Natura II 151-2 'aerias quasi dum diverberatundas' On the Revolutions ed. Duncan p.45 Rerum Natura IV 380-450 On the Revolutions p.44.

Newton Philosophia Naturalis Principia Mathematica 3rd ed. 1726 p.7. R. Westfall Never at Rest 1980 'It was in De Gravitatione (1668?) that he first pronounced his doctrines of absolute space and time. Definition 8 went on to assert that "inertia is a force within a body lest its state be changed by an external force"... a passionate rejection of Descartes ... De Gravitatione drew its four opening definitions from Gassendi and its doctrines of absolute space and time,... Likewise it advanced a particulate concept of matter.' pp.302-3

Galileo Two Chief World Systems ed. Drake p.7. He was thinking of the Dutch, whose dominance not only in Mediterranean but in world trade after 1600, was one reason for the decline of Marseilles. (see note 96): Braudel The Mediterranean in the Age of Philip II (Fontana) pp.631-40

0.0. II p.557.

E. Rosen ed. Kepler's Conversation with Galileo's Sidereal Messenger 1965 p.43. Gassendi wrote of this to Galileo in 1636: There are three examples in the Cabinet des Etampes in the Bibliothéque Nationale 54A589-91; see 0.0. VI p.92 to Galileo (VI) pp.204-5 to Hevelius.

P. Yarrow A Literary History of France 1967 pp.146-50. The Péendant Joué was written in 1645 and mocked an Aristotelian College lecturer. Cyrano knew Gassendi through the Luillier-Chapelle connexion and it is not impossible that he assisted at the experiment in 1640. He was wounded at the siege of Arras, which was over by October 1640, and discharged himself from the army. Nothing is then known of his movements till 1643 when he turned up in Gassendi's company in Paris. De Valois also fought at Arras, and it is possible that Cyrano came to Provence in his company. See Spink Free Thought from Gassendi to Voltaire 1960 p.51.

0.0. III p.94 and he confesses a further affinity with Lucian: 'difficile est satyram non scibere.' p.103.

Quoted in M. Foucault Histoire de la Folie dans l'Age de Raison 1961 p.42.

0.0. II pp.8-9 This is a satire of war—not a mere analogy.


A. Koyré Astronomical Revolution pp.180-4 There are now various edited translations of the Somnium.

Lucian Loeb ed. II p.341.


E.g. geographers like Strabo and Polybius. The term 'Lucianisme', meaning a traveller's talk with a satirical bite to it, was current in Gassendi's circle; e.g. the priest astronomer Boulliau travelling in the Levant wrote to Luillier: 'Nous ferons de bons Lucianismes sur les facons de faire de ceux que nous auront laisse [in France] et de ceux parmi lesquels nous serons.' Pintard Libertinage Erudit p.373.

0.0. IV pp.523-36.

Lucian pp.260-75 and used by Cyrano de Bergerac in Histoire Comique de la Lune et du Soleil.
Correspondence de Mersenne ed. Tannery and Waard. V. p.489. It is easy to laugh at Mersenne's belief that because he could not retrieve all the cannon balls he had fired perpendicularly into the air some of them must have gone into orbit. The theory, if not the practice, influenced Newton's 'cannon ball' diagram.

See GASSENDI AND ABSOLUTE MONARCHY


145 See GASSENDI AND ABSOLUTE MONARCHY

146 O. O. VI p.75 Morin later accused Gassendi of atheism.


149 M. Foucault Histoire de la Folie à l'Age Classique 1961 pp.43-53.


151 0.0. I p.620, III p.505; a comparison might also be made with the 'illusionism' in contemporary art; for example, the ceilings created by Vouet for Chancellor Séguier (see n.97) in 1639-40, where the observer confounds painting with architecture. Blunt Art and Architecture in France 1953 p.145.


'Some was indeed a crisis in French intellectual life.' Spink French Free-Thought from Gassendi to Voltaire p.5. On the other hand for J. Popkin Scepticism from Erasmus to Descartes 1960 all sceptics are really fideists or liberal Protestants at heart.

Gassendi's position is similar to that defended by Bertrand Russell under the title 'logical atomism' in Logic and Knowledge 1956; our knowledge comes in small parcels and although some on unwrapping contain errors it does not follow that all do. Sebastian Brant Narrenschiff 1494 (ed. with translation E. Zeydal 1944) held up mirror to the cupidity and ignorance of the whole of society. Ships transporting unwanted lunatics from town to town actually existed.


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A good example of sophisticated mythological reference is the poem which Maffeo Barberini, himself a Lincean, wrote to Galileo in which he urges Galileo to be as alert as Linceus, because even the hundred-eyed Argus was gulled and murdered. This was published in the Poemata of Urban VIII in 1631 on the Vatican press.

De Revolutionibus Orbium Caelestium Amsterdam 1617 p.5.

Drake Galileo at Work p.337

Lettres de Peiresc ed. Tamizay de Larroque (IV) p.202 'tous ces gens la sont pour le mouvement de la terre.' to Peiresc July 1629

0.0. V 265b 'qui antecebant cursores visos quasi retrorsum nitit, quae distantissima apparebat, momento pene praetervehi etc.' Stevinus was military engineer to the Protestant leader Prince Maurice. His last words were: 'I believe...that 2+2 = 4.'

For Huygens' father, poet and diplomat, see P. Geyl Netherlands Divided; the Dutch regent class had much in common economically and intellectually with the parlement class in France. Just as the parlements had an uneasy relation with ultra-montane Catholics, so the regents faced hostility from orthodox Calvinism. There were numerous contacts between intellectual life in France and the Netherlands. See R. Lebègue Les Correspondants de Peiresc au Pays Bas 1941

A. Bell Huygens 1950 p.30 See ASTRONOMY

Huygens moved in Gassendist circles e.g. Boulliau, Montmor, p.2.


'Gassendi and the Transition from the Middle Ages to the Classical Era' O. Bloch, Yale French Studies n.49 1963 p.55.

Op cit p.55

F. Anderson Lineages of the Absolutist State 1980 p.426

Feyerabend's plea that western science should learn from Chinese culture in Against Method pp.50-1 or F. Capra Tao of Physics etc.

0.0. I p.145 'The universe was modelled on a house or city, where the upper part is God's citadel, and the lower, man's abode.' Moses allowed the people to confound the earth, 'an insignificant fragment' with the universe as a whole because the Jews were a people 'praesertim rudi'. This reproach recalls Julian the Apostate's attack on the Biblical Jews for their parochialism and ignorance of science. Loeb III pp. 367-387. See GASSENDI AND THE CHURCH

Medieval science cannot be regarded as monolithic in the sense that there was any consensus on methods, notations, experimental procedures or solutions to individual problems. See Science in the Middle Ages 1978 ed. D. Lindberg. It was the framework of Aristotelian principles and biblico-theological constraints delimiting not merely potential solutions but the nature of knowledge which was monolithic.
'We have insensibly been drawn in to make use of language expressing the connecting principles ... as if they were the real chains which nature makes use of to bind together her several operations.'

Adam Smith 'History of Astronomy' 1780

Sagredo: So as you see, all planets and satellites — let us call them all planets — are moving in ellipses.

Salviati: I'm afraid some planets move in parabolas. Look at this stone. I throw it away; it moves along a parabola.

Simplicio: But this stone is not a planet! These are two quite separate phenomena!

Salviati: Of course this stone is a planet, only thrown with a less mighty hand than that one which launched the moon.

Simplicio: Nonsense! How can you dare to pool under one hand heavenly and earthly phenomena? One has nothing to do with the other. Of course both may be explained by proofs, but I surely expect the two explanations to be totally different. I cannot imagine a proof which should explain the course of a planet in heaven and a projectile on the earth by one single idea!

Salviati: You cannot imagine it but I can devise it ...

quoted in I. Lakatos Proofs and Refutations 1977

Doncques il est certain
Que la semence part comme un nouvel essain
Au retours du printemps, qui se jette et se cruche
Dans un arbre feuilleu au sortir de la ruche.

De cette pierre done se derobe et s'enfuit
Un mouvement un folt une chaleur qui suit
Ce metal qu'elle anime, ayant de violence
Ecarte l'air voisin, qui lui faisait nuisance.
Dans ce vide aussi tot les premiers elements
De ce fer a l'aimant par doux accrochemens
Embrassez et collez comme par amourettes,
Se joignent serrement de liaisons secrettes:
Qui fait aue Pair enclos dedans ces corps pressez,
Piquez a menus trous, echauffez et percez
D'un mouvoir importun, acolle, frappe, et pousse
La semonce du fer d'une vive secousse
Se recontrant ainsi se collant serrement
L'un a l'autre aussi tost d'un dous embrassement.
Tout ainsi que la vierge eperdument espointe
Des fleches de l'amour de forte et ferme estraine
Serre son favourit et de bras et de main
Luy pressant l'estomac contre son large sein.

R. Belleau, The Magnet 1560
after Lucretius book VI 980-1050
Aristotle's idea of weight was intimately linked to the idea that up and down were absolute directions. This ontology was an obstacle to the emergence of any consistently new physics from the medieval 'science of weights', which remained a discordant blend of Aristotelian and more mechanical notions. The persistence of Aristotelianism, even in Gassendi's own period, should be viewed in the context of the social and moral associations with which the idea of absolute direction had become encrusted. Copernican astronomy challenged the notion by endowing each planet with its own gravitational centre and observational co-ordinates. Nevertheless, throughout the sixteenth and first half of the seventeenth century, poets and theologians insisted on equating the soul and its natural tendency towards heaven with the Aristotelian element of fire; and the corrupter—physical appetites—with earth. Right from Greek times this physics had been politicised: and a French Capuchin preacher of the mid-seventeenth century who equated the nobility with the air and the people with the element of earth, was not being unfaithful to Aristotle's message. The function of Aristotelian teleology in Cardinal Bellarmine's devotional writing tells us more about his distrust of physical Copernicanism than twentieth-century debate about his philosophy of science. It was not simply that heaven and hell, as physical locations, were more difficult to match with a Copernican cosmology. Supernatural and natural law were modelled in the Middle Ages on analogy with such universal physical truths as the upward motion of fire or the corruptibility of earth. The amorality of the new philosophy seemed reinforced by the fact that it was rebels like Bruno who accepted the physical and moral implications of relativity of direction, and the divorce of heavy and light from a geocentric matrix, with the greatest alacrity.

It explains why alternative moralities (neo-Stoicism, Gassendi's
Epicureanism, Descartes' psychology, Kepler's harmonics) were so often proferred by those engaged in reconstructing physics to take account of relativity in direction and weight; it explains why, with one or two exceptions like Hobbes and Spinoza, the utmost cosmetic skill was applied in reinforcing the similarities between these new moralities and traditional Christianity. Natural law, for example, outlived scholasticism; though with its context and significance variously modified. Apart from the example of miracles, the attack on the Aristotelian idea of gravity was the most important area in which science and scepticism could interlock to threaten the established views across the board in morality, politics and physics. It was perhaps for this reason, rather than because he had no real interest in the subject, that the reticences and lacunae in Book One of Copernicus' De Revolutionibus, on the critique of Aristotle's theory of gravitation, are so conspicuously at variance with the technical thoroughness of the remaining books. In Gassendi's work the reverse is rather the case; his theory of matter is developed at length and with a certain audacity, whilst the technical details of his astronomy are left in an obscurity which enables him to add a sentence shifting his endorsement from Copernicus to Tycho Brahe without needing to rewrite elsewhere. In this section I shall propose the view that this obscurity was intentional and that Gassendi's theory of gravitation meshed much more neatly with Kepler's adaptation of Copernicanism than the author deemed prudent to express in his writings; anticipating the Newtonian synthesis more closely than has been supposed.

Gassendi's theory of matter, an adaptation of Epicurus to accommodate Kepler and Galileo, firmly turned its back on the intervening fifteen centuries of Christian— and Aristotelean— scholasticism. Gassendi rejected the teleological basis of weight for the same reason as Bruno, that directionality was meaningless in an infinite universe. This line of argument led him to prune the residual teleology in Epicurus and
Lucretius, with their vision of parallel lines of atoms falling like raindrops from 'up' to 'down' across an infinite universe. Disposing of this theory, he abandoned the 'swerve', or uncaused change of direction which enabled the atoms to collide. Epicurus had introduced this into Democritan atomism to avoid the necessity for human determinism. The ease with which Gassendi abandoned it points to a sympathy with determinism evident elsewhere; in his cynicism about greed for gold, fame or the perennial nature of superstition. Having rejected directionality and contingency as causes of motion, he was thrown back on the idea that it was innate in matter. Even towards the end of the seventeenth century, otherwise liberal latitudinarian divines professed to find this the most shocking and subversive of physical doctrines and Newton himself, who held a view similar to Gassendi's, explicitly purged matter of innate activity. One historian has seen in this insistence on the 'deadness' of matter a pre-condition for the emergence of the human right to aggressive exploitation and manipulation of the universe. Certainly, whether as a consequence of his theory of matter or not, Gassendi always argued for the limitations of the human brain, face to face with the hidden mechanism of nature and, in striking contrast to the entrepreneurially-minded Peiresc, showed little enthusiasm for Baconian schemes of improvement.

Gassendi asserted that God, or the author of the universe, had both created the atoms and endowed them with their tendency to motion. Similarly, when discussing the planets, he found it convenient to assert that their orbital motion was perpetual, because imparted to them by God. This was an old nominalist idea and could be found, for example, in Buridan's critique of Aristotle's concept of movers. In another passage Gassendi attributed to Plato the idea that the planets originally had rectilinear motion till God transformed it into circular motion and they adopted their present orbits. It is hard to reconcile these assertions with his firm rejection of the need for an Aristotelian prime mover, on
the ground that only a God limited in space and time would need to act as the specific cause of motion.21 From the physical standpoint, granted the infinite space and the atoms in motion, the existence of the gravitational forces which are a property of the res concretae would suffice to explain the evolution of our present universe without any divine intervention. This fact was recognised, in a roundabout way, by Gassendi when he argued that if the divine power reduced our present world to a chaos, but retained atoms, the world would eventually be re-assembled.22 God was not needed for the operation of Gassendi's physics and, where he is introduced, to paraphrase Gassendi, he distorts the rectilinear development of the argument and makes it circular. In one sense the caution of the elder Gassendi arose from the boldness of his youth; having committed himself to a theory as radical as active matter, he felt bound to defuse it by hedging in with all sorts of qualifications the logical development of his theory of gravity. Newton, on the other hand, having initially rejected the corner-stone of materialism, was free to develop an audacious theory of gravitation.23

There was the additional limitation for Gassendi, that after 1634 Catholic tolerance of Copernicanism declined. Since a Copernican universe was a pre-condition for the theory of relative weight, and any comprehensive theory of gravitation would involve treating Copernicanism as physical rather than astronomical, the constraints on the development of proto-Newtonianism in France were tremendous. Gassendi's colleagues adopted a variety of expedients to defend Copernicanism in print. Roberval published a book in 1644 which purported to be a new translation of a lost work by Aristarchos of Samos, arguing that the heavens contained a fluid propagating attractive forces and proposing gravitation based on the reciprocal attraction of matter. His theory was discussed in Gassendi's Syntagma. Boulliau resorted to the same expedient in expounding the system of the Pythagorean Philolaus in his book, published in 1645,
which adopted Kepler’s ellipses. Despite these precautions he was advised, during his visit to Italy, to avoid the territories under the political control of the Papacy and the jurisdiction of the Roman Inquisition. Gassendi was not alone in hiding audacious modern ideas under a barrage of covering fire from ancient writers. Indeed he was at the same time bolder and more honest than either Roberval or Boulliau; the name of Epicurus was calculated to arouse suspicion, rather than allay it, and the antiquarian scholarship behind his enterprise was genuine; whereas the Aristarchus and Philolaus were mere flags of convenience for illicit cargo. Boulliau, though a priest, justified his position on the grounds of the distinction of faith and science:

'De quoi se mêle le souverain pontife, d'étendre le pouvoir des clefs à des choses qui ne sont pas de la foi?'

and, in legal terms, on the grounds of the 'Gallican liberties':

'peut être que la chose regarde particulièrement d'Italie et non toute la Chrétienté.'

The argument that papal decrees were powerless to change matters of fact was the burden of Pascal’s attack on the Jesuits in the 1650s:

'Ce ne sera pas cela [the decree of 1633] qui prouvera qu'elle demeure en repos.'

But, despite such filibustering, the Lettres Provinciales were themselves condemned by the Inquisition in 1657, and there can be no doubt that the checks operating on intellectual liberty were real.

Descartes had written, 'If it [Copernicanism] is false then so are the whole foundations of my philosophy.' But he went on to publish his philosophy, using such blatantly double-standards that he was christened 'le philosophe en masque'. But this description fits Gassendi equally well. Although the foundations of his philosophy remained unchanged, the public exposition of an edifice built on those foundations became hazardous. The manuscript of Gassendi's philosophy was broken off
abruptly at the time of the death of Peiresc, an ardent Copernican, in 1637, and that when it was resumed, in the 1640s, it was as if to construct a tomb round an aborted foetus. If the language sounds bitter it recalls the terms in which Gassendi communicated his decision to lay aside his seven-years work to Galileo in November 1636:

Decrevi nihil emitters ex nugamentis illis meis circa Epicuri philosophiam ... Utinam sis ipse superstes, fi is tandem foetus visurus sit lumem.

These lines should be read in the light of Peiresc's advice to write to Galileo with circumspection. Gassendi's decision was probably arrived at in conversation with like-minded friends. In December Naudé wrote to Peiresc: 'It [the MS] should appeal to all gens de bien; lovers of speculations on reality rather than chimeras ... but the fine truths it discovers will not be to everyone's taste, especially the numerous feeble crawlers around at present, and I think there would be problems finding a printer.' Naudé was evidently thinking of religious problems in general, rather than just Copernicanism, as he went on to compare the Epicurus with Bodin's Heptapleromes, an assault on dogmatic religion which continued to circulate among friends but had never found a printer—not even in Holland. Koyré has blamed sensualist psychology and obsession with ancient materialism for the 'sterility' of Gassendi's science. But whilst the contrast between foundations and construction is undeniable, the division between his loyalties to the Church and the logic of scientific discovery, as he saw it, provides a more likely explanation of why he left a scaffolding, rather than a building.

If we consider a list of the elements which Gassendi had assembled by 1644 to advance a plausible explanation of gravity, they appear sufficiently impressive. He had a corpuscular theory of matter and an explanation of how atoms compose structures which then act as wholes; a problem which Copernicus had treated rather vaguely as 'universa
appetatan terminari in sphaeram'; and Galileo, with scarcely more precision, as a 'concorde conspirazione'.

Gassendi rationalised the animistic tendency in this language by denying any analogy between natural and artificial products. Whereas a building was assembled from inert materials, and therefore required an external architect and builder, one of the analogies he chose for nature was that of an army and a general; each unit was granted a degree of autonomy, able to form ranks by virtue of its training, the general merely providing overall direction. Although he ignored Kepler's harmonic and geometrical theories in expounding his astronomy, he was strongly influenced by the idea of lines of force, naturally self-organised into geometrical form, as evidenced by the formation of jewels, vegetables and chemical salts, into self-propagating regular structures. This was the point which Kepler made in his treatise on the snowflake. It was also to be found in the writings of Peiresc, who had been the first to introduce Parisians to the microscope and the structure of snowflakes in the early 1620s. Peiresc has sometimes been described as a pure Baconian, without theories, accumulating observations at random. But running through his notes on natural history, the generation of stones, the formation of mountain chains, fossils, or petrifying caves, is the theme of a germe which propagates itself in regular spherical or crystalline forms. Nor is it surprising that he preferred to keep the idea to a few friends; publishing nothing despite his indefatigable accumulation of materials and encouragement of others to publish. Not only was the whole tendency of the idea evolutionary, rather than creationist, but the source was almost certainly Paduan naturalism; encountered either directly on his Italian travels, in the circles of Della Porta, Galileo and Sarpi, or indirectly through the pantheistic writings of Vanini, executed at Toulouse in 1619. It played a part in the writings of certain early chemists, such as De Clave, whose work
was condemned by the Sorbonne and who was known to both Peiresc and Gassendi.  

It is at least possible that a related idea, unstated, lay behind the otherwise incomprehensibly vague murmurings of Copernicus and Galileo, accounting for the shape of the sun and planets in terms of some 'spherical tendency' in matter. Historians tend to note Galileo's condemnation of Kepler's 'occultism'; for example in the theory of the moon's gravitational effect on tides, whilst ignoring his enthusiasm for Gilbert's work on magnetism.  

Gilbert, too, was an alumni of Padua, described by Pope Paul V in 1606 as 'a seminary of heresy for more than two centuries!'. Gilbert's theory that the forces holding the planets together and those regulating their movements were the effect of magnetic 'souls' was certainly derived from the Paduan school of paganising Aristoteleanism, which devalued man's unique place in the universe by stressing his mortality and contrasting the vagaries of his reason with the superior and immortal intelligences of the spheres:

>'These movements in nature's founts are not produced by thoughts, like those of men, which are contingent, imperfect and indeterminate, but connate in them are reason, knowledge, science and judgement — the source of acts positive and definite from the very foundation and beginnings of the world.'

The existence of such magnetic intelligences played an important part in Kepler's concept of gravitation. The reason that they do not feature openly in the work of Copernicus, or Galileo, may have less to do with their 'rationalism' than with the theological implications of such entities. Giordano Bruno — who carried this line of thought furthest by endowing with souls the individual spherical atoms which were the minima of his universe, each of the planets, and also his plurality of worlds — embraced a pantheism in which homocentric and theocentric viewpoints became redundant. It is possible to see in Copernicus' theory that raindrops, planets and the cosmos itself are all instances of nature's universal tendency towards the spherical a
clear anticipation of Bruno's spherical atomism. This conclusion is made all the more likely by Copernicus' citation of Ecphantus as one of his inspirations; Ecphantus, as Gassendi and Newton pointed out, was one of the few known exponents of Pythagorean spherical atomism, in which, like Bruno, the significance of the sphere is its role in the evolution of the divine in matter. Copernicus, too, was a pupil at Padua at precisely the period when paganising Aristoteleanism first emerged as an intellectual force. It is curious, in view of his ostensible Christianisation of atomism, that Gassendi nowhere mentions St. Augustine's theory of the *rationes seminales*. These were seeds, or reasons for all things; an attempt to synthesise Plato's forms and Epicurean atoms to explain the regularity of God's law in nature. His only references to Augustine are to his criticisms of Epicureanism. His lacuna is all the more striking as Gassendi's documentation of atomism, ancient and modern, is virtually exhaustive. Either Gassendi did not know these passages, or deliberately ignored them. He quotes, for example, a twelfth-century scholastic writer, William of Conches, who had used Augustine's theory. But the theistic and creationist triumphalism, in which Augustine's *semina* are embedded, could not be in sharper contrast to the evolutionary naturalism of the Paduan approach.

Galileo's caution in discussing the causes of gravity in *Two World Systems*:

>'The name has been made a household word by our familiar daily experience. But we do not really understand the force or principle which moves stones downward, moves them once they leave the thrower's hand, or moves the moon around', was partly ignorance, but also caution. Despite the hostility to scholastic Aristoteleans which marked his public career, his private links with the pagan Aristoteleans were sufficiently close for his relationship with Cremonini to be investigated by the Inquisition. It has been insufficiently noted that a Paduan Aristotelian and ex-pupil of
Cremonini, like Gabriel Naudé, saw nothing inconsistent in being an ardent admirer of Galileo and an intimate friend of an exponent of the new philosophy, like Gassendi. Paduan Aristotelianism, another representative of the school being William Harvey, did not foster the symbiosis of science and theology, which was the hallmark of its scholastic and Jesuit rivals. This was most marked in its theories of the soul which, purged of their Christian associations, became an important component in early theories of the existence of form in matter and gravitation. The influence may be seen in Gassendi’s acceptance of an organising, or hierarchical, principle within matter generating the molecules or compound:

\[
\begin{align*}
\text{atoms} & \quad \text{molecules} \\
\text{inorganic (res concretae)} & \quad \text{organic (semina rerum)}
\end{align*}
\]

In addition to corpuscularism, Gassendi possessed the idea of infinite space, also derived from unorthodox sixteenth-century Italian philosophy, and the parallel concept of homogeneous sequential time. For him time was no longer identified with the scythe and Saturn devouring his children, as in earlier iconography, but with an eternal flow of instants. Gassendi’s time/space continuum was of the utmost importance in understanding Galileo’s law of fall, since it led to the generalised proposition that distance travelled through space was a function of instants elapsed in time; a reversal, as Gassendi omitted to explain to an uncomprehending Louis de Valois, of the traditional dictum that time is the measure of motion, which identified time with the revolution of the primum mobile. It abolished also the traditional antithesis between time, in which change was inevitable; and eternity, where it was impossible. From the point of view of perceiving a link between the law of falling bodies and Kepler’s celestial magnetism, Gassendi’s discovery of time and space as an autonomous continuum removed all remaining objections to giving matter the same laws on earth as in heaven; it gave him the epistemological equivalent of two sets of
Cartesian co-ordinates. Gassendi was something of a pioneer in the introduction of Kepler's ellipse into astronomy. One of his closest astronomical correspondents, Wendelin, was an outstanding Kepler enthusiast. In 1635 he used Gassendi's observations to confirm the third law for the planets — Kepler had not always followed his own law in the compilation of the Rudolphine tables — and in 1647 he extended it to cover Jupiter and its satellites. Boulliau made use of Kepler's methods and Gassendi's observations to calculate solar distances in his Astronomia Philolaica (1644). Much of Gassendi's astronomical activity and correspondence, from 1630 onwards, had the collection of information which would clarify or vindicate Kepler as its object. The magnetic physics of planetary motion, expounded by Gilbert and Kepler, formed the basis of the analogy drawn between the galley and the moving earth, as early as 1640; and, with concealed enthusiasm, of the erudite compendium 'De Motibus Siderum' in the Syntagma.

In the field of dynamics he had his own, Newtonian, formulation of inertia and theories of impact, anticipating the other laws of motion. He had an explanation of gravity, in terms of invisible rays of fine particles, which reached out into the tiny vacua in objects like a lace into a hole. He envisaged mass in terms of a quantity of matter, compressed into a greater or a larger size. The force of a ray would diminish with distance, becoming very weak when it reached the region of fixed stars, but was magnified in relation to the quantity of matter. It will be argued that he did not make the essentially Newtonian leap of isolating a circular, or elliptical, orbit into an inertial component, taking the planet into a rectilinear, or 'natural' motion, tangential to its original orbit into space, and an acceleration, according to Galileo's law of fall, directed towards the sun. But such ideas are to be found scattered, like the fragments of a fossil, around Gassendi's work.
example, in discussing how God miraculously transformed rectilinear into circular motion, he casually lets slip the idea that planets are attracted to the sun by gravitation, just as stones are towards the earth. He then goes on to draw the conclusion that each planet is really falling towards the sun and that their different speeds may be calculated, though he makes no attempt to do so, and the balance which is necessary to compound their rectilinear into circular motion found. What is missing here is any suggestion that God is irrelevant to this problem and that it is the balance of acceleration against inertial rectilinear motion which is to be calculated.

There is evidence, elsewhere, that he was able to translate his idea of inertia into a celestial context. For instance, after expounding another of his theological interludes, in which God endows the planets with inertial circular motion from scratch (without dropping them towards the sun this time), he gives his favourite example of inertia; a stone travelling uniformly through an empty universe. But once it reaches the gravitational influence of the earth it is drawn in by the tentacles of its rays. Gassendi seems unaware of the inconsistency between these two images of inertia: a circular motion, imposed externally by God, and a rectilinear motion which the intervention of any external force inflicts into a curve. Another cherished example of the conjunction of gravitational and inertial motion was the pendulum, important to Galileo and Newton; he was aware of an exact analogy between the isochronicity of its swings, under perfect conditions, with the law of motion relating the 'flow' of time to the increments of degrees of speed. He compared the behaviour of orbiting planets to that of a pendulum, and the gravitational rays to pendulum strings. He quoted Mersenne's law of the pendulum, relating the length of string inversely to the duration of the swing, and realised that a weightless string would bring about perpetual motion. Although he was aware of the connection with Kepler's 'equal-areas-in-equal times' rule, he stated it obliquely.
It is sometimes said that rectilinear inertia is not an empirical concept as nothing like it is ever observed in nature. Gassendi evidently believed, mistakenly, that it was; his observations on comets having led him to suppose that Kepler was right in saying that any circular motion was only apparent, and their real path was rectilinear. In his account of the comet, which he believed to be in perpetual inertial motion through infinite space, he correctly attributed the angle of its tail towards the sun to the influence of a solar 'wind' and the attraction of the head to the sun by gravitation. He explained its acceleration by the relative absence of density in the tail and the head's attraction to the passing star-systems. He accounted for the failure of a very fast boat, which skims across the water to achieve lift-off, to the fact that 'the force pulling it is not strong enough to overcome gravity!'. Comparing the comet with the planets, he used the analogy of a river in which the planets were like jetsam, circulating in eddies near the bank, and the comet like a log flying down mid-stream.

It may be objected that all these indications failed to orientate themselves correctly because Gassendi lacked the mathematical perspective which would have enabled him to ask the right questions. Certainly he seems to have had difficulty in evolving a suitable mental picture of gravity; comparing a ray of gravitation now to a chameleon's tongue sticking to its prey, for its almost instantaneous operation; now to the action of light or magnetism; now to threads or chains of particles; now to the way in which the smell of an apple attracts a boy to eat it: 'I hope you will overlook it if what I interpret only obscurely I can only stammer over, confusedly.' Like a good mechanist he rejected the idea of action at a distance, as he did astrological influences and occult qualities. But unlike Leibniz or Huygens he remained convinced of the gravitational properties of matter — at one point holding that gravity could not be transmitted through a perfect vacuum — and therefore
from an immobile earth

(Tycho's observations)

from Kepler's *Astronomia Nova*

\[ \Sigma \text{sines IG} : \Sigma \text{sines ID} \approx \text{versed IH : versed IB} \]

"The magnetic body in balanced in the measure of the versed sine, according to distance; in proportion to the versed sine of the anomaly of the eccentric."

**PRECEPITA**

\[ \text{I} \cdot \text{II prop VI} \]

centripetal force in middle of any arc varies directly as versed sine

\[ QR = \text{versed sine of 2 arc QP} \]

\[ 2 \Delta \hat{P} \text{ from Newton} \]
accepting, like Descartes, that some tenuous fluid formed a cosmic 'aether sea', through which streams of particles like light, heat and gravity could be transmitted. In this respect the experiments of Peiresc, however naive, suggesting that light and sound were propagated spherically, evidently furnished him with a model. In 1635 Peiresc wrote enthusiastically to Wendelin about 'marvellous light shed on abstruse matters', particularly concerning 'the universality of the globe's form' in unnamed experiments by himself and Gassendi. Such obscure physical intuitions were no substitute for calculation. Gassendi had the new mathematics to hand, in the method of tangents of Fermat, circulated in manuscript by Mersenne, or Roberval's summation of indivisibles for the composition of forces. He fully realised its importance, though claimed to be wary of its physical application.

There is also the possibility that although Gassendi put the right questions he was, for ideological rather than logical reasons, unwilling to give the right answers. How else are we to explain his letter to the Jesuit Honore Fabri whose nominal intent, to congratulate him on his refutation of Copernicanism, seems to conceal a theory of gravitation more audacious than anything which Gassendi ever developed in his writings? Gassendi began by pointing out that acceptance of a geocentric view necessarily entailed an acceptance of the physical fact that the planets orbit the earth in spirals; this was also asserted in the Syntagma and Gassendi was evidently thinking of the diagram of the motions of Mars, based on the observations of Tycho, in Kepler's Astronomia Nova. 'But no-one has tried to establish a physical cause of these spirals', although they show a distinct physical pattern, moving more swiftly at their setting and looping much more closely together in the tropics and broadly at the equator. Gassendi agreed with Fabri that these motions might turn out to be a compound of circular motion with accelerated straight-line motion, and went on to propose a number of analogies which might clarify this:
We might compare this oscillating motion from tropic to tropic not improbably with the path of a stone dropped through a perforated earth or with the motions of a pendulum, a thing apprehended not only by the intellect but by the eyes. And it would make better sense, from your position, if in future you apply accelerated motion according to its increments in the ratio of the versed sines; that is, it should in no way differ from that which Galileo, Mersenne, and I must add, myself to have observed.\textsuperscript{78}

It should not be forgotten that the Jesuits, rightly or wrongly, were held directly responsible in Gassendi's circle for Galileo's imprisonment.\textsuperscript{79} They combined an interest in modern physics with a staunch geocentrism. Gassendi's suggestion that a geocentric physics could be worked out for the planets applying Galileo's law of fall to calculate the speed and configuration of their orbits was therefore almost certainly ironic.\textsuperscript{80}

But it would seem to be an incredible coincidence that, by a double irony, Gassendi's jest hit the target which eluded his omniverous treatises. The problem of the stone falling through the earth, the subject of calculation by a number of French savants, including Fermat and Mersenne, and of a slight argument between Wendelin and Gassendi, later proved the catalyst which, when communicated to Newton by Hooke, sparked off the idea of universal gravitation.\textsuperscript{81} The path which the oscillating stone would follow, inside a hollow earth, was actually an ellipse; and this demonstrated that it was gravitation which accounted for Kepler's first law. The analogy of the pendulum again turned out to be another stepping stone in Newton's thought.\textsuperscript{82} The fact that it suggested itself to Horrocks, around 1640, is often cited as evidence that he was a precursor of Newton.\textsuperscript{83} Gassendi's subterfuge, in shifting the kinematic frame of reference from the sun to the earth, and then proposing that the earth's gravitational field be used to provide a physical explanation of planetary motions, underlines the error of those who, following J. M. Keynes, believe that the debate over the earth's motion was purely a matter of choice of reference frames.\textsuperscript{84}
VERSED SINE

from: Cassendi, III.567

Galileo's
1, 3, 5, 7
law of acceleration

→ explains law of pendulum

each instant
an increment:

\[ \Delta = \text{versed sine} = \text{a wave} \]

circle
tangent to circle

ellipse
tangent to ellipse

\[ \left\langle \text{sines} \rightarrow \right. \]

Light as \( d^2 \)
Fabi, Physics, 11, p. 147

"Inversa square law"

Boullian, Philolaica, X1 p. 417
But how far would Gassendi have been prepared to follow his own argument? The reference to Galileo's law in terms of increments in the ratio of the versed sines recalls the critical importance which Kepler placed on the fact that the versed sines of the angle, between the planet and the sun, seemed to trigger off in the planetary 'soul' the need to turn the magnetic rudder, and maintain the balance between the 'sun-repelling' and 'sun-attractive' poles. There was a clear summary of this theory in the *Syntagma.* It has always been supposed that Newton was the first to realise that the versed sines of the arcs of the orbit furnished a direct measure of the centripetal, or gravitational force, transforming rectilinear inertial motion into ellipses; and the first to realise that this agreed with the motion of pendulums and Galileo's theorem, where the tendency to inertial motion was negligible. Gassendi's letter puts a question mark over both these assumptions. He must have realised that Galileo's law of fall and Kepler's equal-areas law measured the same forces as early as 1643.

Gassendi's conclusion that 'thence you will almost too easily explain the origins and variety of celestial motion, as those who make use of the fluxion of a point are accustomed to explain the creation of dimensions as accidents' scarcely seems justified unless he were aware of an irony behind the irony. The notion of the fluxion of a point generating dimension was Pythagorean in origin and acquired a mathematical significance, as a justification of indivisibles, in a work of Cavalieri, as Gassendi was well aware. Newton referred to the idea as evidence that the Greeks had secretly anticipated his method of fluxions. The account of his method of ultimate ratios immediately precedes, in Book I of the *Principia* the analysis of the link between versed sines and gravitation; which is no accident, since the whole method hinges on the comparison of equal arcs in moments of time diminished ad infinitum. In view of the influence which Gassendi's writings are known to have had on Newton it is not impossible that Gassendi's picture of time as a
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Let's find the area of the triangle ABD. 

\[ A = \frac{1}{2} \times BD \times h \]

where \( h \) is the height from point A to line BD.

The area of triangle ABD can be calculated using the formula

\[ A = \frac{1}{2} \times BD \times h \]
quantity 'semper fluens', and of the instant as a segment of that flux.
for which the 'punctum temporis' was an imaginary but idealised boundary,
affected the content, and even the notation of fluxions. One of the
features of Newtonian mathematics is that the concept of ultimate ratios
never became generalised algebraically, as in the Leibnizian school, but
remained tied to the original physical basis of its invention; the motion
of a particle in an infinitesimally diminishing period of time. This
dependence recalls the Gassendist insistence in relation to the law of
falling bodies: 'ut quot fluent momenta temporis celeritatis gradus
acquirantur'. It is clear, from his analysis of Zeno's paradoxes, that
Gassendi rejected the idea that time and space were divisible into
geometrical points; some such idea seems to lie behind the paradoxes of
the infinite in Galileo's work. At the same time his lengthy discussions
of the relation between a geometrical point and a physical minima show
that he was aware of the possibility of the sub-division of space, well
below the visible minima, with the point as a limiting case, just as
the pendulum refined the sub-division of time well beyond the threshold
of contemporary clocks. It is true that all this remained at the level
of epistemology and did not descend to mathematics. The image of the
fluxion of a point generating dimension was used explicitly by Gassendi
as an analogue of the method by which the philosopher ought to build up
the world by summation of its smallest elements; but he never articulated
its relevance to Kepler's 'non-geometrical method' of calculating the
balance of magnetic forces by the ratios of the summation of sines. This
failure is all the more astonishing as the mathematics which would have
transformed his epistemological insights into physics was then being honed
upon such whetstones as Roberval, Fermat, Pascal and Descartes.

Gassendi concluded his discussion of the forces moving the planets
with the words: 'Why this circuit, this track, this degree of speed or
slowness occurs, rather than another? We do not know. The answer is
"because the high and most sapient artisan thus willed to have it". Such a confession of ignorance accords with Gassendin's unBaconian willingness to acknowledge human inability to penetrate the secrets of nature. If it is possible to see in the imagery of 'penetration' and conquest used by many early mechanists a reflection of a masculine urge to discover and subdue female Nature, then Gassendi manifests a defective machismo in allowing her innermost secrets to remain inviolable. But there is reason to doubt the sincerity of the quotation from Lactantius with which the chapter is closed. For one thing, Lactantius was notorious as the Father of the Church who had denied the existence of antipodes. Even the cautious Copernicus, in somewhat Whiggish vein, cites him as among those 'triflers, wholly ignorant of mathematics, who nevertheless arrogate the right to make judgements ... because of some passage in scripture, wrongly twisted to their own purpose, who "speak" very childishly about the shape of the earth." He had argued that the idea of the antipodes was absurd, because anything located on it would fall off. Rather surprisingly he is not mentioned in E. Grant's Physical Science in the Middle Ages. He maintains: 'Contrary to a popular contemporary misconception ... no flat-earthers of consequence are known in the Latin west. Aristotle's arguments for a spherical earth were readily accepted.' The condemnation of Virgilius for asserting the antipodes also eludes Grant's notice, but in the seventeenth century the denial of the antipodes by a number of early Fathers, including such eminent authorities as St. Augustine, and the silencing of Virgilius, were a paradigm (in the old sense) of the Church's reaction to Copernicanism. Just as the voyages of discovery had discredited literal adhesion to biblical geography, so Papal authority would be the ultimate casualty of the decree of 1633. Peiresc thought this argument so compelling that he made it in writing to Pope Urban VIII; and Pascal used it as a stick to beat the papacy for its condemnation of Jansenism.
It would be idle to suppose that Gassendi was unaware of it when he closed his discussion of cosmic gravitation with a citation from an ecclesiastical writer who had argued that the inhabitants of an Antipodes would fall off. Moreover any reader of Gassendi's *De Vita et Moribus Epicuri* (1647) would be aware that Lactantius was one of the ecclesiastical writers who had made misleading insinuations about Epicurus' life and moral character; attacking atomism.¹⁰¹

Even the substance of Lactantius' argument as quoted would arouse suspicion, since he argues for the existence of a creator-God in terms of the analogy between the complexity of Archimedes' clock-work planetarium, unthinkable without the existence of a human craftsman, and the still greater complexity of the universe: necessitating an omnipotent artisan.¹⁰² There is nothing wrong with the argument itself. But no-one who had read Gassendi carefully would find it convincing, as he argues that any analogy between man-made machines and natural systems is untenable because the building blocks of the *res concretae* manipulated by man are inert, whereas the atoms, or ultimate principles of nature, and the *semina rerum* are alive.¹⁰³ It is therefore difficult to avoid the conclusion that though the expression of agnosticism about the causes of planetary motion is genuine the citation from Lactantius, proving the existence of the divine artisan, was intended as an ironic commentary on the intrusion of God into physics and of clerical authority into astronomy. It is a mask which never slips, either in the chapter closed by the quotation, in which even-handed treatment is accorded to 'external' movers of the spheres; the angelic intelligences of the schoolmen; and 'internal' movers, the magnetic souls of Kepler; or in the section as a whole, where Aristotle/Ptolemy/Tycho and Kepler/Roberval/Boulliau are dispassionately considered.¹⁰⁴ What a contrast with Galileo's condemned *Two World Systems*, where the mere mention of an angel, even a purely hypothetical one, aroused the retort: 'Whatever begins
with a divine or angelic miracle, such as the transportation of a cannon ball to the moon's orbit, is not unlikely to do everything else by the same principle'; whereas Tycho was ignored completely and the possibility of human ignorance, before the works of the divine artisan, lampooned in the suggestion that, even though it seemed Galileo's theory was absurd, God might work a miracle to produce the whole effect of the tides by this means. 105 Gassendi, by comparison, was a model of discretion. Yet we know that he was a passionate admirer of the Two World Systems and that both Galileo and Gassendi, like many others in their circle, were profoundly alienated from both the supernatural and the dogmatic elements in the religion which they outwardly professed. Twentieth-century historians have all too frequently closed their eyes to the fact that this alienation from the authoritarian and the miraculous was a mainspring of their efforts to secularise the science of nature. 106

It might indeed appear, from a modern standpoint, that gravitational forces are so innately mysterious that anyone who accepts them, to quote Sir Thomas Browne, need not be squeamish of any point in divinity. This feeling can only be reinforced by a glance at some of the seventeenth-century mechanisms for explaining it: Bruno's colonies of 'souls', Galileo's belief in matter's tendency to 'self-preservation', Gilbert's planetary magnetic intelligence, or Kepler's complicated interaction of poles and souls. Even the eminently rationalistic Gassendi, who rejected the animist hypotheses at an early stage of the Syntagma, revealed his latent sympathy by comparing stars to cities, planets to their citizens, and comets to gigantic whales navigating an aether sea. He calls them 'citizens of the cosmos', intelligent messengers between its principal parts, and declares that men have as much hope of understanding what they are saying as mites and fleas have of learning the business of the princes whose courts they frequent. 107 On reading such a passage we may be tempted to wonder with Fr. Riccardi, Urban VIII's
mayor of the palace, why the Copernicans could not adapt to the supernatural element in Christianity by making more use of angels, 'since these could guide a celestial body wherever it moved'. In order to understand these matters it is necessary to enter into the new perspective of a Judaic cosmos which has been Epicureanised: God is omnipresent but non-interventionist, having no particular interest in human affairs or even the earth. Instead of a hierarchical chain of being, there are relative degrees of it, some conscious of each other like man and the animals, others interacting only tangentially like man and insects, or man and comets. Within this perspective the anthropomorphic claims of theologians, philosophers or princes to lordship over the cosmos, or knowledge of its purposes, appear ridiculous. On the other hand, the existence of mysterious physical forces, like gravitation, which baffle understanding, or of superior forms of higher consciousness, originating in matter, rather than transcendental intervention, was unsurprising. The task of science, for those who shared this view, was to discover a small area of certainty from which to diminish, however infinitesimally, the vast unknown. The fact that this standpoint can be glimpsed in Gassendi, behind the convoluted erudition, explains his popularity with such apostles of the Enlightenment as Voltaire, even though his style was by then long since obsolescent.

From the foregoing it should be evident that many of the elements later assembled into a theory of gravitation, by Newton, were to be found, as it were, pre-fabricated in the pages of Gassendi; and that, moreover, there is good reason to suppose that the connections between these elements were much stronger in Gassendi's private thoughts than the constraints on his position as a priest and dignitary of the Church allowed him to express publicly. However, when Bloch wrote of ideological determinates, or at least inflexions, on Gassendi's thought, he meant social and specifically historical limitations. Gassendi's career may be divided
socially into three stages:

(1) Raised from the small peasant class by education (1592-1617);

(2) identity, through patronage, with the French administrative class, the noblesse de robe, to which many, perhaps the bulk, of France's mathematicians, humanists and savants belonged (1617-37);

(3) whilst retaining important links with (2) drawn increasingly into the orbit of the princes du sang, the Archbishops and political enemies of the parlement; especially De Valois and his crusade with the parlement of Provence.

The death of Peiresc was evidently one factor in the transition from (2) to (3) and, had Gassendi lived, the death of De Valois and the political collapse of the princes in the Fronde (1648-53) might have marked a move back from (3) to (2). His connexions with the Montmor 'academy' in the 1650s indicate this possibility. The make-up of the parlement of Provence, whose members had three principal qualifications: great wealth, often through trade, legal training, and connexions by marriage with each other, was not socially dissimilar to a contemporary English parliament. The main difference was that it had no House of Lords, and therefore no superior but the king, and no electorate because the sale of offices had made it hereditary. Peiresc was a not wholly typical member of this assembly because he had no need to forge a genealogy; his immediate ancestors were not tanners or tradesmen. But in his connections with Marseilles' merchants, or Lyons' bankers, with one brother a fief-owning noble and a cousin a mine-owner in Dauphiné, he was entirely typical. The only difference was that he used his mercantile and international connexions to advance his trade in news, manuscripts, books and curiosities, investing his spare capital in patronage of scientific research; whereas his colleagues were concerned primarily in augmenting theirs by investment in land, trading ventures and, above all, loans. Gallicanism, in the first half of the century, and Jansenism in the second, masked an enduring hostility among many of this group to mainstream Catholicism.
De Valois, grandson of the Charles IX, who inadvertently sparked off the massacre of St. Bartholomew in 1572, seems to have tried genuinely to act as an impartial mediator on behalf of all parties in Provence. But by 1640 he was clearly identified with the enemies of the parlement, foremost among them the traditional nobility of Provence, whose feudal jurisdiction was eroded and prestige in local communities diminished by the judicial monopoly and economic enterprise of the noblesse de robe. In order to weaken the stranglehold which the parlement exercised through a complex patronage system on all the municipalities of Provence, great and small, De Valois used his powers as governor to impose consuls by letters patent—suspending the rights of election. He also introduced new charters to modify, in some cases to enlarge, the electorate and allow a voice to poorer and more radical urban elements, hostile to the parlement. By such means, actively encouraged by Gassendi in his letters who found in De Valois' patronage an ideal means for protecting Church property from rapacious laymen and local magistrates, he was able to promote the interests of his party, headed by the local aristocracy, and weaken the parlement. Not content with that he determined on breaking the real source of the parlement's strength, its exploitation of judicial power in the interests of its members and their clients. To that end a rival Court of Requests was set up, in 1641, and more seriously, in 1647, an alternative parlement semestre. Supporters of the old parlement were exiled to Avignon. The governor relied on his regiment, officered by the aristocracy, and the galley fleet, to help him carry these measures through. But the collapse of central government from 1648 onwards enabled the old parlement to stir up a popular rising and eventually, from 1650, to gain the support of Cardinal Mazarin for De Valois' recall and imprisonment.113

The relevance of these events, which have long since become an obscure by-path of history, should be evident if we compare them to
those of 1679-88 during the period when Newton was writing the *Principia*. The measures of the last Stuart kings, Charles II and James II, to establish an absolutism, with backing from a strong army and fleet, which would shift the balance of power away from the traditional parliamentary classes, who, though elective rather than hereditary, were quite as much an oligarchy, linked by intermarriage, as the *parlement* closely resemble those of De Valois in Provence. The weapon which brought Charles to the point of success by 1685, and which even his brother James found deceptively powerful, was interference by letters-mandate in borough elections, and the remodelling of borough charters; to bring to power more radical elements in the towns, whose hostility against the landed gentry led them to side with the King. Charles, who died in 1685, was able to keep the Tory land-owners in his party, but his Roman Catholic brother found himself heading a party incongruously compounded of old noble Catholic families and radical urban dissenters, allured by the new borough charters and the promise of religious toleration. His master-plan was to use the re-issue of charters to gain a majority in parliament, favourable to the Crown and, were it not for the intervention of William, this scheme had more political potential than its failure suggests. But the combination of popular unrest, especially in London, and William's army, brought it down like a house of cards. The analogy here between the rebellion of January 1649 in Aix, accompanied by the triumphant return of the old *parlement* with the support of their secret organisation, built up during their exile in Papal Avignon, is striking. The main difference is that the religious issue, crucial in 1688, was of little importance in Provence. De Valois did use Huguenot troops from the Languedoc in an effort to stave off defeat, and there is evidence this lost him some support in strongly Catholic Provence.

But the striking feature of this essay in comparative history is the difference in position of Newton and Gassendi. If we, rather
arbitrarily, divide Newton's career at this time as we did Gassendi's
the pattern is quite different:

(1) offspring of a declining gentry, with Tory background, raised
by education (1642-85);

(2) identity, through support of the University of Cambridge against
James II's interference by letters mandate in university business,
with the cause of the Whigs and William of Orange: membership
of parliament (1685-90);

(3) patronage by the financial and political core of the Whig
establishment leading to Mastership of the Mint, Knighthood,
control of the Royal Society etc. (1690-1726).

Even someone sceptical of the relationship of historical events to
intellectual movements cannot fail to be struck by the similarity of
the social and political configurations within which Gassendi and Newton
were involved at a critical point in their careers, and the inversion
of their personal alignment with those forces. Gassendi, as a cleric-
administering considerable Church property, as a personal friend of De
Valois, found himself embroiled on the side of traditional feudal
tenures, against the parlement with its support for the rights of vassals
against lords; supporting the governor's assumption of arbitrary powers
against the insistence of the parlement and its supporters on respect
for precedent and legal forms. Newton, on the other hand, though
opposing a royal scheme for religious toleration which would have
liberated him from the need to conceal his own unorthodox views, was at
least consistent in his support for law, precedent and parliamentary
defence of the liberties of property holders and the freeholds of
clergymen and academics. Nor does he appear to have been troubled that
this brought him into the camp of the city of London and the magnates
of big business and sound money, who between 1690 and 1700 created the
financial institutions which became the hub of a world empire.

It has been remarked, somewhat derisively, that there is no
'Gassendi's law', not even a false one. In fact this is largely
historical accident, because Gassendi, unlike Descartes, did not choose
to present his remarks on motion in a legal form. But within the perspective of the social and political background of Gassendi's transition from phase (2) to (3) this reluctance to legislate for the cosmos seems natural. Descartes, whose five laws of motion were deduced from the divine nature, was himself an offspring of the parlement class, living in leisure on the income of the sort of investments whose existence De Valois threatened. For him, the idea that God made laws for the cosmos in the same way that the king legislated for a state seemed obvious.\footnote{121} No doubt it seemed equally obvious that the scientist, or the philosopher, played the same key role in the registration and application of those decrees, as the French parlements did with the laws. In the same way Bacon linked his campaign to reform philosophy and science with his conviction of the need to reform English law.\footnote{122} Demands for the reform of law and medicine were linked in the commonwealth period.\footnote{123} It seems natural that Newton, as an upholder of parliamentary privilege against the royal dispensing power, should from the 1660s have been committed to discovering a system of the world which was grounded on definite laws of motion; and, through the geometrical structure of the \textit{Principia}, made the understanding of these laws the portal of admission to the whole.\footnote{124}

No doubt Gassendi's scepticism restrained him from generalising his speculations in this way. But, as has already been indicated (footnotes 10 and 97), his epistemological reserve related to social as well as intellectual forces distancing him from that predatory and aggressive attitude towards nature, as a new colony awaiting exploitation and development, which Peiresc, Bacon and Descartes, despite their differences, all shared.\footnote{125} Epicurean hostility to political organisation and the laws on which they were established, whether by tyrants, popular assemblies, or enlightened philosophers like Plato, was reflected in their preference for friendship and mutual contracts
as a social bond. The language of their atomic physics, where foedera or ratio, contract or proportion, are used to express the concept of bond or regularity in nature is evidence of this. It is interesting that Epicurean, in post-revolutionary England, still meant voluptuary, as at the Restoration, but could also suggest someone estranged from the revolution settlement who lived quietly in the country. From this angle Gassendi's attitude to science converged with that of the Jesuits and the Catholic Church in the wake of Galileo's trial. The idea that the scientific community could become an autonomous body, formulating laws of nature agreed on by professional criteria, was exactly what appeared threatening about a Copernican physics, which appealed to a consensus independent of theology. For the same reason the Church distrusted secular lawyers, like the parlements, who encroached on long-disputed medieval privileges in the matter of jurisdiction and taxation; or civil servants who used the concept of sovereignty to present the Church's millenial presence as unconstitutional clerical interference. On the other side of the coin, this helps to explain the appeal of the new science to lawyers, civil servants and professional groups generally, such as the regent class in Holland or the noblesse de robe in France. The movement towards greater standardisation and codification of the law reinforced an attitude which rejected the miraculous, or the arbitrary, as interpretations of human experience.

Just as Gassendi was unwilling to formulate the laws of motion, so he shied away from the calculations which might have tested out, for his example, his relation of lunar motion to gravitation or any articulate formulation of the intuitions which he undoubtedly had relating planetary motion to rectilinear inertia and Galileo's formula for acceleration. Though he realised that gravitation diminished with distance, there is no indication that he realised it was as the square of the distance;
THE PRESIDENT AND HIS FARMERS

Historians have noted the close relationship between the legal profession and distinction in the sciences - especially mathematics. This plate, which is one of a long series, illustrates the critical importance of land-surveying to a group - the *noblesse de robe* - who had acquired their lands at the expense of noble and peasant alike, and who were often absentee landlords depending on management at a distance and disregarding local custom.

The juxtaposition of diagram and figures in the picture underlines what has been said about the abstract and manipulative character of geometrical relations. The president himself is exactly mirrored in the great right angle IMQ. The uncertainty and deference of his farmers (managers) in the three smaller lines NR PN LK. The labourer with his hoe corresponds to the apex of the enterprise KLO. The track of the laden cart follows the line KNI - that is carrying the end product away from the labourer and towards the point I, where all the main lines converge: I corresponds clearly to the calculating head of the president still wearing his judicial mortar-board.
except his analogy between the propagation of gravity and light. Surely, these are matters which can be explained solely in terms of Gassendi's shortcomings as a mathematician or a physicist? Gassendi's ignorance of new developments in mathematics has been, as I have tried to show, greatly exaggerated; and it is not his ignorance of mathematics so much as his failure to apply it which is in question. If the development of algebra and co-ordinate geometry in France is considered in a social aspect then its principal practitioners Viète, Fermat, Descartes and many lesser lights, were all members of the noblesse de robe. The idea of using letters as symbols, to turn a particular procedure into a paradigm for others, came from the legal textbooks where letters were substituted for names in theoretical case histories. Gassendi was certainly aware of Viète's work, since Peiresc had played a part in the editing and publication of his papers, but it was algebra and the techniques of co-ordinate geometry arising from it, from which Gassendi shied away. Hence his interest in the Italian mathematicians who did not use equations full of abstract symbols. It has been suggested that one effect of Cartesian algebra and the immense ease of manipulation which it introduced was:

'To be a symbolism mediating the application of mathematics to physical reality. More exactly, it is the space of commercial exchange which practically makes possible the mathematisation of the physical world—that is the birth of a physics which reduces each object, each element of reality, to a component; abstract, interchangeable, removable—just like a marketable commodity.'

It is certainly true that the noblesse de robe at this time were thoroughly commercial in their attitudes; treating their offices as investments—selling justice, buying land, coining money from government contracts and usurious loans. In Provence the parlement had close relations both with Lyons bankers and Marseilles merchants. Gassendi's distaste for these procedures did not stem from his friendship with De Valois; if anything they had inclined him towards it in the first case.
Epicurus shared with Aristotle a distrust of the unlimited accumulation of wealth for its own sake; and Gassendi's lack of interest in commerce, manufacture and law may help to explain his unwillingness to enter the symbolic space of algebra.\textsuperscript{134} It is notable that whereas Gassendi calls the axioms of logic 'speculative propositions' rather than rules, the mathematician Viète insists that the axioms of his algebra, some of which overlap with Gassendi's, are 'laws' as are those of arithmetic. (O.0.I p.99, Viète \textit{Isagoge ad Artem Analyticem} 1591).

Gassendi's own concept of space is probably best illustrated by the diagram which Charron, his favourite fideist, appended to the first edition of his \textit{Sagesse}; a footnote explains: liberté = espace.\textsuperscript{135} The connection of space with freedom was evident in his 1632 letter to Galileo. This can be linked with Gassendi's insistence, in the earlier part of his career, on freedom to philosophise as the most precious thing: the pre-condition of real knowledge.\textsuperscript{136} These associations should be interpreted in the light of the moral, social and hierarchical restraints attached to Aristotelian place by his contemporaries. The foundation of Gassendi's theory of gravity was that force was located 'non ad locum sed corpus terrae'.\textsuperscript{137} His idea of space and time as existing independent of God, and evading the omnivorous Aristotelian categories of substance or accident, was an irruption of Euclidean geometry into the physical universe every bit as dramatic as Einstein's introduction of non-Euclidean space in 1905. Gassendi, though a Hebrew scholar in communication with experts like Schickard in Tübingen and the rabbis in the papal ghetto at Avignon, does not seem to have been strongly influenced by any mystical notions identifying space with God.\textsuperscript{138} In the \textit{Syntagma} the account of time/space deliberately precedes that of God, who, if anything, is more closely identified with the existence and motion of matter. This exposition disregarded the traditional distinction between metaphysics and physics, but it hints
also at some of Gassendi's earlier and more polemical themes; the foundations of science must be established independent of theology.

It has been said that the new space developed when it did because of the free operation which it allowed to force; liberated from the hierarchical constraints of Aristotelian teleology. Perhaps this accounts for Gassendi's distrust of *raison d'état* and the 'might is right' philosophy which the new absolutism imposed both on its subjects and its enemies abroad. He understood that the principle of order in the new philosophy was to be what Aristotle had meant by 'violence', and he grew ill at ease with the implications. The barriers on the infinite accumulation of wealth, for example, raised by the finite cosmos and teleological morality of Aristotle and the scholastic subordination of free-trade to theology, made less sense in an infinite universe in which commerce, like science, might claim freedom from clerical interference. Viewed in terms of the development of a capitalist economy the Newtonian philosophy supplied both an analogue and a justification. An analogue in the sense that, having already identified inertia with the centrifugal tendency of groups with shared privileges to form a block in opposition to the rest of society, we identify gravitation with the tendency of material interest to re-unite them to the whole. A justification, because instead of identifying material interest with greed, usury or selfishness, as the old morality did, it presented an image of a social order founded on a balance of forces, in which violence and materialism acquired a spiritual dimension, as the levers which an all-wise providence manipulated to secure his ends. This was the ideological position advanced by the Boyle lecturers after the 1688 revolution. Those who notice a resemblance with the spirit of Dr. Johnson's social theory of gravitation, quoted in the previous section, are correct. Johnson was said to have owed his knowledge of modern science chiefly to assiduous
reading of the collected lectures.\textsuperscript{141} Within this, quite different context for morality, the infinite universe lost the perspective of amoralistic intoxication it held for Bruno and became 'God's sensorium' or—more simply, with Kant—'a pure intuition within which all objects must be determined.'\textsuperscript{142} So much a part of our common sense did laboriously constructed Gassendist space/time become that one modern writer on relativity can treat it as a vague common-sense concept that went back to Aristotle or beyond.\textsuperscript{143}

The argument of this section is that though many of Gassendi's ideas were imported into Newtonianism, and incidentally an equally detailed but imperfect pattern of influences could be marked out on Locke or Boyle, it was the ideological constraints on Gassendi's position in early modern France—religious, social, economic and political—and the ambiguity of his own attitudes to the moral and social implications of the new science, which meant that although he conceived a new order he was unwilling to give it birth. It was not merely, as Bloch implies, that Gassendi was too much of a conservative at heart, so attached to the old feudal-clerical order and provincial separatism that the juggernaut of French absolutism passed him by.\textsuperscript{144} He was also too radical, both as a sceptic and materialist, to be able to articulate his real views with any kind of honesty; unlike Newton, who merely had to conceal unitarianism, or Locke, whose case was the same; this must have been a real obstacle to his intellectual development.\textsuperscript{145} The constant denunciations of Hobbism, materialistic atomism, Epicureanism and free-thought which emanated from the Boyle lecturers showed that this element in Gassendist thought was still much feared, even in the relatively freer intellectual climate of England after 1688.\textsuperscript{146} Had Gassendi ever formulated a universal theory of gravitation it would have differed from Newton's in being physical, rather than mathematical,\textsuperscript{147} and in supplying an evolutionary principle which would have explained
reading of the collected lectures. 141 Within this, quite different context for morality, the infinite universe lost the perspective of amoralistic intoxication it held for Bruno and became 'God's sensorium' or—more simply, with Kant—'a pure intuition within which all objects must be determined.' 142 So much a part of our common sense did laboriously constructed Gassendist space/time become that one modern writer on relativity can treat it as a vague common-sense concept that went back to Aristotle or beyond. 143

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the organisation of atoms into molecules, of the densest groups of molecules into massy stars, and of the organised behaviour of stars, satellites and comets without any need to resort to intervention by a Deity. Without gravity, on the other hand, or with a fragmentary and unspecified form of it, Gassendi could continue to insist on the necessity of God's existence to explain purposive form in nature without offending the credulity of his select but critical audience. Even when closest to Newton it was couched in terms of physical analogy: Gassendi's real grasp that the same force which determined elliptical orbits also determined the acceleration of a falling stone was a metaphor rather than an abstract formula. Although he had emancipated himself from the anthropomorphic dualities of Aristotelianism, he remained closer to the poetic imagination of Lucretius, to the quasi-animistic vision of nature which informs the imagery of Belleau in the poem on magnetism quoted at the start of this section, than to the austerity of Euclidean mechanics. Gassendi's tendency to think of knowledge in linguistic terms, and of the problems of knowledge as generated through the limitations of language, is reflected in his fondness for the Lucretian metaphor comparing the composition of words from letters with the construction of the world from atoms. This attitude led Peiresc and Athanasius Kircher to believe that the decipherment of the Egyptian hieroglyphs could unlock nature's mysteries. In this respect Schneider was right to see in Gassendi the latecomer of humanism ('Spätling des Humanismus'); and Hess correctly summed up the apparently multifarious interests of Gassendi's circle as 'Philologie im weitesten Sinne'; textual criticism in the widest sense in which the world itself became a text to be deciphered. This explains why, for Peiresc, and to a certain extent for Gassendi too, at any rate in his theory of gravitation, 'die lebensweise des Chamaleons beschäftigen ihn nichtweniger als der Galileischen Fallgesetze'. For
Gassendi mathematics would only enable us to understand the diagrams in the book of nature; they were insufficient to decipher the text in which they were embedded.¹⁵¹
2. An observer on Mars would find that heavy objects had the quality of 'Marsness' and would measure planetary motions by epicycles and deferents one Martian year long.
3. E.g. J. Chassignet, Le Mèpris de la Vie et Consolation contre la Mort 1594 sonnet 84; St. Teresa of Avila, Way of Perfection c. XIX discussing the contraries of fire and water as applied to the soul comments: 'It would be very useful to discuss this with someone who understands [natural] philosophy.'
5. S. Broderick, Robert Bellarmine 1928 e.g. his De Ascensione Menti in Deum per Scalas Rerum Creatarum based on the framework of the four elements and a ladder to heaven, pp. 382-8.
6. Though modern historians tend to underrate the important contradictions which Copernicanism posed for popular beliefs; for a curious attempt to adjust diabolical geography to Copernicanism as late as 1714, by locating hell in the sun; see D. P. Walker, The Decline of Hell 1964 pp. 39-40.
7. Aristotle, Ethics 1134b18-1135a; Summa Theologica Aquinas I,II q. 90-4.
9. Conspicuously in the work of Grotius, De Jurè Belli et Pacis 1625, a work encouraged and in part financed by Peiresc O.O. (V) p. 289; for Kepler's moral interest see Harmonice Mundi 1619 preface (passim) and G. Simon, Kepler 1975 p. 74.
10. As Kuhn, and most other commentators now admit, 'its incompleteness and incongruities' make it difficult to take the first book 'entirely seriously'; Copernican Revolution 1975 p. 145, Bloch, Philosophie de Gassendi p. 332: the sentence was added around 1650/2.
11. O.O. (I) 388a.
13. See Gassendi and the Church.
14. M. Jacob, The Newtonians and the English Revolution 1976 p. 189; matter 'brute and stupid' according to Bentley's Boyle lecture; H.H. Guerlac, Newton et Epicure 1963 and Koyré, Newtonian Studies 1966 p. 208, where Bentley hastily purges himself of an accusation by Newton that he holds gravity to be 'innate' in matter (1692), also p. 149.
15. M. Jacob, op. cit, pp. 189-91 controlling matter had an analogy with ordering society.
16. O.O. (II) p. 3b, where man's capacity to understand the universe or the mind of God is compared with that of insects to understand the forms of human society. To give just one example of Peiresc's practical bent: he brought in Dutch experts to advise on canals and drainage projects in Provence which led to considerable progress. See (V) 301b and G. Wilson, Dutch Republic 1965 p. 80.
17 O.O. (I) 279b
18 O.O. (I) 355a
19 A. C. Crombie Augustine to Galileo (I) 1969 pp. 82-3.
20 O.O. (I) 636. A similar passage is found in Galileo and is discussed by various writers including Newton; see Koyré Newtonian Studies pp. 201-20.
21 O.O. (I) 334b. It was while working on this section that Gassendi broke off his MS in 1636.
22 O.O. (I) 485b.
23 Barrow, an early influence on Newton, claimed that 'of all sects the Epicurean has become the most dangerous', and Newton's own obsession with incredulity was evident in his accusations of materialism against Bentley (n. 14) and Hobbism against Locke. Never at Rest Westfall pp. 503 & 504.
25 Boulliau Pintard Libertinage Erudit pp. 289-90 and p. 374. It was the mathematician Cavalleri who gave the warning; also Neugebauer Ancient Astronomy 1975 pp. 1109.
26 Quoted in Gusdorf La Revolution Galilène 1969 pp. 124.
28 A. C. Crombie Augustine to Galileo (I I) p. 233.
29 It was accepted in Gassendi's circle that every intelligent man was masked. See GASSENDI AND CHURCH.
30 See n. 21
31 O.O. (VI) 92a
32 Aix Ménages MS 10267 f. 71. Naudé believed that Bodin wrote his treatise on witch-hunting, the Demomanie 1580, as a black joke to allay contemporary suspicions about his religious orthodoxy.
34 Copernicus De Revolutionibus... Iv Galileo Two World Systems ed. Drake p. 23.
35 O.O. (I) 336-7. A general in the 1630s did not have the same authority as in Marlborough's day.
37 O.O. (V) p. 291 The Chancellor, Sillery, was the first to observe the phenomenon.
38 Rochot Les Travaux de Gassendi sur l'Epicure et l'Atomisme 1955 p. 65 Gassendi to Peiresc 1635 'Ces gros solides, solent cubiques, solent octogonales, etc. sont tous composez d'autres moindres, de même figure, et ceux ci d'autres moindres jusques à la révolution en de si menus qu'ils sont presque insensible et toujours figurez de même.' This confirms his 'old reserves' about Epicurus notion of atomic structure because he believed that these geometrical forms must 'of necessity' be traced back to their formation in the atoms themselves. For Peiresc's own observations some are reproduced in Notes Inédits de Peiresc sur Quelques Points de l'Histoire Naturelle ed. T. de Carpentras, Inguimbertine MS 1821. Larroque 1896.
39 H. Busson, *Le Rationalisme dans la Littérature Française de la Renaissance* 1955, quite properly underlines the influx of Paduan naturalism into France. Provence was, geographically, particularly vulnerable. R. Popkin, *Scepticism from Erasmus to Descartes* 1960, reveals the absence of any historical understanding by contesting Busson's entire thesis on the grounds that 'there is no evidence that being a sceptic openly in 1557 would have got anyone into serious trouble.' p.34.

40 For De Clave see O. Bloch, *Philosophie de Gassendi* pp.238-40.

41 Galileo, *Two World Systems* ed. Drake pp.400-417, an exposition which slyly ignores Gilbert's Copernicanism. A. Koyré, *Galileo Studies* p.178 notes the incompatibility of the animist expressions with his image of Galileo's physics but merely concludes that they do not reflect Galileo's 'real' views, whereas the subsequent profession of ignorance about gravity does.


45 Galileo, *De Revolutionibus ...* (I) I.


48 B. Kouznetsov, *Galilee* 1973 p.100. In 1611 Cremonini, Sarpi and Galileo were all members of the anti-papal party in Venice at the time of the expulsion of the Jesuits, which fraternized with Protestants at the 'Golden Ship'. See W. Bouwsma, op cit n.42.


51 Harvey's *De Generatione Animalium* 1651 is informed by the principle of generation from seeds or invisible atoms evolving into eggs in which life was preformed. Crombie, *Augustine to Galileo* II p.286.

52 0.0. (II) pp.114 and 347. According to Westfall, Newton's intuition, derived from alchemy, of a 'new conception of matter, not an unorganized heap of particles like a sand-pile, as mechanical philosophers pictured it, but organised crystals held in definite patterns by forces' in 1679-80 combined with the problem of orbital mechanics and 'made common cause on the issue of action at a distance'. It was Gassendi (I 336a) who contrasted the lifeless bricks and beams assembled to build a house with the mobility of active atoms.
B. Telesio De Rerum Natura (Naples 1586), F. Patrizzi Nova...Philosophia (Ferrara 1591). The idea of replacing Aristotelian place with Euclidean space was with them purely philosophical. Gassendi was the first to show its relation to the new physics.

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Gassendi had already communicated, in February, a complete account of his new theory of time to Sorbieri in Flanders (O. O. VI 178-9), in which he asserted "tempus NON est mensura motus, ut vulgo deflniunt" and "astermam substantiae translata in elius durationem sunt". Yet Gassendi never wrote back to correct his illustrious patron's error. This indicates that despite his fulsome flattery of De Valois Gassendi had a low estimate of his capacity for abstract thought.

Latitude and longitude, which went back to the geographers of Alexandria, was revived by the cartographers of the renaissance and may have inspired Fermat and Descartes to locate a point by a system of algebraic and rectilinear co-ordinates in the 1630s. Descartes la Geometrie 1637 and Fermat Ad locos planos et solidos isagoge MS circa 1637. Gassendi's idea of the 'insignem parallellismum' between space, or location and time, or duration meant that every possible state of affairs in the universe could be described. O. O. (I) 133a.

Wilson op cit p.242

Wilson op cit p.242

Wilson op cit p.242

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Wilson op cit p.242

Wilson op cit p.242
Qua vero interea luna ses habet quasi plumbulum illigatum filo, a quo plumbum dependet; nam bene ut tune plumbum facit vibrationes dquantulum celeriores, quatenus et ipsum dependens a filo breviori appetit vibrari celerius, sique eo facit ut plumbum referatur... oculus dum ex motu Terrae, prout est cum motu Lunae indivisivus, speciem causam repetit specialis inaequalitas.' Also III pp. 495-6 gravitational 'ray' equated with pendulum string.

A. C. Crombne 'Mersenne and the problem of scientific acceptability' Physis XVII 1975 p.196. O.0. (I) p.360ab.

73. 0.0. (I) p.710b.  76 0.0. (v) pp.254-5 Gassendi praises Torricelli and Cavalieri for having created their own regnum of indivisibles. But he adds that their laws do not apply to the regnum materiae. He had obviously read at least Cavalieri's Geometria Indivisibilibus 1615-5.

77. Astronomia Nova 1605 p.4 Kepler's whole point was that Ptolemaic, Tychonian and Copernican hypotheses could be regarded as 'equivalent' (pp.5-9 & 60); but that an elliptical orbit was simpler than a set of spirals; and physically explicable.

78. 0.0. (VI) 167a-98 to Honorac Fabri S.J. I have not been able to trace the book de Caelesium motuum mentioned by Gassendi; but this is the Honore Fabri mentioned in a letter from Bentley to Newton (1692) as yet another source for the paradox of the planets falling into the sun. Newtonian Studies p.30% Evidently Gassendi is discussing some such paradox in this letter but suggesting that Fabri recalculate on the basis of Kepler's spirals and Galileo's law.
Les Correspondants de Peiresc XIII, Naudé p.115; see also S. Drake Galileo at Work pp.312 and 372 and Pascal Lettres Provinciales XVIII accuses the Jesuits directly.

O.0. (VI) p.168b where he praises Fabri for an idea 'dignam Societate, quam quldquid est rarum sublime magnificum deet' should be compared; with his mention of the Jesuit take-over at Aix University (VI) 2b.

Westfall Never at Rest pp.382-90 Hooke has been praised for being the first to eliminate centrifugal force from his idea of gravity; but Gassendi does not introduce the concept.

Principia Mathematica ed. cit. pp.22-7

C. Wilson art. cit n.57 p.250: 'Since the motions of the planets agree with the motions of a pendulum...why should not the causes be similar?' asked Horrocks. He and his circle were students of Gassendi's works; see A. Chapman Three North Country Astronomers 1982 pp. 5, 7, 13.

Newton discusses Gassendi's subterfuge (without naming him) in his System of the World (p.553 Matte/Cajori) 'The explication thereof requires a composition of forces so involved and so variable that it is hardly to be reconciled with any physical theory.'


The construction of lines from points, surfaces from lines etc. is described in Geometria Indivisibilis 1635 (see n.76) and the use of fluens for a variable magnitude in Exercitationes Geometricae 1647 p.152 see Dictionary of Scientific Biography 3 1971 p.111 article 'Cavalieri'.


Principia ed. cit 'Ut arcum aequalibis temporibus descriptorum sagittae illae qua convergent ad centrum virtut, et chordas hiscitant ubi arcus illi in infinitum diminuuntur.'

The key passage is O.0.(I) pp.220-8 e.g. Temporis ita in fluxu posita est (223a) Tempus invariable semper fluit (224b) sic fluxu horologii metiamur fluxum temporis or quantitate illius fluxisse tempus (225a) etc. It is interesting to note that one of Galileo's closest approximations to formulating a rectilinear principle of inertia concerned water flowing down an aqueduct. His pupil, the papal engineer Castelli, worked on measuring devices to meter the water rate charged to the inhabitants of the Papal States more accurately.

From Calculus to Set Theory 1980 ed. Grattan Guinness p.53. 'The terms fluents and fluxions indicate Newton's conception of variable quantities in analytic geometry he saw these as flowing quantities, that is quantities which change with respect to time... in time he introduced the dot-notation, where the fluxions of fluents z,x,y are \( \dot{z}, \dot{x}, \dot{y} \) ... By this conception of quantities moving in time Newton thought himself able to solve the foundational difficulties inherent in considering 'small' increments of variables, so small that we may discard them, and yet not equal to zero, In his theory of prime and ultimate ratios the flowing quantities are essential.

'Non esse id Tempus quod dicitur praesens accipiendum strictius, sive instanti puncti mathematici; sed latius et pro tempore minimo, sub sensum cadenti, in quo tum quod futurum est tum quod praeteritum iungantur.' 0.0. (I) p.223b.

Yet to divide an instant of time up into past/present/future was impossible; like measuring the curved with the straight, weighing by the inch or measuring by weight.

For Gassendi the instant in time, like the atom in matter, was determined in magnitude by the limits perceptible to the senses, on the one hand, and the non-existent geometrical point, on the other.

Astronomia Nova p.274 He called it 'non-geometrical and defective', because it involved the summation of infinitesimals, contrary to Greek logic, and the neglect of 'insensible differences'. Cavalleri acknowledged his debt to Kepler.

B. Easlea Witch-Hunting Magic and the New Philosophy 1980 p.246 seq. A further distinction between Peiresc and Gassendi (see n.16) may be noted, in that Peiresc's letters reveal a Baconian confidence in man's capacity to penetrate and subdue nature; e.g. Peiresc to Campanella 1636: 'La natura non piu concepita come sacra e quindi degna d'ammirazione ma come oggetto di lenti conquista da parte dello scienziato che me sappia umilmente seguire ed annotare in moti e le leggi per coglierne la più profonda essenza et penetrare gli effetti i delle divina Providenza.' quoted in G. Rizza Peiresc e Italia p.245.

Copernicus De Revolutionibus... dedication to Pope Paul III.

E. Grant Physical Science in the Middle Ages 1977 C.U.P. p.61.


e.g. 0.0. (V) p.199.

In the chapter 'Esse Deum Authorem, seu Causam productinem Mundi' the argument is quoted again, this time attributed to Balbus. Lactantius is quoted several times in order to refute Epicurean materialism; and once, p.319a, in support of the view that the universe was made for man alone; contradicted elsewhere in the Syntagma e.g. I p.151.

0.0. (I) 336a

0.0. (I) 588-631

Two World Systems ed. Drake pp. 237 and 422


0.0. (I) pp.155-62 discusses and rejects the idea of a world-soul; on comets: p.710b.

Drake Galileo at Work p.291

There are various favourable references to Gassendi in Voltaire's works. To quote from his Le Siècle de Louis XIV 1737: 'Newton et d'autres ont démontré depuis ce que Gassendi avait affirmé, Il eut moins de réputation que Descartes parce qu'il était plus raisonnable.' (2) p.230 ed. Flammarion. Voltaire was the great
architect of the downfall of Cartesianism in France and the propagandist of Newton. Voltaire's conte Micromegas encapsulates the Gassendist vision of the universe described in this paragraph. Voltaire's Lettres Philosophiques were burnt by the hangman in Aix in 1734.

See PROVENCE: MENTALITIES

B.N. na. fr. 9514 f.16-20; MS Carpentras 1864, f.6

Histoire de la Provence ed. Privat pp.376-9. The scandal which led to the dissolution of the Jesuits in the eighteenth century was fomented by Provencal Jansenists.

See GASSENDI AND ABSOLUTE MONARCHY


pp. 635-9.


Lettres Spirituelles du P. Yvan 1669 ed. G. Goudon pp.99-105 Fr. Yvan, De Valois' confessor, reproached him in graphic terms for the atrocities of his troops in general and especially for the desecration of churches by Huguenot recruits in particular. It was also noted, with some surprise, that he kept a Huguenot tutor in his household.

Westfall Never at Rest pp.473-98 Newton was a member of the convention parliament, summoned without royal assent; pp.550-59, pp.629-31. Newton's patron was the Whig financier, Montague.

F. Borkenau Der Ubergang Vom feudalen Zum Burgerlichen Weltbild 1974 was the first to draw attention to these features of Gassendi's social position and suggest that they might have a bearing on his philosophy pp.435-8.

Cresme, Copernicus and Newton all believed passionately in what used to be called 'sound money'; and other lesser figures, such as Peiresc, took a close interest in depreciation and exchange rates. Gassendi's interest in this matter seems to have been confined to the antiquarian; a table of conversion of ancient moneys into modern French equivalents for the guidance of scholars, O.O. (V) pp.337-42. Connections between the function of money and scientific attitude are proposed in Murray Reason and Society in the Middle Ages 1978 pp.34-170.


Descartes Principia Philosophiae 2nd ed. Paris 1647 II 24-40 'Certain rules which I call laws of nature and which are the secondary causes of the different motions we see in all bodies.' p.37, Letter to Mersenne, April 1630 God = royal legislator Lettres de Mersenne ed. Tannery/Waard; New Cambridge Modern History IV p.131 analyses the political significance of the differences between the scholastic and the scientific concept of law.

Legal Philosophy from Plato to Hare 1949 H, Cairns p.57.

C. Webster The Great Instauration 1975 pp.256-64.

The main constitutional issue in 1688 was that James had been using a 'dispensing power' to relieve Catholics, collectively and as individuals, from a number of penal acts imposed by parliament. According to Macaulay 'no Crown lawyer was willing to defend the dispensing power... which... would have sufficed to overturn the whole polity of the State.' History of England I pp.569-60 everyday ed.
John Evelyn, to whom the English translation of the Vita Peireskii was dedicated, sums up this spirit in his ode to Creech's English version of Lucretius:

'Persuaded that there was rich ore
I boldly launched and new worlds would explore,
But was too weak, too poor myself to trade.
Much less to make a conquest and subdue,
That glorious enterprise was left to you.'

Farrington, Faith of Epicurus p. 31

Bailey, De Rerum Natura 1947 (II) p. 605; also (I) 1.585, (II) 1.298, (V) 1.308-45.


Kepler did not call his laws 'laws'; and Boyle preferred to write of 'rules' of nature because this allowed God freedom to work miracles. Hooykaas, Religion and the Rise of Modern Science 1972 pp. 18-19.

A. Klein, Greek Mathematical Thought and the Origins of Algebra 1968; species was the term used for both symbols. There was also a resemblance with a specific type of legal document, the bill of exchange.


The Memoires of Réguisse, a versatile entrepreneur and leading opponent of De Valois, are refreshingly frank about his activities. Memoires pour servir à l'histoire de la Fronde en Provence 1870. See also the 'Memoires' of Valebelle (a Marseilles merchant). Aix Mójanes 43 and PROVENCE: MENTALITIES.

R. Pillorget, 'Les Luttes de Faction à Salon 1608-15' Provence Historique 1968 pp. 293-311: Lyons bankers and members of the parlement, both using prête-nom, were the principal creditors of the bankrupt community.

Epicurus ed. C. Bailey 1970 p. 113 XLIII 'the love of money, if unjustly gained, is inimrous and, if justly, shameful; it is unseemly to be merely stingy, even if it is justified.' pp. 133-45 '... in reference to unlimited desires the greatest wealth is poverty.' Gassendi condemned usury in the conventional manner, but added a rider evidently directed at the parlement of Provence: (II) 753b.

P. Charron, La Sagesse 1601, frontispiece.

O. Bloch, Philosophie de Gassendi pp. 33-7.

O. O. (I) p. 346b.

M. Jammer, Concepts of Space 1954 place in Hebrew = Makom, Arabic makam, which was also used for God. Gassendi's distrust of the Kabbala, and of Campanella, who, outlined a similar concept of relative space, perhaps explains this (pp. 32-4). Jammer passes Gassendi over because he contradicts his main thesis that concepts of space are a function of mysticism. For a more balanced view see M. Capel: 'Was Gassendi a precursor of Newton?' Actes du Xe Congrès International d'Histoire des Sciences 1962 and Philosophical Impact of Contemporary Physics 1955.


Op cit p. 162
142 S. Clarke in Leibniz-Cla rke correspondence p. 201 Leibniz (Everyman) E. Kant Critique of Pure Reason 1973 ed. Kemp Smith p 71

143 J. Bernstein Einstein (modern masters) p. 73.

144 O. Bloch Philosophie de Gassendi pp. 492-3.

145 Westfall Never at Rest pp. 490-1.

146 M. Jacob op cit pp. 196-8 suggests that such denunciations would make a study in themselves. There are several analogies between the relations of free-thought and orthodoxy in the 1690s and 1700s in England and the 1620s and 1630s in France; see her chapter 6.

147 Koyré Newtonian Studies p. 16 points out that Newton's insistence on gravitation as a mathematical force, about which he would not make hypotheses, though the reader may 'conceive' it as physical, was not so much the caution of an empiricist as the determination to rule out either a 'world soul' or materialism.

148 M. David Le Débat sur les Écritures et l'Hiéroglyphe au XVII siècle 1965

149 Schneider Die Stellung Gassendis zu Descartes 1906.

150 G. Hess Pierre Gassendi 1939 pp. 6 and 11: 'The habits of chameleons were of less moment than Galileo's law.'

151 O. O. (III) 208-9.
GASSENDI, ASTRONOMY
AND THE IDEAL OF OBJECTIVITY

1) Methodology
2) Concealment
3) Hypotheses and Evidence
4) Hypotheses and the Church
5) Astrology
6) Motivation

1. Iamque Astronomiam si vitam diutius prorogasset, conscribėbat
   intra limites scientiae certae et indubitatae cui
   fundamenta per multiplices observationes substraverat.
   Montmor

2. Solo Euclide armatus deballandis errorum monstris vel
   Physicae difficultatibus referandis. Facile Astrologiam
   explodit.
   Sorbière

3. Sublime aquilae instar syderum penetravit orbes et planetas
   et si errantes tanquam pencillo depinxit.
   Anon. Christ Church,
   Oxford 1655

Translation

1. If he had been spared, he would have conscribed astronomy
   within the bounds of a certain science whose foundations
   were laid in his multiple observations.

2. Armed with Euclid alone he dispelled the monstrous errors and
   resolved the difficulties of physics. Easily he exploded
   astrology.

3. Like the sublime eagle he penetrated the stars and drew the
   orbits of the planets, despite their wanderings.
LUNAR ANOMALIES

"Be Content with your Tables..." Gassendi to Wendelin 1644

Xa D.P. Gassendo, & I. Bullialdus ad tempus medium reducta ad Meridianum Valburgi.

Table by Gassendi and Boulliau, published 1644.
GASSENDI, ASTRONOMY AND THE IDEAL OF OBJECTIVITY

1 METHODOLOGY

Judged by the historical record, Gassendi's astronomical activities mined a seam which scarcely justified the immense efforts he expended. There is no Gassendi's law, no system or set of tables bearing his name. Although others, such as Wendelin and Boulliau (referred to by Newton), incorporated his data in their tables he was apparently content to leave it in diary form. This Journal, impressive enough in itself, covers 400 pages in folio. It contains some 12,000 separate observations, starting with the the comet of 1618 and ending with an observation of Saturn made, at his express direction, a few months after his death. But it does not record a single discovery. This is, on the face of it, surprising. Even his mentors, Peiresc and Gaultier, with much less time available for astronomy, had minor 'firsts' to their credit. This negative record is the more remarkable since Gassendi's technical excellence and organisation were outstanding for his time. Though he was conservative in that he clung throughout his career to the cross-staff, or astronomical radius (with cylindrical non-telescopic sights), his book-keeping was meticulous. His work is regarded as a unique record of how that deceptively simple instrument, the astronomical radius, which was already passing out of fashion by the time of his death, could be employed in calculations of remarkable accuracy. Thanks to new techniques of calibration (logarithmic and Vernier scales), this portable instrument was able to rival the massive machinery deployed by Tycho Brahe a generation earlier. Another element was Gassendi's skill in selecting and training assistants. Halley was struck by the accuracy obtained by non-telescopic instruments, as late as the 1670s, when multiple
observations of the same star were made by several instruments from different positions at the same moment. This was exactly Gassendi's method.

For grand occasions, like an eclipse or a transit of Mercury, he would superintend, with workshop precision, the division of tasks among his assistants. When tables were so uncertain, many hours of watching might lead to neglect at the critical moment. Equally characteristic were his solitary walks across desolate countryside, with no other companion than a quadrant or radius. Gassendi had accustomed himself to such excursions from early adolescence, when he would get into trouble for breaking out of the parental home at night. Such expeditions evidently gratified a deep need for solitude, celebrated in the nature-poetry of such friends as Du Perier and Saint Amant or the Epicurean Theophile de Viau. No-one familiar with the Provencal Alps by night would seek to minimise the personal courage required in setting aside the peasant tales of demons and werewolves in the cause of science.

As well as supplying an excuse for solitude, astronomy conferred membership of an exclusive international club. Many of his letters deal exclusively with technical astronomy and others, like those to Peiresc, are peppered with sometimes obscure technical asides. Practical astronomy was a component in the profile of any educated person in post-Copernican Europe. It is easy to forget the geographical scale of the astronomical community at this time and the obscurity of the channels through which information was transmitted. Although hopes of observations from India and Ethiopia were disappointed, he had communications from Quebec, Egypt and Syria. These were often from missionaries, co-ordinated expressly on his behalf by no less a figure than the Pope's all-powerful nephew Francesco Barberini. One laconic entry in the diary records data on on
eclipse from Canada, memorised by a Jesuit who lost his notebook after being tortured by Indians.\textsuperscript{6} Another important source were the gentlemen scholars: the international jurist Grotius, friend of Milton and Peiresc; the Dutch orientalist Golius; the English mathematician Wallis. Despite their eminence, all three clearly regarded it as an honour to be swapping observations with Gassendi. The astronomical community began as an epicycle on the great wheel of the republic of letters; and the intellectual affinities between science and scholarly humanism were much greater than is sometimes supposed.\textsuperscript{7} This is why it was so easy for astronomy, in its early phases, to transcend national and religious boundaries.

Gassendi had visited the United Provinces and his links with Dutch astronomers were particularly strong. Lutherans, Calvinists, and Socinians from all over northern Europe, were among his regular astronomical connexions. The Catholic clergy and Jesuits were naturally well represented.\textsuperscript{8} There was also an important community within France itself, and our relative scarcity of data should not lead us to neglect it. In Provence there was Peiresc, Morin and the Gaultier family. In neighbouring Dauphiné one of Gassendi's earliest collaborators, Jacques de Valois, was an important official in the tax office.\textsuperscript{9} Of the many resident in Paris Fr. Bouilliau's co-operation with Gassendi was particularly important. Bouilliau was an original mathematician in his own right, as were two other Parisians by adoption, Mydorge — the expert on conic sections — and Roberval, Gassendi's colleague at the Collège de France. The interest of all these mathematicians in Gassendi's programme of observations has been passed over in silence. However, under the loose umbrella of Fr. Mersenne's mathematical academy, some sort of clandestine research programme into every aspect of Copernicanism seems to have been proceeding. The letter in which Mersenne announced the formation of
this academy to Peiresc, and invited Gassendi to join, was written in the immediate aftermath of Galileo's trial.

As discussed in FRIENDSHIP the links which bound this scholarly community together were elusive, but there were certainly channels of communication which have been lost to view since. Take the community of English astronomers, centred on Horrocks, Crabtree and Gascoigne, supposedly isolated from continental contacts in the wilds of Lancashire. Gassendi's writings were evidently studied in their circle, even though he had published little before 1649. Horrocks' observation of the transit of Venus, in 1639, was modelled on Gassendi's transit of Mercury in 1631. Even more striking is a summary of one of Gassendi's private papers on sun-spot observations, with a direct quotation from the Latin original, in a letter from Crabtree of 1640. It was not until 1658 that Gassendi's paper was given to the public. Speculations by Horrocks, explaining the lunar motion by analogy with pendulums, were cited approvingly by Newton in the Principia. The work of Gassendi's old friend Mydorge on conics supplied Gascoigne and Horrocks with their mathematical basis. Perhaps Mydorge inspired a rather different theory of gravitation, applying the theory of the pendulum to the moon, in the works of Gassendi, Boulliau and Wendelin in the 1640s. All this suggests a current of mutual influence by pathways now obscure. Horrocks' observation of the transit seems to have been virtually unknown in Britain, till it surfaced among the papers of the Danzig astronomer Hevelius. Hevelius was one of Gassendi's most regular correspondents, and had encountered him as early as the 1630s on a visit to France. Halley stayed with Hevelius in 1679.

Gassendi's interest in the circulation of astronomical intelligence reflects his Baconian methodology. Although it was a philosophy of science which he never wholly discarded, the
astronomical notebook itself supplies ample evidence that the 1630s mark a peak of fanatical Baconianism. The sheer bulk of his astronomical observations from 1633-9, over three-quarters of the total from 1618-55, compels this conclusion. Observations on meteorology follow the same pattern. Complete weather maps for Digne and Provence could be drawn up for this period from his data; which is not without interest to the modern historian, demonstrating as it does the graphic deterioration in Mediterranean weather conditions at this time. This was the period when he was most strongly influenced by Peiresc, preferring to live under his roof for much of the time, rather than in his diocese. The surviving papers of Peiresc, under such headings as 'vision', 'unusual phenomena', 'history of Provence', 'alignment of mountains', 'underground winds', etc. are fragments of a vast Baconian research programme. Gassendi contributed to these obscure memoranda; and the information in his own Syntagma reflects this enthusiasm for collecting data on geology. The hypotheses were deliberately suppressed in order to mirror the Baconian technique of induction. But nothing could be more mistaken than to assume that he had no interpretations to offer. We return to this point in the sub-section HYPOTHESES AND EVIDENCE, but two small examples, the one relating to sun-spots, the other to aurora borealis, will illustrate the principle. Although he suggested a number of theories about the nature and causes of sun-spots in the Syntagma, the notebook contains page after page of pure data only. Like Newton, Gassendi classified mathematical measurement and tabulation as a part of the pure phenomenon. The aurora borealis, which Gassendi was the first to name and describe, received no published physical explanation until the posthumous Syntagma. His magnetic solar-wind speculations, by chance or shrewdness, were curiously close to those accepted today. It was not a shortage of ideas which made him distrustful of hypotheses,
but philosophical principle. It is an excellent example of the contrast between their styles of thought that Descartes published, without acknowledgement, Gassendi's paper on parahelia—which had been circulated privately among friends—as an example of his new method in the *Discours* of 1637. Whereas Descartes was keen to show a logical dependence of observation on theory, whether or not it existed, Gassendi went to the opposite extreme, burying hypothesis and evidence in different corners of his work.

Historians of science who have dismissed Gassendi as an example of the sterility of a Baconian refusal to theorise, promote the rectitude of some ideal 'method' at the expense of a serious effort to understand seventeenth-century practice. The whole point of Gassendi's extraordinary biography of his friend Peiresc was that it accorded, to a thoroughly secular Baconian pilgrimage towards truth, the sort of heroic historiography normally reserved for saints and generals. Something of the same spirit may be discerned in a poem written on Gassendi's own death by an anonymous Englishman in 1655:

'Whilst the peoples raged in wars and assembled incredible forces, by land and sea, for the most horrid deeds, a Gassendi emerged to outrival even the ancient generals in his achievements.'

To the historian of science obsessed with the glory of a dramatic personal discovery, Peiresc's biography appears singularly sterile. The discovery of a nebula in Orion and the introduction of the angora cat to France seem little enough to show for a life of dedication to science. But for Gassendi, and his circle, Peiresc's refusal of grand theory and his utter indifference to personal glory were virtues, rather than failures of will. Enormous personal effort for very slight tangible accretions in knowledge was seen as one of the notes distinguishing the new empiricist from the old scholastic. Tremendous ingenuity exercised in the quest of limited and perhaps
inconclusive results is much more characteristic of normal science than the brilliant flashes of illumination announcing the total certainty of great discovery. There was no 'open sesame' to method.\textsuperscript{20}

It might be argued that Gassendi's distrust of hypotheses and 'hallucination' was excessive. But it must be remembered that contemporary astronomy offered many examples of how premature theorising could distort the evidence of the senses. Take Galileo's proud announcement of the discovery of two satellites of Saturn which later vanished. Or Kepler's 'transit of Mercury' which was probably the first western sighting of a sun-spot. Or still more embarrassing the Jesuit Rheta's discovery of the shortlived 'Urban VIII' satellites of Jupiter, exposed by Gassendi himself. Astronomical theory and practical technique interacted at this time on the 'wing-and-prayer' principle of early aeroplanes. Historians of our own day often overlook this. Hence the necessity to isolate errors of observation from errors in theory, as far as was humanly practical. Gassendi criticised the pro-Copernican astronomer Lansberg because his widely used astronomical tables did not reflect raw observational data, but had been 'doctored' by the author's own epicyclic hypothesis.\textsuperscript{21}

In contrast, Gassendi had a deep admiration for Kepler, whose tables were based on minimal adjustments of Tycho's observations. The laws of astronomy, developed in his own books, were not used to make wholesale corrections of the tables but kept separate. This precaution was prudent. Until Newton demonstrated their universality, in the context of mechanics, no-one (including Kepler) described the elliptical orbit, the equal-areas rule or the periodic-times ratio as 'laws'. Kepler, like Gassendi, did not believe that working hypotheses, derived from a first approximation, should be confused with the sort of higher level theoretical analysis which only became possible once objective regularities had been established.\textsuperscript{22} In this
sense, far from being mystical, Kepler's methodology was an important influence on Gassendi. It was possible for Gassendi and his circle to compare the results of predictions based on Kepler's tables with the rather different results derived from deductions from his planetary laws. This is what Gassendi's distrust of hypotheses was all about; not the sterile philosophical debate of the eternal a priori versus fact-gathering. It was a practical question of methodology in the face of the problems of relating theory to observational practice in contemporary astronomy. But it had an ethical dimension, linked to the Epicurean and Aristotelean doctrine of the primacy of sense-data. Those who did not respect this principle were cheating nature. Gassendi's ethics were grounded in natural description, rather than supernatural imperatives, so that morality was not separated from utility in his approach to knowledge.

Consider Gassendi's debate with Descartes in the early 1640s, not in the light of the existence of God or the soul—the alleged subject—but in relation to their uses of astronomical examples. Descartes set great store by the distinction between the mathematician's idea of the sun and the crude sense-data of the peasant. The mathematician had a clear and distinct idea of the true nature of the sun—a body about 160 times bigger than the earth placed several thousand miles distant. The peasant thought it about a yard wide because terrestrial objects, like houses, clouds or mountains were his only standard of comparison. This illustrates the mathematical nature of truth. Gassendi's answer blended objectivity with relativism in a way which twentieth-century philosophers find unfamiliar:

1) Can any mathematician claim that he has a clear and distinct idea of the size of the earth's semi-diameter? Or can he claim to have a clear and distinct idea of its semi-diameter multiplied by 160
and extended between the earth and the sun? Surely the peasant's notion is more 'self-evident' than the picture induced by such mathematical operations.

2) Descartes' ideal astronomer would have to be blind and deaf from birth. It is not that the senses deceive and astronomical instruments give us true images instead. It is an observed fact that the senses do not give us exact or reliable information about quantities; even on a very human scale instruments of measurement are always needed for a precise result. But these instruments, like those of astronomy, are not contradicting sense-data but improving and supplementing it.

3) The antithesis between senses and measurement is false. We measure the astronomical sun in earth radii because the earth is known to our senses. We guess that the sun is a sphere, not a disc, because of our experience of seeing round balls on earth and our knowledge that perspective can make them seem flat.23

Gassendi's own philosophy is characterised by relative approximation on analogy with the following triplicity:

1) THE SENSES          2) INSTRUMENTAL KNOWLEDGE          3) ABSOLUTE KNOWLEDGE

Early 'Poetic' Civilised Societies God
Science

The key to the relationship of 1) and 2) to 3) lies in contemporary philosophy of mathematics and of the calculus in particular. Although absolute truth was, in principle, inaccessible to humans—this was the point of his rejection of Descartes' claim to knowledge of God and the soul—1) and 2) might be regarded as converging towards 3), without actually reaching it. Instrumental knowledge, through the accumulation of data and the acquisition of new perspectives from other civilisations, possessed an empirical
Another mathematical idea, probability, explained why degrees of certainty were possible, though absolute certainty was not. This justified Gassendi's emphasis on accumulation of data over very long periods of time, transmitted and processed by a variety of civilisations. Gassendi was neither a sceptic nor a realist in the sense which philosophers of science attribute to these words. He dismissed as fantasy Ramus' theory that an astronomy could exist which merely described observations, without venturing any hypothesis. He denied Ramus' claim that the Babylonians were an example of astronomers who relied on pure data. This gives us an insight into Gassendi's view that astronomical data were building blocks in the temple of knowledge which might be impacted or distorted by the over-hasty hypothesis but were virtually indestructible. There is an obvious parallel between the atomic theory of matter and this atomic theory of truth.

Aware that Copernicus and Ptolemy were observationally equivalent, Gassendi drew a conclusion diametrically opposed to that of modern advocates of a paradigm-theory of science. Precisely because the astronomical data could survive so many different constructions, it had the same primacy over the hypotheses as did primary over secondary qualities in the constitution of the cosmos. This may be illustrated with reference to Democritus' prediction, based on the atomic theory, that the Milky Way was a mass of individual stars. Not until Galileo was there data available confirming Democritus. This was a classic example of Gassendi's view that science was a millenial process (2,000 years separating Democritus from Galileo) and of the intertwining of fact with conjecture over that period. Democritus was not making a 'pure' conjecture any more than Galileo's telescope imaged 'pure' fact. In his original guess Democritus had been guided
Figure 2. Moon, age seven days (first quarter).

GASSENDI'S MOON MAPS (1635) a series of 12 later used by Hevelius for a *Selenographia*. Nellen's engraving compares well with modern photography.
not by the 'authority' of atomism but by observed facts about the earth and heavens which led him to an informed analogy. Science argued through 'signs', not absolute demonstrations. The improvement of telescopes would certainly yield new facts about the stars to modify or confirm Galileo. 26

The views expressed by some historians of science about the metaphysical complexity embedded in 'the scientific fact' or the impossibility of pure description make some of Gassendi's thinking appear simplistic. 27 But the argument that, in the long term, fact is prior to interpretation and that, in the short term, pure and value-free description is perfectly possible has at least citizen rights in the republic of letters. In this respect it is instructive to compare Gassendi's maps of the moon with those of Galileo, which Feyerabend cites as evidence for the impossibility of pure description. The deficiency of Galileo's map should be attributed to purely technical causes—as is clear from the fact that Gassendi's maps, done by a professional engraver with a better telescope over a much longer period, are indistinguishable from modern photographs taken through similar instruments. It was characteristic that these maps should be unsullied by any misleading nomenclature of seas or famous scientists.

This dull empiricism does not mean Gassendi and his circle were without theories about the lunar landscape. Gassendi knew Kepler's son, the publisher of the science fiction Somnium and Cyrano de Bergerac's fantastic voyages to the sun and moon were based on ideas current in Gassendi's circle. Speculation about circular temples and even observed activity on the moon was rife at the time Gassendi did his maps. It was Kepler who had called for accurate moon maps as a guide to future space travellers. It was the distinguishing of fact from fiction which was Gassendi's peculiar skill. As he wrote
GASSENDI'S MOON-MAP CONTRASTED WITH
GALILEO'S (made twenty years earlier)
to Descartes, answering the latter's claim that he had no means of telling whether he was dreaming or awake: 'Though I have dreamt that I am in Paris and wake up in my old room in Digne, a thousand minute circumstances present themselves to persuade me that I am really in the Deanery. Familiar possessions, books, the memory of the preceding night's journey from Paris, all cohere one with another—whereas my memories of the dream have no such consistency.' It is not the early-modern scientists, but those who—for reasons which are unclear—have sought to emphasise the irrationality of the cognitive enterprise who are the sleep-walkers.
1) Methodology


2 0.0. IV passim. Because no copies survive, the radius has been little understood by historians of science. I am grateful to Dr Chapman for discussion of some of these points and for showing me his model of a radius. Also to John Roche for drawing my attention to his article in Annals of Science 1981 38 pp.1-32 which is especially interesting on problems of calibrating the radius. He points out that historians have neglected the analysis of Gassendi's notebook, and that his methods remain obscure.

3 C. Ronan Edmund Halley 1968 p.59 Halley claimed an accuracy of 5'. This is about the same order assumed by Gassendi (though seconds feature in his calculations because of the fineness of the scale).

4 P. Humbert L'Oeuvre Astronomique de Gassendi 1936, Philosophes et Savants 1953, etc. has a very high opinion of Gassendi's technical skill.

5 Lettres de Peiresc 1893 IV ed. Tamizay de Larroque, who disliked astronomy and cut out passages without warning. Therefore should be checked against BN f.fr.12772.

6 0.0. VI contains many letters on astronomy, which may be cross-referenced with IV. Gassendi composed an astronomical handbook for amateurs, commenting: 'Perhaps this may one day be used on the banks of the Ganges.'

7 0.0. VI pp.38, 46-7, 332.

8 Among Protestants: Kepler, Rivetus, Revensberg, Snell, Schickard, Bainbridge; among Catholics: Fr. Wendelin, Bishop Caramuel, Lobkowitz, Fr. Scheiner S.J., Fr. Kircher S.J., Cassini (founder of an astronomical dynasty), Galileo (whose numerous letters to Gassendi between 1626 and his death have unfortunately disappeared).

9 Jacques de Valois—one of Gassendi's earliest patrons outside Provence—should not be confused with Louis de Valois (Governor of Provence). But Jacques, whose mother was Scottish, was also a Valois bastard.


12 Philosophical Transactions of the Royal Society 1711 p.274-5: It has been argued that this letter (Crabtree-Horrox 7 August 1640) was an attack on Gassendi. (n.10 p.7). It is actually a confirmation of Gassendi.

13 For the original Latin text 0.0. IV pp.99-100, which was communicated only to Peiresc in 1626. B.M. Add. 4021 f.5l-61 (Gascoigne to Horrocks Nov.1641). Gassendi knew Mydorge from the early 1620s.

14 He published it in 1662.

15 There is a catalogue of the Peiresc papers at Carpentras, but see also B.M. Sloane 767 f.68 and W. Gravit The Peiresc Papers 1955.

16 Crabtree's use of his own sun-spot observations, combined with those of Gassendi, was in the spirit of Gassendi's epistemology. Both claimed they provided 'probable reasons' for suspecting that Kepler and Galileo were correct.
Among the more probable causes (cf. n.17) of the Aurora were an irruption of magnetised particles from within the earth; a phenomenon which he compared to the solar production of sun-spots on a much smaller scale.

Rochot points out that through Eli Diodati, the fourth member of the Tetrad, who travelled in England and the Netherlands, Gassendi was intimate with someone who had actually met Bacon. Les Travaux de Gassendi 1944 p.27 Rochot and Koyré both assert, mistakenly, that Gassendi refused to accept anything not known to our five senses.

B.M. MS 6193 add.f.996.

Feyerabend Against Method 1975

0.0. VI p.209 A History of Astronomy Dreyer (Dover) p.420

J. Hübner Die Theologie Kepler Zwischen Orthodoxie und Naturwissenschaft 1975 seriously modifies the picture of an astronomer with a 'medieval mind', integrating physics with theology.

Spinoza re-stated Gassendi's argument Ethics (Everyman) p.17. Gassendi's argument was strengthened by the widely differing estimates of the sun's size and distance current at that time among astronomers (see R. Lenoble Mersenne: Naissance du Mécanisme pp.455-7). Much of Gassendi's own correspondence is taken up with comparing different estimates. Mersenne regarded the sun as 140 earth radii in size, Gassendi, 'more than 160'. The modern estimate is 218.

The first to draw attention to the importance of Gassendi's theory of vision was Bloch La Philosophie de Gassendi, chapter 1. 0.0. III p.653a.

0.0. V pp.574-5 'Non habeamus astronomiam immunem hypothesibus.' Compare Ramus Scholarum Mathematicarum Libri 1569

0.0. I pp.82-4.

e.g. L. Fleck Genesis and Development of a Scientific Fact 1979.
If Gassendi's insights into the nature of astronomical method were so profound why were his practical results so meagre? In this sub-section I propose to argue that they were not meagre at all. The distrust of hypotheses was so far-reaching that it frequently prevented him from publishing his own conjectures in full. Examination of the notebook shows that although its Baconian form makes it appear a mass of random observations it was actually a tool for a very precise research programme. Observations were often closely related to 'conjectures' — problems which Gassendi preferred to leave unstated and which are not fully elucidated in his published work. We can document this from the text, where Gassendi inserts references to 'hallucinations' — his term for a theory which has apparently been confirmed by facts but which may still involve an element of wishful thinking — or to unnamed 'conjectures', a term which he substituted for 'working hypothesis'.

Fr. Boulliau, in his *Astronomia Philolaica*, stated that he used Gassendi's data to calculate the elliptical orbit of Mercury — thereby confirming Kepler's law. He further credited Gassendi with a study of the lunar orbit and particularly an elucidation of the phenomenon of libration. Gassendi's own works are silent on these claims. We have the most indirect references, such as the letter he wrote to Schickard of Tübingen, who had been Kepler's draughtsman and collaborated on his *Harmonice Mundi*. Gassendi sent Schickard what he called 'raw data' on Mercury, straight from the notebook. Gassendi wished Schickard to make certain calculations to confirm an existing 'conjecture' but seemed to be carrying Baconianism to absurd lengths by refusing to tell Schickard what theory he was checking. But there were other than scientific reasons for Gassendi's caution. He was writing the year after the condemnation of Galileo and stated cautiously
that if he revealed what his theory was it might expose Schickard, as a Lutheran pastor, to accusations of 'hallucinating' but Gassendi, as a priest, to the charge of 'sacrilege'.

What was the conjecture? The use of the phrase 'leges numerorum Mercurii' (numerical laws governing the orbit) in both the letter to Schickard and in Boulliau's analysis of the elliptical orbit, suggests that the same problem (Gassendi sent them both similar observations) was in question. Yet there is no reference to any of this activity in any of Gassendi's other letters or treatises. We do, however, have a very curious Latin poem which Gassendi wrote, on the death of Schickard. The astronomer had collapsed and died, in the middle of writing to Gassendi, soon after receiving this commission. But the poem implied that this was not before he had been able to confirm the truth of Gassendi's own conjecture: 'Weaving the numbers so as to expose the orbit's certain laws...unfurling the radii of the wandering stars, cutting the thread of fate, to trace the labyrinth.' But without Boulliau's book, published ten years later, and the correspondence with Schickard no one would have any hint as to what this discovery might be. The most striking thing about the poem is that for once in his career Gassendi implied that he himself had discovered something to wax lyrical about. For him this secret conjecture (was it on the ellipticity of the hidden part of Mercury's orbit?) turned out not to be an hallucination. Granted the significance of Mercury as the most strenuous test-bed for any new astronomical hypothesis, the problem might possibly have had a more general significance. This dimension is explored in the next section. Gassendi's obsessive secrecy in this case, and the fact that he could only unburden himself to a Lutheran, undermines the twentieth-century view that the Church's hostility to a Copernican physics had no effect on Catholic science. Kepler, just as much as Galileo, was
under the clerical ban. Gassendi's caution on this occasion was
amply justified by the accusations made against him twenty years later.
(see section iv)

Apart from Boulliau, the best evidence that Gassendi was using
his observations to make a serious study of lunar motions is the
series of twelve maps of the moon, already referred to, which would
have been indispensable if trying to measure the libration effect—
or the variations in geography which the one visible half of the
moon presents at different times of the year. How typical of Gassendi
to send a set of these maps to Galileo, before he went blind, for a
study which he was making of the same phenomenon. By piecing
together what Boulliau and Wendelin attributed to Gassendi in their
books with the somewhat enigmatic remarks on lunar motion scattered
round Gassendi's published works, it is possible to guess the reason
for his reserves about making the direction of his research public.
In his own work Gassendi often referred to lunar motion in terms of
a composition of pendulums. As an analogy, in terms of the physics
then known, this was imaginative but inadequate. But his application
was more subtle than appears. As correspondence with Wendelin shows,
they were actually thinking of a mathematical analogy. Just as the
period of a pendulum was determined by the square root of its length,
so the gravitational action of a planet varied as the square of the
distance. The reason why so many observed phenomena relating to the
moon were harmonic, periodic oscillations, from which the planetary
orbits were relatively free, was to be sought in the joint influence
on the moon of the earth and the sun. This interpretation was very
close to that of the nineteenth-century astronomers, who pictured the
moon's eccentricities as the complex resultant of distinct mathemati-
cal series of overlapping waves (the graphs of the lunar anomalies
discovered by Ptolemy and Kepler).
Gassendi's mathematics was neither complex nor powerful enough to resolve these problems. But that does not detract from his insight in seeing that gravitation must be viewed as a series of isolated systems, interacting at different levels in obedience to universal principles. This enabled Gassendi to resolve the earth's tides into three wave-effects: the earth's rotation, relative to astronomical space, the 'pendulum' of the sun, and the 'pendulum' of the moon. Gassendi's casual claims to be able to resolve the anomalies which had troubled Kepler's magnetic system—the rhythmical precession of the nodes, the equinoxes, the oscillation of the planets in latitude—have passed unnoticed. But those are startling assertions from someone who distrusted hallucination and hypothesis. It should now be clear why, although the moon might seem a safe enough topic even for a convinced Copernican, Gassendi presented a mere verbal sketch before the public. No system of universal gravitation lent itself to the demonstration of a Tychonian cosmology, even when confined to the moon.

That Gassendi was convinced of the existence of a material, universal, reciprocal gravitation, he did not conceal. But far from seeking to muster all the evidence in its favour, he contented himself with what appeared to be largely assertion—an attitude which seems impossible to reconcile with his sceptical rejection of hypotheses. In the notebook is a clue to the possibility that these assertions did not contradict his sceptical methodology. Rather, he had deliberately weakened his case by suppressing his best evidence in order to beguile his clerical critics. This is especially evident in his controversy with Morin, where he would clearly have destroyed the credibility of his claim to accept geocentrism 'on faith and the prejudice [praecjudicium] of the papal decrees alone', if he had at the same time deployed the full weight of his own physical and astronomical evidence. An excellent example of his caution in this debate is his use
of the Foucault pendulum—which he correctly surmised demonstrated the daily rotation of the earth—and his observation of meniscus 'lag' in a rotating bucket. Both these experiments implied a definite answer to Cardinal Bellarmine's question, 'If the earth is a boat where is the fixed shore to measure its relative motion?' The answer was space itself. But, although Gassendi quoted the examples, he refrained from stating the conclusions—even though inertial motion relative to a fixed space was central to his cosmology. This sort of precaution, or astronomical double-think, was not second nature to Gassendi, but became so after 1633. For example, in a private letter to De Valois, on his 1640 galley experiment, Gassendi emphasised that one of his principal motives was to refute Fr. Clavius and the Jesuits, who had been the most insistent about the impossibility of inertial motion. But there was no mention of any falsification of the views of the distinguished papal astronomer in his published treatise or in the long controversy that followed.

A more serious example of information suppressed is in the low profile given to Kepler and his laws in his published works. Although there are many detailed observations of Jupiter's satellites, their positions and variations in brightness in the notebook, it is only from a casual aside in an obscure pamphlet of 1643 that we learn that Gassendi had used these observations to verify that what he called 'the admirable proportion' (the 3/2 constant between periodic times and semi-major axis in any planetary system) applied to the satellites as accurately as it did to the sun and planets. His observation of the transit of Mercury in 1631 was publicised throughout Europe, with copies to Kepler and the Pope himself. But this blaze of self-publicity, which was Gassendi's only achievement in astronomy to be recalled, grudgingly, by Bailly in the eighteenth century, contrasts with the secrecy in which he enveloped the total research programme
nulla tesselatione versus basem procederet, aequitatemque in ellipsi, 
pro evidentia erit, peines angulos eccentricitatis. Non cerniunt tamem 
qua constitutione concinnitas illa, quam in ellipsi liber. Hucus operis 
appellimus, nec aequales sunt FH, EG in ellipsis sectione, cuius 
vmbrius cum aequo contientur.

Aliam demonstrationem conficiemus in alia parte ellipses Mercure 
habita observatione. Petri Gassendi ab ipsa habita anno 1635. Di- 
ne Decembris die I. Hor. 5. 30. Vranibergi 1. 5. 3, Accepit distinctas 
Iludicam duarum, quae & Borealis Seapulz finisre Ophiuchig: 31. 25. 
\(x^0 a \text{ lucida seu } x, \text{ cappis } g. n. 1. \text{ Vnde Mercutii locis colligitur, in } \) 
\(g. a^0 3^a 4^b 49. \text{ Meridionalis } g. 1. 32. \text{ fere. Est supra horizontem auras } \) 
\(g. 1. 10. \text{ ita vera alterius illius } \) 
\(excederet g. 1. 20. \text{ ita ver infra dictum est. } \) 
\(g. n. 12. \text{ cuisi in longitudinem aequatis fere, } \) 
\(g. 1. 26. \text{ Porro refractio qui Canam Mercurium plu- } \) 
\(mi attollat, causa est, quae ex calcule inuenimus latis in } g. r. 
\(g. 1. \text{ equabat. } \)

Boulliau and 
Gassendi work out 
Mercury's orbit (following Gassendi's 
early work with 
Shickard)
on Mercury. Gingerich has claimed that the transit was the first convincing factual verification of the heliocentric ellipse.\textsuperscript{10}

Evidently this was not Pope Urban's view but, in the light of Gassendi's complete calculation of the dimensions of the Mercurian orbit (some time in early 1635), it is not difficult to understand why Peiresc and Cardinal Francesco Barberini (who were both close to Gassendi) should have been so dogmatic in their insistence that the Galileo decree was a disaster for the Church.

Saturn's rings were discovered by Huygens the year after Gassendi's death. Even a casual glance at the notebook shows Gassendi's special interest in Saturn, perhaps—after Mercury—his favourite planet. It is impossible not be struck by the similarity in the series of drawings of the planet in the notebook and Huygens' own drawings, made shortly before and after the discovery.\textsuperscript{11} Once again, Gassendi seemed to miss the 'glory' of discovery. Or did he? Remember that the notebook was pure data. But the formation of private conjectures was to be the principle on which data was collected, absences and presences registered. His observations on Saturn were a model of effort to achieve value-free description and observation. Even the most orthodox modern subjectivist would be impressed.

Starting with the primitive 'lemon' observed by the tireless Peiresc, he was envisaging by 1633 'a planet like a silkworm in a cocoon, with rays on all sides forming two handles'. By 1652 his drawing shows the two 'handles' explicitly, like two halves of an oval track, with Saturn symmetrical in the centre. 'The handles were so elongated, they seemed to fuse together as the white round the yolk of an egg.' At this time Gassendi had a rapidly growing number of personal and political problems, but Saturn clearly had aroused his intense interest. He noted that the 'handles' appeared now parabolical, now hyperbolical, in shape (two of the three conic sections), and he described the 'handles' as 'sickles'. Here an element
Drawings of Saturn after those made by Huygens

I. p. 322. One of the first drawings.


VI. p. 443. Saturn observed May, 1669 (Huygens, Picard and Cassini).

A drawing from Huygens's Manuscript K. (1675).

Dec. 27, 1657.
of mythologising crept in, for the sickle was Saturn's traditional attribute. But no one who has seen the shape of the instrument held by Saturn in Greek paintings can doubt that two sickles equal one ring. But Gassendi's fidelity to his professed priorities: accumulation of data, estimate of probabilities, refusal to speculate, proceeding by approximations to truth, meant he would not take that step. Further 'signs' were required. Gassendi was particularly interested in the cycle of appearances and disappearances of the 'sickles' which had so misled Galileo. Although he never formulated the conjecture explicitly, his notes show that he had grasped that their pattern was determined by the relative positions of Saturn and earth, at the extremes of the former's thirty-year orbit.

Even on his death-bed Gassendi was excited by 'certain reasonings' (unstated) about the planet Saturn. He would not rest until La Potherie promised to make a test-observation after his death. But why did it have to be after Gassendi's death? Because Gassendi had realised that the disappearance of the 'handles' followed a fifteen-year cycle, determined by Saturn's thirty-year orbit. They were so thin that they became invisible when viewed 'end on' with earth and Saturn directly in line. This explains the point of the strange posthumous entry in the notebook showing a Saturn 'without rings on January 1656. The following month the rings reappeared and were observed from Holland by Huygens with a new powerful telescope, superior to Gassendi's. But Huygens' discovery was no lucky piece of chance. Two years before he had discovered a moon of Saturn near (he used Gassendi's term) the 'ansa'. He already had a number of close links with Gassendi. The ubiquitous Eli Diodati had been a guest of his diplomat father. He had corresponded, almost as a child, with Gassendi's friend Mersenne. Wendelin, Gassendi's old teacher and tireless correspondent, was a friend of the family. Huygens' invention of the pendulum clock, shortly after Gassendi's death, was inspired by the problems of using
Cassendi: Astronomer

Fixed

lines of sight

adjustable pinnacilia

(observer)

ball & socket to allow for earth's motion

adjustable pinnacilia

sun

astronomical globe

transverse scale

level

quadrant: showing
till the type with a movable sight and the type with a plane line for measuring

0 10 20 30 ÷ 10,000 ÷ 5,000 (use Tables)
a free-standing pendulum to time astronomical events. Gassendi had passed this technique on to Wendelin, who taught it to the young Huygens. But in July 1655, when Gassendi—according to Sorbière's pious fiction—was entirely occupied with 'preparing for his wedding to the immaculate lamb', Huygens was frequently closeted with Gassendi. Their topic of conversation was unlikely to have been religion. Huygens' later writings show him to have been of one mind with Gassendi on this question.

No doubt the problem of Saturn, in view of Gassendi's mysterious 'reasonings' and Huygens' recent discovery of a satellite, was aired. Another likely subject was Gassendi's theory that scientific method was a quest for 'the aurora of probability', rather than the 'covenant box' of certain demonstration. Gassendi's theory was that absolute truth as envisaged by logicians and theologians was, in modern terminology, 'an empty set'. We know that Huygens first became interested in the mathematics of probability at this time and in his classic introduction to the *Traité de Lumièreg* he expounded a purely Gassendist view of the limits of certainty in the scientific enterprise. It is therefore curious that, until recently, Huygens was classified as a Cartesian. Gassendist elements are conspicuous in his wave-theory of light, his science-fiction writings, and his sceptical reserves about Christianity. Though a physicist and mathematician of the first rank, whose alleged credo was 'The world is my country and science my religion', Huygens has been unaccountably neglected by twentieth-century historians. The obscurity of Gassendi's astronomical achievement is more comprehensible. Fear, not so much of being burnt at the stake—though Mazarin did threaten him with the gibbet in 1653—but of embarrassing a Church which had pinned its faith to propositions which he knew would prove untenable, kept him in Pythagorean silence. Then there was the added complication of his probabilistic-descriptive
model of science, his distrust of causality and absolute demonstration. These were compounded by a Delphic addiction to signs and tokens, scattered liberally through his work, presumably for the benefit of 'golden spirits' and 'philosopher-kings' yet to come.

Gassendi's work displays a picture of meticulous effort, an extraordinary willingness to exchange ideas and information within the astronomical community, and an unprecedented enthusiasm for comparing sets of observational results: his own, those of his contemporaries, Greeks, Arabs, Persian, medieval Jews. It is important that we realise, as Gassendi clearly did, that astronomy is a cumulative process. Revolutionary change is only one perspective; and somewhat narrowing if we lose sight of Gassendi's dictum that every astronomical observation is unique. It is an illusion, due to our inability to register the changing relative positions of all astronomical bodies everywhere, that makes us regard astronomical events as purely repetitive. The talents of the humanist were needed, in seventeenth-century astronomy, to interpret ancient texts and measure accurately any long-term changes. There was nothing freakish about Gassendi's interest in ancient history and the astronomy of other cultures. Boulliau, Halley, Peiresc and Greaves had a similar mix of classical and mathematical interests. It was part of the pluralism of the humanistic outlook that it was necessary to see the universe through what might be termed the 'parallax' of two or more cultures. Gassendi measured the parallax of the comet of 1653 by matching his own sightings with those of a Dutch observer and using Snell's measurement of the distance between them. This sort of comparison explains why Gassendi was so keen on observation 'for its own sake'. Precisely because two astronomical events were never the same, the comparison of two similar sightings, distant geographically or in time, was the best way of generating reliable data. In the same way, to
study the problem of vacuum through Greek writers put seventeenth-century experiments on the subject in a more exact perspective.

Gassendi was particularly interested in measuring astronomical distance—an area which had been blown open by the Copernican introduction of the 'great circle' of the earth's orbit as a yardstick which dwindled to a point beside the fixed stars. Kepler's work, which made it possible to derive distances from periodic times, was fully appreciated by Gassendi. The possibility of applying the ratio of Galileo's law to the heavens also brought in distance. Gassendi, Fabri, Mersenne and Wendelin all discussed together the problem of bodies 'falling' from one orbit to another. They considered the pendulum effect of gravitational attraction translated into the problem of an earth, pictured as a 'stone', falling towards a sun 'earth'. He discussed the problem of an exact measure for the earth radius with Snell—the expert—as early as 1618. Gassendi's pupil Picard, who had been a gardener's assistant, was turned into his personal astronomical and terrestrial surveyor—using Snell's' triangulation techniques. The abbe Picard was a sceptic in religious matters. It was he who supplied the earth measurement used by Newton in the *Principia*. He co-operated closely with Huygens after Gassendi's death and used the satellites of Jupiter to make the first accurate measure of the speed of light. Interestingly, if Newton had used Gassendi's private estimate of the earth-moon maximum distance (61 Snellian earth radii) his earliest calculations of lunar gravitation would have been a much better fit. It was this preoccupation of seventeenth-century astronomy with establishing better approximations to true distance which distinguished its methodology from that of the ancients, primarily concerned with predicting appearances. The astronomer was closer to the surveyor at this time, both in goals and in techniques, than either before or since.
1) Concealment

1 Loc. cit. pp.178-81.

2 0.0. VI pp.71-2. The text is heavy with enigma and mystery:
'longe sum tamen ab eo tempore quo expetitum usam deducam et
livoris expers nihil plane est quod habeam quasi in arcanis...
certo consilio anim.' (August 1634)

3 0.0. VI p.64 This poem was not for publication. It was sent to
Bernegger at Strasbourg, who was a key figure in the underground
circulation of Galileo's work. The poem refers to Schickard and
Gassendi as Pythagoreans who were sworn not to reveal their
science.

4 0.0. VI p.92b December 1636 Drake Galileo p.385. This work was
complete by November 1638. For a more philosophical influence of
Gassendi on Galileo, see our ATOMS AND INDIVISIBLES.


6 0.0. III p.276; II pp.9-10 - 'no proof' the earth moves, therefore
Church and Bible to be accepted. He distinguished geocentrism from
doctrines, where the authority of the Church was absolute.

7 0.0. IV p.50 In his public astronomical lectures Bellarmine's
argument is presented as unanswerable (1646). There is no mention
of pendulum or bucket, IV pp.520-22; both known to him since 1635.

8 0.0. VI p.109b.

9 0.0. IV p.518a As early as the 1620s Gassendi noted the 3/2 proportion
of the axis to the diameter of a snowflake.

10 Actes du- XIIe Congres International d'Histoire des Sciences 1968
p.60 O. Gingerich O.0. IV pp.499-510 dedicated to Schickard.
M. Bailly Histoire de l'Astronémie Moderne 1785 II p.237 merely
mentions the inaccuracy of his measurement of Mercury's diameter.
His silence on Gassendi contrasts with his interest in Hevelius and
Wendelin, who are very fairly treated, and may not be unconnected with
Bailly's membership of various secret societies, including masonry,
See FRIENDSHIP and the article by E. Smith,'Astronomy, Mystic, Revolutionary —
Bailly', Transactions of the American Philosophical Society 44 1954
pp.465-7

11 Gassendi 0.0. IV passim.
Huygens Oeuvres Complétes I p.322 II p.224 etc.

12 0.0. IV p.441 October 1641 no rings. It had been 1626 when they
disappeared for Galileo. Therefore, a fifteen-year cycle would
predict their disappearance in January 1656.

13 0.0. IV p.480

14 Dictionary of Scientific Biography IV art. 'Huygens', Bell Huygens 1950
pp.27, 105.

15 Sorbière preface (non-paginated) Opera Omnia.

16 0.0. I p.2868 'I may still seek for physical causes, in the manner so
described, and the soul should not despair because certain intimate,
privileged, special areas are forbidden it. It is not a matter of
lamenting our unworthiness but of realising that there are various
gradations of cause and degrees in our understanding...it is only the
similitude of that splendid sun of truth, the aurora of probability,
which brings us as close to the summit as possible.' cf. Huygens
Traité de la Probabilité 1690 p.3 seq.
17 Op cit n.14

18 Panurgii De Tribus Impostcribus pp.109-10 Gassendi's secret Copernicanism and contempt for the papal decrees was one issue. Secret paganism and infidelity were evidently more serious.

19 Neugebauer's Ancient Astronomy (3 vols) and his Exact Sciences in Antiquity reflect an outlook closer to Gassendi's, on matters of tradition and methodology, than more popular books on the history of science.

20 0.0. IV pp.497-8


22 For Picard's notorious bi-sexuality see Chatsworth Hobbes archive (57) Du Verdus to Hobbes. This also contains a coded account of Huygen's discovery of Saturn's rings. For Picard's science see Huygens et la France ed. R. Taton 1982 pp.86-7, 34-8 and 70.

23 0.0. VI pp.6-10 to Snell Principia p.469 (3rd ed.) In his public Astronomical Lectures for Newton's early knowledge of these see Whiteside Journal of the History of Astronomy I 1970 p.7 and J. Harrison Library of Isaac Newton 1978 p.62). Gassendi gave the less accurate figure of 59 semi-diameters for the mean distance of the moon.
Of his analysis of the transit of Mercury Gassendi wrote to Schickard 'serio ludo' (It is all a game but one I take seriously.) To use such a motto at that particular time was strangely ironic. Gassendi had just (1631) completed his treatise against the Rosicrucians; 'serio ludo' was their motto. This attitude was explicable in terms of Gassendi's new philosophy of science. This led him to insist on the primary seriousness of assembling, and deducing regularities from, phenomena alone; whilst treating all hypotheses with a touch of humour, indicating sceptical suspension of judgement. This applied particularly to hypotheses which turned anthropomorphic values into universal principles; like Kepler's planetary harmonics. Gassendi's view of hypotheses is most clearly expounded in a letter to Wendelin of November 1644, in which Tables, and the deductions to be made from them are contrasted with the subjectivity of theories which invoke any universal cosmology. The similarity of the argument to that presented by Boulliau in his Astronomia (published the following year) is evidence of the interlocking methodological perspective held by these three writers. Boulliau used the distinction, in exactly the same way, to drive a wedge between Kepler's cosmological metaphysics and the principles which could be geometrically deduced from the regularities which he had uncovered among the phenomena. This consensus indicates the total eclipse of Mersenne's earlier arguments, that the certainties of science were a check on the religious sceptics, and that the successes of science justified the dogmatic position of theology. Perhaps most significant of all was Mersenne's own desertion of this argument, at some time in the 1630s, for a position very similar to that held by his friend Gassendi. But, whereas Mersenne still wrote of certainty in heaven, Gassendi's own views were fixed on the possibilities of knowledge open
Science was an edifice in course of construction; jerry-building would leave only more 'hallucinations' to confuse the builders of the future. Therefore Gassendi preferred to leave the theorising to others (judicio posteris relictio) for 'a good wine needs no bush so be content with your tables...just as the ancients left us much to discover, which has filled up the time nicely, we should not rob the future of all occupation?' What is important to realise is that Gassendi and Boulliau regarded geometrical deductions, based on the phenomena, as part of the phenomena—not hypotheses; also that Gassendi was not condemning hypotheses in principle (his Syntagma is full of them) but re-classifying them on a conjectural level. This attitude recalls the classification of conics, according to equation, undertaken by his friend Fabri.

One curious feature of the letter is that it implied that Wendelin and Gassendi were in possession of some important yet unverified hypothesis themselves. It would make little sense for the latter to urge the former to renounce guesswork and the possibility of personal fame (commendationem ultra fas non quaerunt) unless some spectacular conjecture had been discussed between them. We shall return to this point. Meanwhile, note two Newtonian echoes from this letter (published in 1658). One is Newton's proud boast 'hypotheses non fingo'—a claim which has been much discussed by later commentators and whose meaning is clarified in the context of this letter. Newton was asserting that his hypotheses were congruent with the phenomena and were not mere speculations twisting the evidence to gratify his love of fame. Like Gassendi, he was not arguing that all theory was bad and science a mere jumble of facts, but that certain attitudes to theorising were undesirable. This parallel gains added point from the publication of Descartes' Principes, which Newton firmly rejected, just before Gassendi's letter was written. For Gassendi, as for Newton, Descartes was a classic example of twisting the phenomena to the hypothesis from
dubious motives. Another echo may be traced from Gassendi's expression to be moderate in fame-seeking and not to seek praise beyond the divine limits (fas)." In the final line of his ode to Newton, Halley wrote of a fame which reached so close to the divine limits (fas) no mortal could come any closer. Both Newton and Gassendi used 'hypothesis' to mean a statement which entailed assumptions about the universe as a whole; whereas Gassendi argued we could know it only piecemeal, and from a human standpoint.

Gassendi's concept of hypothesis and evidence combined objectivity and relativity, scepticism and realism in ways unfamiliar to those nursed on post-Cartesian dualisms. Gerhard Hess understood that objectivity was the key to Gassendi's attitude to Copernicanism. It provided criteria for immobilising religion in such a way that it would do minimum damage to itself, while allowing science that freedom which Gassendi regarded as a pre-condition for all pure enquiry. Hess extracted the following maxims from Gassendi's writings, and I have amplified them with examples:

A) NO OCCULT CAUSES OR ACTION AT A DISTANCE
nullus effectus sine cause, nulla causa sine motu (0.0. I pp.449/57)

B) EVERYTHING DEVELOPS IN STAGES THROUGH TIME
Atoms and molecules form seeds which are sub-microscopic and generate all visible things (0.0. II pp. 283--47). Time itself is a fluxus (not a series of points).

C) ALL SUCH DEVELOPMENTS AND CHANGES FOLLOW CERTAIN LAWS
ordinemque cursumque naturae, certe lege succedentes (0.0. I p.494). Everything is natural—the categories of the violent and the unnatural are anthropocentric errors. Although these laws may be obvious (e.g. nature always acts by the shortest route) they are not absolute. It is for mathematics, observation and records to uncover slowly their hidden application. Astronomy is the exact science which came first in time and therefore models for the rest.
D) CONSERVATION OF MOTION ipsa principia (I 638b)

Principles of motion (see sections GALLEY, GRAVITATION) formulated by Gassendi were not codified into laws, but in practice they were applied by him universally to the nervous system, comets, boats, geology, animals etc. The constant flow of time was closely linked to motion and acceleration.

E) UNIFORMITY OF MATTER, UNIFORMITY OF SPACE

This was part of C), making nature—though unknowable in essence—uniform with itself. He made no distinction between heavens and earth, planets or a field of decaying corpses, so far as hidden harmonies were concerned. If there were a plurality of universes in Gassendi's cosmos, it would be unimportant. However diverse their inhabitants, they would conform to the same physical laws: that is, they would be one universe.

The whole point of these principles is that they were not offered as absolutely certain axioms. Collecting them together would distort the subtle nature of his objective/relative mix, if we did not recall some of the qualifications imposed by his scepticism on human capacity for knowledge. For example, although A) seems unambiguous enough, it was substantially modified by Gassendi's principle that knowledge was limited by the senses. The sources of all natural activity were not merely sub-microscopic but beyond any conceivable microscope. Vapours or gravitational action were mysterious in a technical sense; not because their principles were magical but because they were unknown. The best mechanical explanation available, from a range of possible models, was a mere human approximation. Although everything might have a cause, causes had to be deduced indirectly from signs and observations. There could be no direct knowledge of cause in the Aristotelian sense.

Gassendi's God was a conjuror—not the magician but the great illusionist.

Similar qualification might be made to B) and C). The ultimate mechanisms of growth, the semina, might be imagined but could never be
known absolutely. Although he regarded nature's laws as certain and universal, Gassendi—unlike Descartes—drew a sharp line between the order actually in nature and the laws abstracted in human textbooks. Although he admitted that we need to understand nature as best we can in terms of our available data, Gassendi did not accept that such 'figments', even when supplemented by the accumulating capital of human experience, could pass beyond the limits of human understanding itself (modulus). The modulus was a natural limit on penetrating the true laws (or harmonies) and a 'shadow of probability' fell between the best approximations science could make and the truth. Accusations that he was not a consistent sceptic, because he dabbled in metaphysics are beside the point. Gassendi's methodological presumptions about nature cannot be called a metaphysic, since no transcendent claims were made for them, and they received only a token integration with any supernatural perspective. Their purpose, for their author, was strictly utilitarian. He wished to give science a scaffolding of assumptions to establish criteria for analysing data. He wished to set limits to the scepticism he had himself deployed against the scholastics, the Rosicrucians, Descartes, and the defenders of the newly fashionable natural religion. Hess remarked on Gassendi's astonishing failure to make even a nominal link between propositions A), B), C) and some aspect of God or the Divine Nature. Only the conservation of matter and motion and the uniformity of space were specifically linked to God. But even these stick out like stray dolmen on an abandoned stone circle; they lack the integration with theology so conspicuously bestowed on Descartes' laws. Newton deliberately avoided conservation laws, because they seemed to him innately atheistic.

His doctrine of the limitations on human intelligence, and his rejection of absolute knowledge led him to root objectivity in
relativity. Our mental picture of the universe ('that complex heap of 'all existing things') was a product of our sense-experiences, diversified by a variety of possible perspectives and deductions based on probabilities. His criterion for rejecting hypotheses was that either the quantity of information was insufficient; or that their apparent success consisted in an arbitrary exclusion of alternative viewpoints. This method was continually in evidence in his astronomical notebook. The emphasis was on accumulating accurate information in quantity and, by reference to other astronomers past and present, providing a more objective context for its interpretation.

This brings us back to the question of whether Gassendi and Wendelin had any specific hypothesis in mind in 1649. One clue is in the letter itself, where Gassendi urged Wendelin: 'Be content with your tables.' These were those partially published in the previous year in Wendelin's Luminarcani. It is known that Wendelin used some of Gassendi's observations; and there is a reference to Gassendi on the first page. The tables are records of distance, similar to those which Newton took from Boulliau and republished in the Principia. They showed that the periods of the planets and their distances from the sun on what Wendelin called "Kepler's hypotheses" (3/2 law) matched very closely the relative distances determined by astronomers. Like Gassendi, and probably years earlier, Wendelin had determined this for the satellites of Jupiter. There was one gap in the table. Where the measurements for the planet earth should be was the anonymous tertium corpus (some third body neither sun nor earth). There is other evidence of censorship in the book, as in the omission of calculations partly begun for determining the effect of the sun's gravitation on the moon. Such details point to a situation already noticed:
Gassendi's hesitation over hypotheses was not purely methodological. It was inspired by the need to evade the dead hand of the Counter-Reformation. Fr. Wendelin, Fr. Fabri, Fr. Boulliau, Roberval, Fr. Mersenne, and others, were all in the same boat. Whether they privately subscribed to Christianity or not, in their public statements on astronomy the decrees of what Cassendi described as 'self-styled Holy Office' bound them hand and foot. 11

All too often those who argue that these decrees had no effect on science make the tacit assumption that Catholic scientists were not about to make any great discoveries in any case. This dovetails neatly with the Puritanism-caused-science thesis, which has a vested interest in not distinguishing the decree as a purely police measure from the problem of spiritual and ideological affinities. However, there is good evidence that not merely Cassendi, but the circle to which he belonged, had been making steady progress for some years towards a synthesis of Kepler's laws with Galileo's physics. The letter of Cassendi to Fabri, dealing with this very question (studied in GRAVITATION) was written less than a year before the letter to Wendelin on hypotheses. Cassendi used the loaded term 'hypothesis' to commend Fabri's 'most ingenious possible attempt...so worthy of the Society of Jesus' to fit Kepler's physics to a geocentric cosmology. This is a classic example of Cassendi's subtle irony. He could risk writing in this way because Fabri himself secretly shared Kepler's view and used irony on system in his own books. But he had already been examined twice by the Inquisition. 12 There was no alternative for such dissidents but to go on philosophising through a style of double-think which the adept alone would recognize as a code.

Cassendi had known Fabri in Provence as early as the 1620s and already the seeds of a Copernican physics were in his mind. Instructive in this respect is Cassendi's analysis of the comet of 1618.
Pendulum and Inverse Square Law

Gassendi's and Fabri's Synthesis of Galileo and Kepler
Circa 1643

At each instant this is:
I impulse of inertia (constant)
I impulse of attraction (varying with distance)

A speculative author's reconstruction

Compact diagrams pp 366-9
Apart from the need to keep a meticulous record he was particularly keen to register speed, change in angle and apparent deflection of the tail in the neighbourhood of the sun. This was a matter of some importance for him. He was still pursuing his inquiries on these questions with others who had seen it as late as 1625 and 1628. In his life of Peiresc (1640) he noted, without comment, that Peiresc thought 'the comet passed above the moon and perhaps also the sun'. This tied in with Gassendi's notebook jottings: I rejoice in my conjectures, special to the behaviour of comets, in this philosophy of mine, which concern the variation noted in their deflection opposite the sun.' As early as 1625, Gassendi was puzzling over whether comets followed the same laws that Kepler had applied to the planets.

It is possible that Gassendi's interest in atomism dates also from this comet of 1618. Wendelin recorded that when he had observed that comet (from Marseilles) he wondered if the structure of the insubstantial tail could be explained only on the atomic theory. As early as 1607, Wendelin (Gassendi was then fifteen) had observed what we now know as Halley's comet, which stimulated much scientific discussion, 'particularly among the parlement at Aix'. Wendelin's own theory of comets treated their trajectory as a parabola, like a cannon ball—contrary to the straight-line theory of Kepler. But 'pendulum' impulses from the sun and planets further deflected its course. Taken in the context of the pendulum theory of multiple gravitational attractions, formulated by his former pupil, Gassendi, this is obviously an attempt to assimilate the behaviour of comets to the moon and planets. It was published with the same treatise Luminarcani in 1643. We do not know when Gassendi developed the ideas on comets published in his posthumous Syntagama. But we do know that he planned to include a discussion of comets and other
Sunspots

Quomodo sunt maculae quas somnium mobilis despexit, interpositis aliis quibusdam minutulis, quas sequenti heme- 
mate exhibere licuit. Vraeque maiuscula ad diem video victimam huius mensis peruenuerunt, 
& sequens etiam, seu que ad laudem ad primam video Mensis Decemberis. Cetera minutulae 
puissu santerunt, mutandae etiam nonnullarum: imo sequens illa, seu maior in quoddam quae- 
rustra abruptum invenitrum (propterea hic spectaturosque in in Caelo consitit superne) diebus 
27. 28. & 29. donec illa etiam rustra cuanterunt.

Porro diebus 16. 17. & 18. macula quassam longiuscula, cum minutore asscla & sub-
nata, & visa est, propterea hic quoque representatur. Plaeent autem schemati interponere obses- 
ionis dies, ut vitetur confusio.

Videtur macula sub sinem pingi debuisse elevatur: sed chartam imitatus sum, in qua Sol 
ipse ipsum pinxit. Varietas forte ex eo fuit, quod non fuerit exquisitme metides.

Ex quo Maculae ita excederunt, nulla profirm apparuit diebus Decemberis 1, 3, 5, 6, 7, 9, 
10, 11, 12, 14. & 15.

Eadem 11, 14. Post meridiem. Occurrentes forte in conspectum sub horam secundam 
revoexit, in mentem quod, quem huc cum quod habuit. Ratus tamen quod debere ipsi tum 
imineret, haud dixit consequitam et deprehendi, et falsa in tantumdem praeterissimae videterur 
eius perpendicularum, quantum illa lata fuit. Distiner adhuc vsorque ad meridiano plurimum.

At lumpio Radio emenas similis qui tertis se disfunt, distiterunt vero adhuc alto grad. 
15°, ac proinde hora 
41° sunt Boreae, vicinaeque & 2000—1610. hoc est 2 grad. min. 57° Post 4 alta superiori 
eiuspide

From Astronomia, I

430A
astronomical questions in the second part of his paradoxes, to have been published around 1628. Without this work we can only guess at what 'philosophy' Gassendi was meditating, which explained the deflection of the 1618 comet's path round the sun. But he had written to Galileo, in 1625, that he lamented the hostility of the French clergy to Copernicanism and the absence of philosophical freedom which prevented his turning his conjectures about comets into proof. This would supply exactly that 'confirmation in law' which was the only thing lacking in Copernicanism. The mere decision to suppress this treatise, 'from fear of the times and the customs', is itself a clue to the contents. Why should he have referred to its suppression as a 'tragedy' in a letter to Schickard unless it impinged on that revision of Kepler's astronomy which was one of the main topics in the correspondence between the two? As Fabri tactfully put it: 'The book was abandoned because of the bad stomach of the scholastics and on the advice of Gassendi's friends.' (see FRIENDSHIP) In this way the Church's refusal to admit that Copernicanism was a viable physical system became something of a self-fulfilling prophecy.

Anyone who imagines that Ptolemy or Tycho were as well able to explain all the known astronomical phenomena in the 1630s, as any known version of heliocentrism, might find some surprises in the pages of Gassendi. He was well aware of the complex geometrical arguments on the rotation of sun-spots which demonstrated the motion of the earth; and probably before Galileo hastily added an obscure summary of them to his banned dialogues. This was the evidence he was referring to when he told Fr. Scheiner S.J. in 1631, shortly before Galileo's arrest, that his book on sun-spots, Rosa Ursina, might have been even better if it had followed Gassendi and adhered to 'Galileo's way'. This was uncharacteristically tactless of Gassendi, since Fr. Scheiner allegedly played a key role in promoting Galileo's prosecution next year.16
In his notebook Gassendi plotted the course of the 1653 comet according to the earth's diurnal motion, and then according to the ecliptic co-ordinates; which makes the apparent motion irrelevant. This enabled him to approximate the comet's ascending node, as it cut the earth's orbit: 'the more probable track of the comet itself in relation to the ecliptic'. From the changing direction of the tail, which Gassendi noted to be almost opposite to the sun, it might have been possible to conjecture that the apparent deflection of the comet—viewed from the earth—was the projection of real physical deflection determined by the sun itself. But Gassendi, disdaining to indicate any confirmation of his youthful conjecture, merely added a terse note to his discussion of the solar deflection of comets, referring the reader 'to the very full set of observations' of the 1653 comet in the astronomical notebook.  

Very similar, mathematically, to the problem of calculating the path of the 1618 and 1653 comets was the problem which Gassendi addressed first to Schickard, then Boulliau, in the 1630s; determining the real orbit of Mercury. It was by measuring first the apparent position of the planet from the earth, then its co-ordinates at the same moment in time, relative to the sun, that the magnitude of its deviation from the circular could be calculated. This required no great originality; it was mathematically derived from Kepler. But no-one who used this method and believed the celestial physics of the interaction sun/comet, sun/Mercury similar to the physics of Galileo could regard geocentrism as other than wildly improbable. But the physics of Kepler did not square with the known behaviour of masses and magnets on earth. Gassendi's 'conjectures' about the comet of 1618 rested on the calculation of the physical interaction of sun and comet. If it fetched a circle round the sun, how could it be travelling in a straight line as Kepler predicted?
The law of rectilinear inertia, furnished him in 1629 by Beckmann on his visit to Holland, provided the way forward from Kepler's magnetic fibres and attractive-repulsive gravity. It is not difficult to see why Gassendi's letter announcing his Copernicanism to Peiresc, in 1629, omitted the cautious reference to the need for final confirmation (perhaps to be found in cometary theory) made in a letter to Galileo four years before. In the *Syntagma* Gassendi wrote of comets voyaging through the cosmos with a path closely approximating to rectilinear inertia. But, whenever they approached a star system, the sun attracted the matter in the comet's head—a solar 'wind' repelling the tail—and deflected it from its course. The comet was accelerated by the sun or any other star, although in deep space its speed would be uniform. Gassendi was emphatic that the comet's motion was a composition or 'mean' motion of its own 'animal' rectilinear motion and the material attraction between the head and the sun. He had illustrated this with numerous examples from terrestrial physics, but the reader would have to follow cross references carefully before the universal significance of the analysis was apparent. In his earlier section on motion Gassendi had described an idealised particle, in an ideally empty space, being 'twisted' from right line inertial motion by its approach to a body like the earth. The same term, deflexio, was used for both the ideal 'stone' and the comet's sharp change of direction in the vicinity of the sun. More telling still, it was applied to the balance of force and gravitation inflecting an idealised projectile into a parabola. It was used, in the same sense, in the analysis of comets in Newton's *Principia*, book III lemma iv. Gassendi, like Newton, was well aware that any physical deflection of the comet by the sun was only indirectly related to the apparent deflection at perihelion to the earth.

It has been generally held that no one before Newton imagined any trajectory in space which was not circular, elliptical or
rectilinear. It is interesting therefore to turn to the works of Fabri. In a book published in 1646, with an approving preface by Gassendi, Fabri dismissed such restriction on curves in celestial motion as nonsense. Heavenly bodies might describe any of the three conic sections: ellipse, hyperbola, parabola. In his 1645 Philolaica Boulliau insisted on presenting elliptical orbits as sections of a cone with the sun on the intersection of axis and focus. This elaborate scheme had no practical justification, unless he and Gassendi privately shared Fabri's view and envisaged bringing comets and meteors into the scheme as parabolas and hyperbolas. This would explain the otherwise incomprehensible accusation by Morin that, although Gassendi knew from their trajectory that the meteors described in his book fell from heaven, he persisted in pretending that they had spouted from local mountains in Provence.

It seems improbable, or at least counter to our accepted images of a Newtonian thunderbolt, that Gassendi should have taken this momentous step of picturing the motions of comets and planets as a compound of accelerative gravity and rectilinear inertia, as early as 1634. But what else did Gassendi mean when he claimed in his poem: 'I restored that degree by which the sun appears to be arbiter of heaven.'? This was extravagant language if he merely meant he had confirmed Kepler by showing Mercury to be elliptical. Why had it been necessary to shield from Kepler's ex-pupil, of all people, in 'secret council' the 'arcana' of Mercury's elliptical orbit? Even Morin was prepared to accept ellipses.

The comparison of comets and planets with different types of ship, sailing an ether sea, furnishes the key. In his correspondence with Schickard about Mercury, Gassendi discussed errors in certain 'maps': 'To argue so many errors in the geographical reckoning, and to demonstrate them to all, would be the height of impudence. Hallucination
VOYAGE OF PYTHAGoras

If becomes a curve as intervals diminish infinitely.

- actual orbit
- sun's force
- planet's inertia

versed sines = mid-points of $E_2$, $V_B$

Principia

I prop 1

from Newton
versed sines measure gravity/inertia balance

$A$ = Malta $B$ = Crete $C$ = Cyprus $B_1$ = Crete on chart $C_1$ = Cyprus

Gassendi's diagram of a ship navigating with two different sources of navigational "error" which cancel: wind, $A \to F$; $D \to C$ cancels chart error $B \to B_1$, $C \to C_1$

Boullion
Philos. Rer. 1415

Mercury's elliptical orbit, using Kepler's method and Gassendi's observations. Tangents to ellipses $PN, OL$ correspond to "chart error." Path of sun at $O$ corresponds to wind. Boullion noted difference in the versed sines measured the orbit's shape.
in you, to accept. Verging on sacrilege for me to propose.' Could this relate to Gassendi's claim to resolve a problem in map-making in a little treatise on the Voyages of Pytheas (see GALLEY) written for Wendelin in the year after Schickard's death? Gassendi's mention of Schickard's queries about charts at the end of this treatise suggest that it did.23 The Pytheas reported Gassendi's observations on the apparent path of the sun by means of a gnomon. These observations, which he checked against a Foucault pendulum, would enable him to observe that the sun (or rather earth) travelled with unequal speeds, like the other planets, its 'analemmata' matching Kepler's equal-areas-equal-times estimate. At the end stood a seemingly irrelevant nautical problem. A ship is sailing with an inadequate chart which leads the pilot to steer due south of his objective. At the same time, another compensatory error, which may arise from contrary winds, current, magnetic variation (he does not care which), takes it due north of its objective. The two errors are as 1:32. The result is that the ship will always reach its proper destination, despite the pilot's ignorance. Gassendi added that he would like to have been able to communicate this result to Schickard, who had been so interested in cartography and longitudes. Kepler's theory that the planet was a ship, with a magnetic rudder, balancing its sun-attractive, sun-repellent fibres as it navigated round the sun was the true context of this problem. Mentions by Gassendi of Kepler's errors and Gilbert's theory of planetary magnetism were pointers to this meaning.

If we apply Gassendi's diagram of this navigation to the diagram calculating Mercury's elliptical orbit according to Kepler's mathematics in *Philolaica* then the chart error corresponds to the tangents drawn to the sines of Mercury on the ellipse.24 The tangents would correspond to the inertial thrust of the planet outwards from its orbit; the path which would be followed if the sun were to be
The second source of navigational error becomes the radius vector, drawing the planet and sun together. The increases or decreases in the versed sines would measure either the balance of sun-attractive to sun-repelling fibres or of gravitational attraction to inertia. That Gassendi envisaged the problem of a planet and a comet in navigational terms is evident from the *Syntagma*. There he recalled the tearaway mountain river of his boyhood, the Durance: 'How great logs are carried down the centre of the stream on a visible crest, whilst the jetsam eddies in the region of the banks. The comets are the great logs, the planets like the jetsam. Or the planets are like galleys, which put in frequently at ports: the comets are like great Indiamen carried across oceans by their sails.' When he plotted the course of the comet of 1653, and claimed to be able to predict its position, he used a method very similar to nautical dead-reckoning: the line of latitude corresponded to the motion from the sun and the longitude to the inertial motion.

Decisive evidence that Gassendi's navigation was celestial comes from Boulliau: 'The observations of celestial phenomenon are not more accurate than those Mediterranean sailors who navigated from Malta to Syria. They computed their itinerary as if they were describing a straight line but actually described a sort of circle.' In fact, it was a ballistic parabola. But in view of Wendelin's comparison of a comet to be shot from a bombard, and Gassendi's view that artillery was a paradigm for terrestrial and celestial motion, this fits very well. Fabri, borrowing Gassendi's inertial motion (which he misleadingly dubbed 'circular') argued that the orbits were made up by composition of inertia with an acceleration towards the sun, initiated by a sort of divine artillery officer at creation. But elsewhere in Fabri's work is a clue that such theological absurdity was to throw dust in the eyes of his
LUNAR MOTION

"ridiculous path of the moon round a moving earth" Fabri  Physica IV p.484-5

Explained on Cassendi's "pendulum" theory:
1. sun and earth attract moon inversely as square of its distance
2. moon has its own "regular" inertial motion
3. precession of lunar nodes (like precession of equinoxes) rhythmic swing caused by a balance of 2 unequal forces
4. moon in tug-of-war determined by "period" of 2 pendulums; sun's and earth's attraction.

Moon = ship, with its own motion, "steered" by sun and earth (1669.6468)

From: H. Fabri Physica 1669 IV p.420-1

uniform inertial motion or direction

determinatio

gradient

gradient

actual orbit or course

"determinatio": each instant of time a known + cumulative pull from earth

"I first wrote this down many years ago. But now realize it is false to compare heavenly and terrestrial motion. I include it so the reader may smile at its absurdity."
superiors. He wrote of the moon, sailing around the earth like a ship. A great wind (Gassendi's inertia) was driving it, at uniform speed, at a tangent to its course. But the moon did not fly off, because it was at the same time falling towards the earth on the same Galilean proportion as a pebble falling from a cliff. This idea (Fabri says) writing after Gassendi's death, had occurred to him 'many years ago, but this is clearly false, since terrestrial laws do not apply to celestial motion. I publish it so you may laugh at its absurdity.'

Bearing in mind the long association of Fabri and Gassendi, and the known collaboration of Gassendi and Boulliau, who can doubt that their circle must be credited with a striking conceptual achievement? It is sufficient to recall the point made in GRAVITATION that the relationship of the proportion between inertia and gravitation was measured by the increase or decrease in versed sines. Fabri understood the mathematics of this and paid particular attention to calculation of variations through the versed sine (later known as 'the differentiation triangle') and their application to planetary speeds by a primitive form of fluxional calculus. Gassendi guessed that this method was the clue to relating Galileo's law of fall to the planets. He realised that the elliptical orbits were as much a composition of forces as the semi-parabola of the stone falling from a mast-head in motion. He also realised that it applied to comets. It is not coincidence that the diagram in the De Motu showing the stone falling from the masthead also looks like the graph of a parabolic comet, with the ship's mast as its axis. If the stone were isolated by the destruction of the ship and earth, it would continue to orbit in space with the direction and force impressed at the start.

Boulliau related how astronomers could dispense with Kepler's harmonies and magnetic fibres for a simple inverse-square law. But historians have ignored this assertion apparently unsupported by
argument. The fact that it follows the passage on Gassendi's navigation problem, and that he wrote in the following sentence of the 'shipwreck' of Kepler's magnetic fibres and occult harmonies, suggests it was not isolated. Gassendi's claim that he and Schickard had 'cut the thread of fate, unfurling the radii of the wandering stars...limiting the sun's role as arbiter of heavenly motions' would have been justified if it had referred to a technical problem at the heart of gravitation: the changing balance of inertia and gravitational attraction as measured by the fluctuating ratio of the versed sines. The calculation of this ratio was exactly the problem which Boulliau resolved for Mercury, using Apollonius, in the diagram which 'fits' that of Gassendi's navigation.

How far Gassendi's understanding reached must remain uncertain. Did he, for example, use his numerous observations of the planets to make a very simple but effective check on Kepler's equal-areas law? Fabri's analysis of that law, concealed for prudential motives, suggests that he did. One further point of interest is Newton's first demonstration of the elliptical orbit from the inverse-square law. This was the calculation which he told Halley in 1684 he had already made but 'mislaid'. When he tried to re-calculate, he confused the axes of the ellipse with the conjugate diameters. This would be a very childish error, but explicable if Newton had been working originally from Boulliau. It was the latter's idiosyncrasy to refer to the diameter of the ellipse as the conjugate diameter—a term more usually applied to its transverse axes. Newton later remarked to Halley that he would sooner acknowledge Boulliau as his original source for the inverse square law than he would Hooke, and his notebooks show clearly his familiarity with Boulliau's methods.

According to Ruffner, Newton had been studying the information on the comets of 1618 in Gassendi's notebook as early as 1664, and
later derived much of his technical and historical data about comets from the analysis in the Syntagma. But did Newton understand the Gassendi we have presented in this chapter? Newton referred both to Fabri's planetary theory and to Gassendi in his correspondence with Bentley, in 1691, explaining how best to approach the study of the Principia: 'For astronomy read first ye Copernican system in the end of Gassendi's astronomy.' Newton here seems unaware that there were two volumes termed Gassendi's Astronomia: the lectures of 1645, published separately; and the lectures and notebook combined, published as vol. IV of the Opera Omnia. It was Tycho's system which concluded the former. On the other hand, the diagram of the Mediterranean navigation ended the latter. Was Newton ever conscious of fulfilling Gassendi's prophecy: 'Posterity must roof the building which we leave unfinished and that must be our monument.'?
H45 440

Hypotheses and Evidence

1. 0.0. IV p. 449
2. 0.0. III pp. 262-4
3. Compare to Schickard Nov. 1631 0.0. IV p. 503
4. 0.0. VI p. 209
5. *Astronomia Philolaica* p. 178

Lenoble Mersenne 2nd ed. p. 351 attempts to gloss over Mersenne's mysterious volte-face, which led him from being an entrenched defender of the certainty of all Aristotelian sciences in the 1620s to a purely Gassendist position by the 1630s. Whereas in the 1620s he offered a proposition in Euclid as proof of the certainty of theology and the existence of God, by the 1640s he could write: 'Why bodies descend we do not know. We are not only ignorant of divine things but of those which we call natural as well.'

7. 0.0. VI p. 209, IV p. 441 'We are the ancients...the moderns are yet to come.'

8. VI p. 209 Gassendi wrote: 'Ut alias fingant hypotheseis quae sint Caeli consonantiores.' Let others frame hypotheses more in agreement with the astronomical phenomena.


10. Luminacani pp. 1, 33, 64

11. 0.0. VI p. 64 This letter is dated August 1633, but Bloch shows that it must have been written in June (Galileo recanted on 22nd of that month). Written to a Protestant, it is a rare indication of Gassendi's real attitude to the ecclesiastical rulings on science.

12. 0.0. VI pp. 167-8 article Fabri in *Dictionary of Scientific Biography*.

13. IV pp. 77-9, V p. 286 'Ego pro mea quaedam speciali de cometis philosophia gaudebam, conjecturis meas non infeliciter cedere quod attineret huius deflexionis a sole opposito.' Gassendi to Snell 1625.


15. 0.0. VI pp. 5a. 35-6

16. 0.0. IV pp. 99-100 shows he may have realized this as early as 1627. In a letter to Fr. Scheiner (0.0. VI p. 55 Nov. 1632), he first stated categorically that sun-spot appearances were best explained by allowing the earth's motion. The arguments were not published until after his death (0.0. I pp. 650-1). Although there are many diagrams of sun-spot motion in the notebook, characteristically no diagram accompanies the complex explanation. There is no doubt that the argument was correct. See Clavelin *Galileo* p. 400 or Drake *Galileo at Work* pp. 310-1

17. 0.0. IV pp. 479-80 Gassendi gives tables, but no diagrams.

18. *Philolaus* pp. 413-6, with clear diagram.

19. See Whiteside *Mathematical Papers* VI pp. 50-3

Kepler *Astronomia Nova* c. VI
Beckmann's notebook, Journal Tenu par Isaac Beckman ed. De Waard 1939-53 shows that he was considering a gravitational theory of lunar motion, taking account of the distances from earth and sun, at exactly the period of Gassendi's visit in June 1629. For Gassendi's high opinion of Beckmann, expressed in June 1629, and his declaration of Copernicanism to Peiresc (July 1629) see F. Sassen De Reis Van Pierre Gassendi in de Nederlandde, Amsterdam 1960. 0.0.1 pp.709-10, 355-7, 0.0. IV pp.78-9.

21 Philosophiae Tomus Primus 1646 Lyons I pp.358-63. Planets have a sort of ship's rudder which can steer a course of any shape.

22 0.0. II pp.97, 108. A number of meteorites fell on Provence in the 1630s; Gassendi made observations himself and collated those of others. He made a careful examination of a 38-lb stone. It is likely that Morin was right and that Gassendi's public denial of any extra-terrestrial origin was linked to his public rejection of an Epicurean plurality of worlds. He did not want to offend theologians.

23 0.0. VI p.71, IV pp.523-36 and 534.

24 It was Kepler who originally suggested picturing the planet as a ship, alternately repelled and attracted by a magnetic pilot or 'rudder'. Astronomia Nova lvii and Epitome Astronomiae Copernicanae ed. 1635 p.601. He pictured force driving planetary ships as wind and wrote of Deflexions in the orbit. This was clearly Gassendi's source. Newton never read Kepler.

25 Astronomia Philolaica pp.41 Boulliau claims here to be solving a problem which baffled Kepler.

26 0.0. I p.709-10. He calls it Decussationis of longitude and latitude increments. Fabri op cit n.21 vol. II pp.170-200 cites a fluxional method for handling such variables as diminishing ratios. Gassendi recognised the utility of this for astronomical calculations as early as 1643. (see GRAVITATION)

27 Philolaus p.98.

28 Physica 1669 IV pp. 331 420-5 (see diagram). This is the problem which Newton claimed to have solved as early as 1665, though there is little evidence to support the 'orchard' myth.

29 Physica IV pp.302; II p.301 Opusculum Geometricum De Linea Sinuum 1659 passim There is no evidence that Fabri applied these methods to comets, but he certainly did tc planets. Like Gassendi, he referred to 'the myth that comets travel in straight lines'.

30 Astronomia Philolaica 'In ratione nempe dupla intervallorum sed eversa p.23. Gassendi and Mersenne also refer to an inverse-square law. It is not clear who had the idea first.

31 A. Roy and D. Clark Astronomy 1977 p.324 show how simple this calculation would be with Gassendi's observations on Mercury, for example. Physica IV pp.331-44

32 Westfall Never at Rest 1980 p.403, Turnbull Correspondence II p.438, Whiteside IV pp.171-5


34 For Newton and the lectures see ii n.23.
The custom of Byzantine Greek historians in excluding the supernatural dimension from their secular histories—however devout the historian might be in private life—has been followed from the seventeenth century until relatively recent times by the most exact historical writers in western Europe. Gassendi's own historical writings scrupulously followed this maxim. His influence on the ecclesiastical historian De Launay (see THE GALLEY EXPERIMENT) has long been known. It has more recently been traced in the sudden turnabout of France's greatest contemporary historian, Mazaray. From writing chronicles of miracles, battles, saints and kings, he was transformed, during the 1640s, into a critical historian of the evolution of French society, treating the Church as a historical fact like any other. Despite the Renaissance, this sort of secular-minded attitude, which Gibbon, Hume and Voltaire were soon to turn into a commonplace, was still very much a novelty in the west in the seventeenth century. The determination to free both the exact sciences and the humanities from their obligation to serve primarily as instruments of religious propaganda and only incidentally as sources of exact information, had no necessary connexion with unbelief. But despite the absence of any logical necessity (Jesuits, for example, participated in this process), the sociological and personal connexion between objective secularism and unbelief was very strong in seventeenth-century France.

It is impossible to consider Gassendi's position—caught between his acceptance of the authority of the institutional Church and his equally public commitment to philosophical liberty—without noting that his attitudes furnish a significant counter-example to recent efforts to locate a spiritual origin for modern science which have now achieved something of the status of an orthodoxy. It is interesting
to note that the standard bearers of this movement, Catholic and Protestant, still preserve their sectarian preferences. Those who regard the Jesuits as the acme of modernity are unlikely to be found pressing the view that Bacon, Boyle and Newton were vehicles of the Puritan ethic; and vice versa. On the Catholic side Fr. Yaki has subsumed the entire scientific programme from Thales to Einstein under the all-embracing 'first cause' of belief in Christian Theism. On the other hand Biblical Christianity comes to the fore in the work of Hookyaaas, where the scholastics are shown to have been somewhat at sea until the reformers produced the new science out of the Bible. Such writers face two methodological problems. How can we be sure that the fact that a scientist was a Jesuit, a Puritan or a priest is a guarantee that he held certain stereotyped opinions? How, in the absence of any clear criteria as to what constituted 'modern science' at this period, can we say categorically that this or that Christian made a positive contribution to it? There is a more serious sociological problem. Unless we are in a position to show that science is the result of supernatural grace—a divine intervention in the course of history—what are the grounds for regarding any religious belief as an uncaused cause, operating independently of other social and cultural forces?

It is not surprising that there should be many disagreements on how to place individual Christians in relation to this thesis. Fr. Lenoble favours a link between scholasticism and what he calls 'Catholic empiricism', attributing the greatest importance to Fr. Mersenne's circle. He does not blush to use a quote from Roberval—a notorious unbeliever—as evidence that 'both the scientific spirit and the most modern principles of science were the work of theologians, whose principal concern was God's freedom.' Perhaps this is not so surprising in view of Lenoble's personal view that the Church may
legitimately make use of miracles it knows to be false, if this helps to confound the sceptics. Fr. Yaki, that learned Benedictine, rightly uneasy with the many inconsistencies of Fr. Mersenne, dismisses his approach as superficial, accusing him of 'blindness and myopia', a paradoxical combination of qualities. Only a few years ago M.B. Hall was writing off Hobbes as an unbeliever and therefore scientifically sterile. More recent writers have rediscovered not only the genuineness of Hobbes' interest in science but a devotion to orthodox Christianity, unsuspected even by his contemporaries. A similar turnabout seems on the way in regard to the reputation of Mersenne's correspondent Fr. Thomas White. Once regarded as an obscure heretic, time-server and embezzler, he is now being increasingly presented as an ecumenist before his time, who sincerely sought to modernise the Catholic faith and reconcile it with the new science. Since Vatican II he has been emerging as 'one of the few priests with any awareness of the philosophical speculations of his own times' or 'a genial anticipator of modern trends'. Certainly his handling of the finances of the English recusant community anticipated, on a more modest scale, the operations of the Banco Ambrosiano.

There can be no doubt that our interpretation of the seventeenth century has been enriched by the efforts of modern historians to put the best possible gloss on the relations of science with Christianity. It is therefore all the more puzzling that the case of Gassendi has been ignored by Catholic and Protestant alike. Though cited, en passant, as 'proof' that the new science was deeply moral and clerical, no one has ever made the slightest attempt to display any causal connexions between Gassendi's professed Catholicism and his science or philosophy. Even Fr. Brundell, after some perfunctory efforts to link Gassendi's thinking to the Jesuits, fell back on asserting his total insignificance to the history of science and philosophy.
can therefore be sure that if a historian as learned in theology as Fr. Brundell cannot establish these connections, the thing is impossible. Whether or not Gassendi was a Christian (and I do not believe that he was) Christianity had no positive influence on his science, his morality or his philosophy. If it were merely a question of Gassendi alone, then perhaps this exception might be thought to prove the rule. But the contention of this thesis is that unlike, for example, Copernicus or Newton, Gassendi was not an isolated figure. Although only an inner core of disciples knew his private thoughts with any accuracy, a very wide circle (see FRIENDSHIP AND THE SECRET SOCIETIES) shared his secular and humanistic attitudes. Many of that circle were involved in science and in the reaction to Galileo's condemnation. Others were affected by the Church's attitude to a whole range of questions: not just biblical literalism, Copernicanism, animism, materialism, naturalism and critical scholarship, but such practical matters as clerical control in education, interference in economic activities, law, censorship and government. 9

The story of Gassendi's attitude to the 1616 and 1633 condemnations of Copernicanism has been well told and well analysed by Hess and Bloch. 10 It has been touched upon in different sections of this thesis and need not be narrated here. It should be clear, from the previous sub-section, that the earth's motion, rose from the status of a 'conjecture', through accretions of evidence, both astronomical and physical, till at some time, probably by 1630, it acquired in Gassendi's mind a degree of probability superior to any geocentric alternative. 11 Nothing could be farther from the truth than to attribute Gassendi's total agreement with Galileo—obvious even when he chose to be silent or repudiate him—to blind dogmatism. Gassendi's attitude was not isolated but typical of his whole circle. Fr. Wendelin, Fr. Boulliau, Mersenne, Roberval—all, in Fr. Lenoble's view,
exponents of that 'Catholic empiricism' which he presents as the heir of medieval scholasticism—privately or publicly regarded the Church's condemnation of Copernicanism as an unwarranted intrusion by religion on science. In this respect their attitudes were indistinguishable from those of Englishmen travelling in France, like Hobbes and Boyle, who were able to express themselves more openly. These facts place a large question mark over the view that there was an element of 'Catholic empiricism' in Urban's condemnation of Galileo. If that had been the case, all the above-mentioned priests, led by Cassendi, would have hastened to applaud Urban for correcting Galileo's dogmatising, instead of wringing their hands.

Gerhard Hess suggested that though Fr. Mersenne submitted to the decrees in public, this was merely a smoke-screen to enable him to propagate Copernicanism in general, and the quest for a Copernican physics in particular, more effectively. Apart from his clandestine publishing operations, smuggling manuscripts by Galileo (and others) through the Protestant Eli Diodati, he did not blush to pull the wool over the censor's eyes in his own books. It is evident, even as early as the 1616 decree, that Fr. Mersenne was prepared to write all kinds of doctrinaire nonsense—condemning the new science and Copernicanism en bloc, as anti-Christian—simply to beguile the censor. Fr. Lenoble was sufficiently trusting to take all this at face-value and no one has thought to question his conclusions. But what was really in Mersenne's mind when he wrote:

'The Church may forbid any book it pleases, just as kings may outlaw such dangerous pastimes as hunting, cards, dice etc. It has the powers to forbid Euclid, Aristotle, and the Bible, if it be necessary to do so.'

The friar was laughing up his sleeve in this and other passages. Examples of Mersenne's duplicity are legion. In the Prussian Staatsbibliothek Hess found a copy of the innocuously named Questions
The apparent change is explained partly by the fact that the 'liberal' views were mostly expressed in letters or unpublished papers, partly in the more permissive attitude adopted by Richelieu's government, especially after 1630, to Protestants, Jews, religious toleration, and the new science in general. That would explain why his 1623 book condemned Copernicanism without appeal, whereas his 1624 book, published after Richelieu came to power, found no scientific arguments against it and was actually dedicated to Richelieu. His next book (1625) which for the first time brought the doctrines of Deism (clumsily refuted) in clear and simple form before the eyes of the general public became, in the absence of overtly anti-Christian publications, a prime source of libertinage. It is at least possible that the 'anonymous' author of the 'quatrains du deist' was actually well known to Mersenne and was one of the libertins with whom his name is so often linked.

The duplicity which Mersenne and Gassendi were compelled to exercise with regard to their real religious beliefs meant that the crisis over Copernicanism was not an exceptional intrusion upon lives of innocent scholarship. Gassendi's whole concept of a consensus of scholars, cutting horizontally across religions and cultures; vertically through antiquity and forward through posterity; demanded a secular 'libertas philosophandis'. For him absolute truth was what modern logicians call an 'empty set'. Total certainty was a myth, to be replaced by 'conjecture'. In theory this fallibilist epistemology, weighing all generalisations on the scale of probabilities, did not apply to the Church or to spiritual questions. But the Copernican issue strained the public credibility of his position to the utmost. Although he was extremely cautious about phrasing his objections, Gassendi regarded the Christian formula 'faith seeking understanding' as a regrettable reversal of the methods of Greek
science. He sympathised with the view of the Emperor Julian that Christians only pretended to look for truth because they wanted evidence which would confirm the truth they already held. Gassendi's thesis that ideas of science and of religion were anthropocentric 'fictions' determined by cultural variables was modulated only by the objectivity which the study of a variety of such cultures conferred. The idea that the Bible or the Church possessed a supernatural authority, giving them privileged access to natural truths, entitling them to bridle the speculations of philosophers, was accepted by Gassendi as part of the rules of the game. But this formal acquiescence was a long way from the genuine fideism of those who regarded Christianity as beyond normal logical rules and therefore untouchable by scientific discoveries. Gassendi was no Pascal, nor even a Sir Thomas Browne.

The Church's view of hypothesis, as formulated by Bellarmine in 1616, was totally unacceptable to Gassendi. Naturally, he could not challenge it openly and this seems to explain his extraordinary ignorance, or amnesia, on the exact nature of the Church's decrees on Copernicanism whenever they surfaced in discussion. It is indeed remarkable how often his circle contested these decrees in purely legal terms.

'Were they binding in France or just in Rome? Did they apply to all Catholics or just to Galileo? Did they condemn Copernicanism as a scientific fact, or simply when some heretical conclusion, like the impossibility of the ascension, was drawn from it?'

It would be easy to regard such chicanery as evidence that it was merely (as Mersenne pretended to believe) a police matter like banning cards or dice. But the issue resolved itself into such equivocations because the Catholic clergy (as the progressive erosion of their privileges by the monarchy shows) were not trained to articulate a challenge to authority. If the debate was largely
conducted in legal terms that was out of respect for the canon law.

It was left for a layman like Pascal to present the real issue:

'It was in vain that you obtained from Rome the decree against Galileo, which condemned his opinion regarding the earth's movement. It will take more than that to prove that it keeps still.'

If we try to place Gassendi's thinking within the tradition of Aquinas and Augustine (rarely cited in his work) it will be seen how completely Lenoble's concept of a Christian empiricism, rooted in scholasticism, breaks down. For Augustine science was mere guesswork beside the certainties of faith; for this reason he confidently denied the antipodes and declared the motion of the earth or the shape of the heavens to be matters of complete indifference. Unlike Galileo, Gassendi never pretended that these opinions made Augustine a harbinger of modern science or Copernicanism. St. Thomas, on the other hand, emphasised the importance of the predictive element in determining which hypothesis to use. He made a qualitative distinction between physical statements which were demonstrably true—like the certainty that the motion of the fixed stars was an absolutely uniform physical motion—and those which were merely hypothetical like the epicycles. This distinction was the basis of Bellarmine's claim to ban Copernicanism from the realm of demonstrable physical statements and confine it to hypothetical prediction.

Gassendi was too tactful even to recognise that he knew of these arguments. But for both himself, and Fr. Mersenne, the category of demonstrably certain physical statements (like the prime mover itself) no longer existed. For Gassendi the element of contingency and fallibility could not be excluded from science either by logic, experiment or supernatural authority. As for prediction, Gassendi agreed that, for a variety of reasons, an erroneous hypothesis—or a working hypothesis with some erroneous components—often gave useful
predictions. But for all the care which Gassendi devoted to comparing the accuracy of different tables he did not regard mere prediction as an exclusive criterion for determining whether or not one hypothesis was more congruent with the facts than another. Bellarmine's definition of mathematics was mere calculation: following Aquinas' distinction between logical proof (physics) and prediction (mathematics). Gassendi, on the other hand, rejecting logically demonstrable certainties in nature, regarded all science as knowledge of mathematical regularities and patterns. He did not make the distinction, commonly made in the twentieth century, between the largely classificatory sciences and mathematical physics. He saw merely degrees of exactness and a disparity between the congruency of theory and phenomena available at a given historical moment in different disciplines. The scientific attitude was a component of a higher wisdom which incorporated our image of the whole universe. The modern definition of science (pure research, technology) is much less liable to conflict with religion than Gassendi's version, which was one component in a secular philosophy of life.

A crucial issue for the Copernican case was that Gassendi and his circle no longer required physics to be about absolute demonstrations and (privately) did not accept the Church's demand for absolute proofs as legitimate. This was a consequence of the extent to which Gassendi, Mersenne and their circle were committed to the epistemological guidelines laid down in HYPOTHESES AND EVIDENCE. It is clear for example that by 1630 (and probably long before) Gassendi, Mersenne and Peiresc simply did not see the Bible as an authority on matters of fact. Gassendi was looking for confirmation in nature of theories of a material origin of the planets, an extended time-scale for the evolution (his term) of the terrestrial globe, the organic from the inorganic, the diversification of species. (See LIFE AND SOULS).
This indicated a total inward emancipation (however cautious its outward dress) from attitudes which according to Gillespie were general until the 1820s. Before we ask if Gassendi was sincere in coming down on the side of Tycho's hypothesis in 1652-3, it is pertinent to ask whether he ever believed in a God who would move either heaven or earth to sway a middle-eastern battlefield. Since the answer to this last question is certainly 'no', it becomes academic to enquire whether he thought Joshua's miracle was more or less probable with Tycho's hypothesis than with Kepler's. Unlike Galileo he did not even pretend to approach the problem in these terms.

Gassendi's whole attitude to this cynical business is summed up in his use of the old phrase 'saving the appearances.' Whereas this originally meant a theory which would account for the facts, but was not necessarily true, Gassendi applied it to the Christian efforts to rejig their astronomies to fit the Bible. It is sometimes argued that to view the Church's attitude to Copernicanism as a conflict between science and religion is anachronistic — putting nineteenth-century views into seventeenth-century heads. Certainly, it is true that only a minuscule elite within the seventeenth century understood the issue in those terms. But that does not mean we can ignore them. It is not surprising that Boyle, travelling in Italy at the time of Galileo's death, saw the decree as an extension of the principle that 'philosophy like religion was to be infallibly determined'. What is surprising is Boyle's report that the majority of Italian gentlemen whom he met were not only anti-papal but anti-Catholic in their private sentiments. This does not mean they were all Protestants; but it confirms Pintard's view of the extent of free-thinking in Italy; and echoes Naudé's opinion that Galileo would prove another Socrates and that the 'revolutions in science' (his term) posed a much greater long-term threat to the Church than any heresy. It is easy for
highly educated modern Christians, whose religious beliefs do not conflict with science because they have been carefully configured to meet scientific criteria, to forget that their liberal Christianity emerged relatively recently. In the seventeenth century, the sceptic saw religion, in Hobbes' witty phrase, as 'a kingdom of fairies'.

The clergy of all denominations were presented as running a sort of supernatural protection racket, and the scientific assumptions outlined in HYPOTHESES AND EVIDENCE threatened to neutralise their principal weapons. The existence of active anti-clericalism among peoples and secular rulers must have made priests, like Mersenne and Gassendi, who understood the implications of the new science, much more careful than Hobbes about developing them publicly.

Hobbes' close friendship with Mersenne and Gassendi creates a puzzle for anyone not entirely convinced by recent efforts to show that Hobbes was a sincere and a devout Christian. Gassendi found it necessary to dissociate himself from Hobbes' unorthodoxy (although Mersenne did not) but both were quite extravagant in their praise of his political writing. Hobbes returned the compliment and was even more lavish in his praise of Gassendi. Unlike the two priests, Hobbes was free to denounce the condemnation of Galileo as a 'usurpation' by the clergy of questions beyond their competence and to declare (using Gassendi's language) that the motion of the earth was becoming daily more probable. But he did add, following Mersenne, that the secular State might, indeed should, ban dangerous books, especially if they were true. Since in Rome the Pope's secular authority was unquestioned, even by Protestants, this looks suspiciously like a saving-clause put in to placate his friends like Fr. Gassendi, Fr. Boulliau, Fr. Wendelin etc., who favoured such arguments as that the decree was an act of police, not an act of faith, and binding in papal territory, not on all Catholics. A
The number of features of Hobbes' argument seem to echo statements in the works of Mersenne—for example both held that if the clergy were to ban scientific ideas their seminaries should teach the new science properly. This suggestion was evidently made with tongue in cheek. For if the new science were taught in seminars, this would be a most effective way of ensuring its wider dissemination.

Another hint that Fr. Mersenne and Hobbes secretly agreed over Galileo is Mersenne's letter to Peiresc establishing the new mathematical academy of 1634. Mersenne's claim that this academy, which contained the names of all the highly distinguished mathematicians then at work in France, would be set to work to discover a treasure guarded by seven devils who threw rocks at the workmen, has been cited by historians as evidence of his naivety and credulity. Unfortunately the credulity is on the other foot. Treasure frequently stands for hidden wisdom in Mersenne's books. There is no record of any such buried treasure in 1634, and the story seems to come from a book by the Deist Bodin published fifty years earlier. The workmen would be the mathematicians, including Gassendi. The seven devils would be the Jesuit and scholastic philosophers who had hounded Galileo. Mary Magdalene, who was possessed by seven devils in scripture, had a particular interest not only for Provencal sceptics like Peiresc and Gassendi, but for Urban VIII himself.35

It is interesting that not one of Gassendi's letters recalled Galileo's name at the time of his death; an omission which speaks volumes, in view of the custom of extravagantly praising friends on the occasion of their death. But Gassendi's concealed memorial was the publication in that year of the letters De Motore Impresso a Motore Translato—a treatise which modestly claimed to show only that 'the stability of the earth must be placed on firmer reasonings' than those on offer. This involved him in a rolling astronomical and
physical polemic, which took a nasty turn in 1649 when his former friend J.B. Morin accused him of being a convinced Copernican; parading under a mask of demolishing the geocentric arguments on purely hypothetical grounds. Gassendi was less crude than Galileo but there can be no doubt that Morin—who knew Gassendi well—was correct. Gassendi, perhaps already anticipating Morin's betrayal, had taken out insurance in his astronomical lectures, from 1645. These conformed rigorously to the letter of the decree, treating astronomy hypothetically and without reference to gravitation or physics. They suppressed the author's real views more effectively even than the posthumous Syntagma. They were dedicated to the primate and the clergy of France. Precisely because Gassendi had so many of his powerful protectors among the clergy and the nobility, Morin's attack demonstrated the fragility of any independent research programme in a Catholic State, even when protected by the most assiduous public conformity. When Morin joined accusations of secret infidelity to secret Copernicanism it was evident that the situation could no longer be laughed off. The Alae Telluris Fractae of 1643, which was content to describe Gassendi's astronomy as Romifuga (repellent to the Church) gave way to the Tribus Impostribus of 1653 which presented Gassendi's physics as the prime mover in a new secret Epicurean anti-Christian cult into which the aristocracy were being gradually initiated.

The arguments of twentieth-century scholars, that the medieval subordination of hypothesis to logical demonstration and of both to biblical and clerical authority, sounded the dawn of empirical science would have brought a wry smile to the lips of Gassendi and excited unseemly mirth among his circle. Gassendi's desire to emancipate science not only from superstition, but ultimately from legitimate clerical tutelage, was the key to his epistemological emphasis on the
probabilistic and sceptical. It was the key to the duality of thought and language which can be detected at every level of his activities. His close identification of the quest for truth in physics with the quest for a higher wisdom in morality and politics, suggest that his horizon was not limited by the desire to secure freedom for the scientific community to conjecture free from superstition (as he saw it) or religious tutelage. He may also (and this is pure speculation) have imagined a long distant day when an enlightened Catholic Church, piloted by an élite of golden spirits, submitted its own doctrines to dispassionate and sceptical examination. Underlining Gassendi's restraint over the Vatican's attitude to Copernicanism was his unswerving belief in the Church as an historical institution and an authority. His knowledge gave him the power to inflict on the papacy a more spectacular blow than Cromwell or Gustavus Adolphus combined. Despite (or because of?) his rejection of doctrinal Christianity he never seems to have been tempted to break his elected silence.
iv) Hypotheses and the Church

1. The astronomer Boulliau was a great admirer of the Greek historians and translated them extensively.

2. 'From humanist to enlightenment historiography' F. E. de Mazeray P. Leffler French Historical Studies x:3 1978 pp.417-38.


4. Lenoble Mersenne pp.389-91 and 378

5. Op cit n.3 p.64


7. See n.6 and G. Tavard 'Seventeenth-Century Recusants'; Theological Studies 25, 3 1964.


11. See GALLEY and GRAVITATION sections and preceding sub-sections of ASTRONOMY


14. Quaestiones Celeberrimae in Genesism 1623 preface and passim. This book makes such celebrated claims as: 'No art or science can survive among atheists. All heretics are atheists...there are 50,000 atheists in Paris [population 150,000]'. It offered thirty-six 'proofs' for the existence of God. 'The atheist must believe when he sees the capstan turn, because he is forced to recognise God to be a wheel,' is one of the least ridiculous.

15. Lenoble's analysis of Mersenne's Copernicanism is based on a misreading of the texts, e.g. his Mersenne pp.388-401.


17. Hess op cit n.9, pp.135-6


19. Mersenne pp.505-6 and 556.

21 See GASSENDI AND THE CHURCH n.127, ON LIFE AND SOULS n.78.

22 Professor Hall The Revolution in Science 1500-1750 1983 p.360 argues that the view that 'nature might be in a fundamental sense unknowable and indeterminate...that the idea of nature might be an artefact of the human society entertaining it' was totally unknown to western science until 1933. We might ask him the question that Hobbes posed to Mersenne in 1645: 'When did you last see Gassendi?'


25 See the 'Letter to the Grand Duchess Christina' in Life and Opinions of Galileo ed. S. Drake pp.200-3. This was banned by the church and smuggled into print through Mersenne's underground. In this letter St. Augustine's real sense was cynically reversed by Galileo.

26 The reader is referred to Aquinas S.T. I.I Q XXXII A I for the original context of a concept which has been misplaced by Duhem, and others, in the context of twentieth-century positivism.

27 This was the whole point of the 'ship' example, which showed that, although Gassendi was offering a physical theory different from Kepler's, not only the appearances of the planets, but their orbits in real space would be the same.

28 C. Gillespie Genesis and Geology 1959 pp.4, 42.

29 S. Drake Galileo at Work quotes the letter to Dini in which Galileo offers Copernican versions of biblical passages, p.246.

30 R. Maddison Life of Boyle 1968 pp.39-43

31 The arguments of Hobbes Leviathan (Everyman) pp.376-85 were echoed in the Theophrastus Redivivus. Since that work was not aimed at publication, it was openly directed against all religions, whereas Hobbes pretended to be writing only against popery.

32 See GASSENDI AND THE CHURCH n.161

33 Leviathan pp.375-6

34 Qwæstiones Celeberrimae in Genesim c.1510

35 Correspondants de Peiresc ed. Tamizay de Larroque XIX Mersenne 1894.

36 O.O. IV 1-73.

37 For the recent acquittal of Galileo by Pope John Paul II, see J. Campbell 'The Living Reality of the Galileo Case' Clergy Review 1984 LXIX. 12.
Gassendi's uncompromising rejection of astrology struck his contemporaries as one of the most characteristic elements in his philosophy. It has, however, been little noticed since, even though the spectacular collapse in the prestige of astrological writing followed so closely on the publication of Gassendi's attacks. Recent historians, though aware of Gassendi's hostility to astrology, have been more interested in the evidence for seventeenth-century magical beliefs than in the origins of rationalism. It sometimes appears that analysis of Gassendi's role has been neglected precisely because his rationalistic attitude to religion, alchemy and astrology, do not fit our modern methodological presumption that 'the past is a foreign country' whose ways were not our ways. Any attempt to locate the landmarks of eighteenth or nineteenth-century rationalism in the seventeenth century is viewed as anachronistic, or even discourteous.  

Gassendi deployed his arguments against astrology with a caution inversely proportional to their intensity. Although he admitted that at one time he had accepted 'these boyish speculations and deliriums of old women', he implied, in 1633, that this period already belonged to a remote past. The attacks on astrology, prudently kept in MSS form, were probably written about twenty years before they were published. With reason, Gassendi feared that publication would add the powerful lobby of professional astrologers to his enemies. With consummate hypocrisy Gassendi treated both the old astrology of Ptolemy's Tetrabiblos and the new astrology of Kepler, with all due solemnity in his astronomical lectures of the 1640s. This double standard seems less surprising if we recollect that these lectures also expounded orthodox views on the Trinity, the argument from design, the balance of probability of the geocentric and heliocentric alternatives which were a travesty of his private beliefs.
from placating astrologers, like his colleague Morin who was among the audience, he knew astrology to be an accepted political weapon of both the cardinals. To call it in question, as Morin gleefully pointed out in the 1650s, was to imperil national security by attacking simultaneously both the integrity of Cardinal Mazarin and his foreign policy, whose success the astrologers had so confidently predicted. The evidence suggests that Gassendi's decision to publish his attacks on astrology was influenced by his own role in the Fronde and that his measured attack on the dangers of using astrology for political purposes, published in the posthumous Syntagma, was of a piece with criticisms of Mazarin's policies in other sections of that work. It was a continuation, from the tomb, of the Fronde against the Cardinal. Gassendi never explained either how he came to be interested in astrology or what brought about his conversion to the views of its Renaissance critics, such as Pico, whom he certainly read. But what we know of the Provencal shepherds, with their reputation for magical herb and weather-lore—practices closely related to their professional exposure to the stars—suggests that, for Gassendi as for Kepler, folk-astrology was the gate through which he passed into astronomy. Ladurie has emphasised the unique character of the community of shepherds, their propensity for magic and secret unorthodoxy. The wizard priest Gaufridi, to whom Morin maliciously compared Gassendi, came from a shepherd family in the Basse Alpes. St. Vincent de Paul, whose early interest in alchemy is known, minded sheep for his father in neighbouring Languedoc. Bitter reflections in Gassendi's text, that his astronomical studies had revealed the folk-lore of rustics, shepherds and mariners to be a surer guide to the weather than any astrologer, ancient or modern, suggests that his earliest ventures into academic astronomy had been guided by the hope of making accurate predictions of the weather. The appeal of this project, in a peasant
community during a period of dramatic climactic variation and hardship, would have been much greater than the modern reader might suppose. It helps to explain Gassendi's interest in Kepler, whose new 'aspect-astrology' was devised with weather conditions in mind. The emphasis on recording the weather, in conjunction with appropriate astronomical measurement, in Gassendi's notebook may reflect his early interest in Kepler who had pursued a similar method, in the attempt to put his new astrology on an empirical basis. Gassendi's early mentors at Aix, Wendelin and Gaultier for example, shared Gassendi's hostility to astrology by the 1630s. What is difficult to know is how far back in time their scepticism may be projected. Du Vair and Morin, members of the same circle in Gassendi's youth, were very firm believers in the art.

Gassendi's rejection of astrology was not a priori, like the theologically motivated attacks of the early Fathers, the Calvinists, or some Renaissance sceptics. He had actually tested weather conditions, in conjunction with astronomical observation, over a period of about half a century. His attack on astrology, despite occasional resort to polemical device, had a strong empirical component. It is notable that theological considerations, such as the celebrated argument from freedom of the will, played no part in his reasonings. As Morin indignantly pointed out, the distinction made by the Council of Trent between astrology which infringed on human freedom (the personalised horoscope) and astrology which was necessary for medicine, navigation, farming etc., played no part in Gassendi's thinking. Whereas the Catholic Church followed the teaching of St. Thomas and permitted, or actively encouraged, astrology in these purely utilitarian or technical areas, Gassendi condemned without discrimination. The neo-Platonist and Paracelsian attack on astrology provided some of Gassendi's ammunition. But it is
easily forgotten that Paracelsians and others who denied the validity of horoscopes and astronomical practices often asserted the influence of the stars. Pico's view was that this power was too universally and generally diffused over the whole earth to make particular predictions in time and space meaningful. This neo-Platonic belief in stellar influence in general was strong in Vanini; and traces of the idea may be found in Gassendi's acceptance of the possibility of stellar radiations reaching earth. But Gassendi's refusal to build any talismanic or astrological magic on a mere possibility emphasised his reluctance to be led beyond the inductive data. It was only rarely—as in generalising from his own failure to demonstrate any objective connexion with weather conditions, to the invalidity of astrology in a whole range of other areas (where it is doubtful if he had done exhaustive testing)—that induction hardened into dogmatism.

It would be easy to accuse Gassendi of inconsistency; of exposing astrology to the full weight of a sceptical critique, from which materialism, whether Aristotelean or Epicurean, emerged in his writings relatively unscathed. There is the even more singular point that Gassendi's concept of light, magnetism, gravity, electricity, and the nervous system, all depended on a sort of animism, enabling material particles to be conscious of one another across space. It was realised, for example by Huygens, that the existence of gravity necessitated some such occult properties in matter. Certain modern historians have alleged that the idea of universal gravitation must have been astrological in origin, since action at a distance was the means by which the stars governed events on earth. To argue in this way is to ignore the whole principle of astrological influence, which operated hierarchically, the quintessentially superior heavens imprinting commands on the inferior earth by the same causality as master upon slave. Both Gassendi and Kepler noted the anthropomorphic
and middle-eastern social imagery upon which such explanations were founded. Both dismissed out of hand the idea that such political concepts as the fief, the frontier, or command/obedience were viable, even as metaphors, in astronomical space.

It is instructive, in this respect, to compare Gassendi's rejection of Morin's moon-tide connexions, based on astrological language, with his own explanations of the same phenomenon. (see HYPOTHESES AND EVIDENCE). The argument of Duhem and Thorndyke that the astrologer Morin anticipated a Newtonian gravitation—which the mechanist Gassendi rejected—then dissolves. It is true that the magnetic gravitational models of Kepler and Gilbert (which both influenced Gassendi) linked the magnetic 'ray' with their efforts to reform astrology. But the whole direction of their reform was to replace hierarchical with mechanical causation. Gassendi noted with approval the efforts of such new astrologies to bring in explanations based on agitations of the ether caused by light or magnetism. 'They evade the total arbitrariness (of the zodiacal houses) because they are referring to causes which are tolerably known.' He admitted, as the condemned Vanini had done, that the stars and planets might emit all kinds of unknown 'rays'. He did not rule out, for example, that embryos or climate might be affected by some such phenomena; though he argued that the problems of quantifying any such influences in terms of specific stars or planets were insuperable. What was clearly absurd was to use such mechanical explanations merely to justify the continuance of an arbitrary system of influences and affinities which was (Gassendi argued) unscientific even by the criteria which Ptolemy or the Babylonians had applied to astronomy. The clarity with which Gassendi insisted on the principle that 'space' cannot exercise any determinative or physical powers, paralleled his rejection of the traditional four-elements scheme. Action at a
distance, on the other hand, need not necessarily entail anything more drastic than adding a hitherto little understood property—consciousness, to matter. The possibility that Gassendi was influenced in his theories of gravitation by the naturalism and pantheism associated with the philosophy of Vanini in no way conflicts with a serious commitment to rationalism and materialism.

One of his most significant claims was to have repeatedly tested astrological predictions against experience and to have found the correspondence with truth to be no greater than might be expected in games of chance. In view of the importance of probability to Gassendi's philosophy of science, and the particular claims made for Gassendi's application of probability to the structure of matter in ATOMS AND INDIVISIBLES, this argument carried more weight than earlier assertions that astrology's successes were mere chance. 

His accusation that the rules and technical jargon of astrology were a mere 'game', that its assumed connections 'were below a probability', was turned into an issue of professional competence. We know what Gassendi thought of the uncertainties of law and medicine and his view that in both cases freedom from involvement might be a better means to justice and health. It is therefore particularly telling that he argued the superiority of both these professions to astrology: a superiority instanced in terms both of professional training and of the congruency of their maxims with the phenomena. It is particularly striking that Gassendi introduced a sociological criterion, judging astrology purely as a profession, in relation to other professions in the quality and consistency of its end product. He was on sound historical ground here, for the absence of standardised astrological training led to a variety of methodologies, which was itself a loophole for explaining error. Law and medicine, as Gassendi was well aware, were by no means perfect; so the argument that astrologers were
Gassendi's main case rested on the failure of astrology to fit the phenomena. He saw it as a classic example of the type of 'hypothesis' denounced in HYPOTHESES AND EVIDENCE. He did not deny that genuine 'phenomena' had been incorporated in its fabric. It was a matter of common observation that the movements of the sun correlated with the seasons, or that sunlight was essential to the growth of seeds. There was nothing unreasonable, on such analogies, in making a possible correlation between certain planetary conjunctions and certain types of terrestrial event. Where Gassendi parted company from the astrologers was that they went on to erect a system of beliefs and practices upon this slender probability, which depended for an appearance of success on nothing more than the consistency of rules. Unlike a legal precedent, or a known set of symptoms, the assumptions behind these rules were arbitrary and independent of the phenomena. Here Gassendi drew on Kepler's critique of those systems of astrology which had preceded his. Both condemned the obvious dependency of astrological symbolism on abstraction from a purely subjective framework of opposites: up, down; above, below; light, dark; wet, dry; male, female; active, passive.

But he then went on to criticise Kepler's own aspect-based astrology, which, unlike horoscopic astrology, did not pin-point one locality on the earth's surface. To be consistent, he argued, Kepler should have made predictions for the poles only. One of the things which troubled Gassendi was that any great astronomer should ever have credited astrology. Here he had recourse to his utterly cynical social interpretation of science, which was that astrology had been invented to provide astronomers with the cash and leisure for their real research. He was unwilling, for example, to admit that Ptolemy
was the author of the *Tetrabiblos*, the astrologer's bible. He was only inclined to admit the possibility that he might have been, because the *Tetrabiblos* clearly stated that certainty in matters astrological was so much lower than in pure astronomy, that astrology had been excluded from the great *Almagest* and relegated to a separate book.\(^\text{21}\)

Recently, philosophers have re-opened the debate on whether astrology can be sharply demarcated from science or not. Gassendi's answer to this question has a strikingly modern ring. He admitted that astrology, in its methodology and subject matter, was 'tangential' (exosculantur) to several ancient arts and sciences. But he wished to distinguish the speculations of astrology from more promising theories (like his own semina concept) even though they were, as yet, no better quantified or able to give accurate predictions. He argued that astrology, by providing closed explanations, obstructed the development of other embryonic studies which provided more probable secondary causes for what astrology explained away. 'The study of geology, the effects of vapours released from the earth's crust, agriculture, psychology' (Kepler's new science) 'fails to progress as it might because men seek for causes instead in their astrological books.' Even if there was some influence from the stars, it should be obvious that the semina was clearly the dominant agent. But astrology obstructed the need to develop a corpuscular theory of genetics and inheritance.\(^\text{22}\) This thoroughly utilitarian argument, in contrast to the fulminations of the theologians about what was 'false', 'diabolic' or 'damnable' in the arts of the 'mathematici' was entirely typical of Gassendi's utilitarian habit of thought.\(^\text{23}\)

Another, equally utilitarian argument, was Gassendi's conviction that astrology was profoundly unsettling for State and society. His
only publication in the vernacular was written, at the request of Vincent de Paul and the almoner of France, to prevent a potentially disastrous panic among the Parisian poor. In the summer of 1654 the city was packed with refugees from the recent civil war. The rumour, spread by astrologers, that the eclipse of 1654 would produce magnetic rays fatal to anyone found in the open air, was particularly disturbing to the homeless poor. It may well have been a ploy, spread by agents of Mazarin, to prevent public assemblies and any repetition of the riots which had driven him from the city a few years earlier. This same story was exploited by the parlement in Provence to outwit the leaders of a peasant revolt against taxation imposed following the defeat and death of Louis de Valois. We know that at this time Gassendi was trying to return to Provence, on health grounds, but was refused permission to leave Paris. There was undeniably a political (as well as a utilitarian) element to Gassendi's critique of astrology. The pamphlet of 1654 seems to have been deliberately provocative. Gassendi picked a pseudonym—Andreas—used in an earlier defence of Louis de Valois. Moreover, since the previous year, Mazarin and Morin had been plotting to have Gassendi put to death in connexion with an earlier attack on Mazarin's sponsorship of astrologers made in a pamphlet of 1652. This had indicted Mazarin's personality and policies—particularly his influence on the Queen Regent. The parlement of Provence supported Mazarin. Vincent de Paul had been expelled by Mazarin in 1651 from his post as confessor to the Queen and membership of the royal conseil de conscience. It would seem that the innocuous-seeming anti-astrological pamphlet—of which few copies survive—was part of some now obscure manoeuvre by the Compagnie du Saint Sacrement to discredit Mazarin's policies on poor-relief, propaganda and the handling of popular revolts. It is interesting that Morin,
replying to Andreas (whom he guessed to be Gassendi) denied all responsibility for the predictions of 1654 — even arguing that the astrologer concerned was a disgrace to the profession and should be sent to the galleys. 28 It is arguable (see APPENDIX I) that only Gassendi's death in 1655, prevented Mazarin taking this matter further — even though spectacular public trials were not to his taste.

The interesting point is that Louis XIV's government, after Mazarin's death, seems to have taken its cue from Gassendi, treating astrology as discredited and astrological propaganda as counter-productive. Gassendi's anti-astrological propaganda was translated and discussed in a number of countries, including England, the New World and the Mogul Empire. Bernier told an anecdote from India of how the imperial gardener, converted by Gassendi's arguments, refused to consult the court astrologer about favourable times for planting any more. But the astrologer, taking matters in his own hands, planted a whole conservatory with rare trees whilst the gardener was absent. The enraged gardener plucked up all the saplings on his return. The astrologer brought the Emperor to view the devastation. 'Can you give any reason why you should not be executed on the spot for this wanton damage?' The gardener trembled and was speechless. 'Is it true, astrologer, that these trees were planted by you, and at the most favourable aspect of the heavens?' 'Oh yes, Excellency, it was calculated precisely by the rules of the art.' 'Then in that case, astrologer, your head should be forfeit, too. For if you did the calculations properly, why did you not foresee that someone would uproot them the day after?' 29 This incident raises an interesting point: if Gassendi's arguments indeed delivered a coup de grace to astrology in Europe, why had they no such lasting influence on the sub-continent?

Our traditional theories of influences communicated by books are
about as adequate, in terms of identifying causal mechanisms, as the theory that the influence of Saturn causes melancholy. As Gassendi himself put it, anticipating Kant and Hume:

'An event cannot be a singular entity, even when a single person is involved, since it derives from a plurality of circumstances: time, space, modes of operation. How much more absurd to write of "an event" involving a single cause for whole armies and kingdoms?'

Gassendi's belief that 'things in themselves' were never the direct objects of human thought and discourse and that our knowledge of causality was based on 'signs' rather than ultimate connexions, sealed his rejection of astrology. Even the individual atom and its individual 'ray' were little more than useful fictions, so far as Gassendi was concerned. It was not to be expected that astrological entities could carry more than a negative ontological status. Astrology did not recognise the sceptical element in all human knowledge and for that very reason was insensible to the millenial process of evolution, from the poetic towards the more exact, which Gassendi saw as the hall-mark of true philosophy.
v) Astrology

1 K. Thomas Religion and the Decline of Magic 1971 p.350. 'Both Galileo and Kepler hesitated and it took...Gassendi to deliver the coup de grace to astrological claims.' L. Thorndyke History of Magic VIII pp.426-65 and pp.446-51 on Gassendi and Astrology

2 0.0. I p.719a Lettres Familières...ed. B. Rochot pp.31, 142-53.

3 0.0. IV pp. 20, 40.

4 Panurgi De Tribus Impostoribus 1654 pp.108-11

5 0.0. I p. 733

6 Guide de la Provence Mystérieuse pp.xii-xxx Ladurie Montaillou passim

7 0.0. I p.731a.

8 See General Crisis in the Seventeenth Century ed. Parker Smith 1978 Essay on 'The Mauder Minimum' by J. Eddy suggests a possible link between the unusual sun-spot activity 1600-44 and the little ice age.

9 0.0. I pp.725-6 Kepler's new astrology, Gassendi argued, was less arbitrary' than the traditionalists but had similar failings.

10 0.0. I p.731b The piety of astrologers is called into question because they 'pervert God's general order', but the point is not stressed.

11 Op cit n.4 p.78

12 0.0. I p.725 Art. 6, Q.115, Art. 3 pt. 11-11. There is no mention of chance or coincidence in St. Thomas' discussion.

13 Bell Huygens p.84

14 In fact Newton's theory of gravity and especially the lunar theory of tides was historically speaking an offspring of astrological lore.' K. Popper Conjectures and Refutations 1978

15 Duhem The Aim and Structure of Physical Theory 1954 pp.238-43 Thorndyke op cit n.1 pp.476-91

16 0.0. I pp. 728, 734b.

17 0.0. I p.726a 'Dimension cannot exercise multiple powers.'

18 0.0. I p.729-31

19 0.0. I p.731

20 0.0. I pp.719a, 31

21 Pederson Early Physics and Astronomy p.402

22 0.0. I p.732 See ON LIFE AND SOULS

23 Calvin's attack on astrology: that it stressed 'secondary causes' and diminished God's Providence reversed Gassendi's argument that it was an impediment to finding true secondary causes. T. S. Kuhn uses Gassendi's argument against Popper in Conceptions of Inquiry Open University 1981 pp.107-121.
24 'Sentiments de Gassendi sur l'Éclipse du 12 Aout 1654'
25 Haitze Histoire de la Ville d'Aix V pp.303-4
27 Op cit n.4 pp.108-11. For the original libel, by Bernier (which expressed Gassendi's private views), Favilla Ridiculi Muris 1653, references to 2nd ed. pp.168, 221. See FRIENDSHIP.
28 J. B. Morin Remarques Astrologiques 1654 pp.52-5. Morin modestly limited his own predictions for the aftermath of the eclipse to the advent of anti-Christ as the false Messiah of the Jews, plagues, wars and upheavals in Church and State, followed by the conversion of the Jews.
29 Événements Particuliers dans les États du Grand Mogol 1671 II p.66
30 O.O. I p.734b.
What criteria do we apply to appraise the motivation of long-dead astronomers: pure curiosity, utilitarianism, religious faith, Utopianism? These are often presented as exclusive alternatives. There is a certain unreality and arbitrariness about any historical analysis conducted from such narrow premises. A central premise of this study has been that the publications of the individual scientist or philosopher do not supply a sort of microscope into the private world of inner consciousness or motivation. This is perhaps more obvious, in the case of Gassendi, than for those who have left purportedly self-revelatory accounts, like Descartes or Kepler. But this must always be seen as a delicate and sensitive area in which sweeping generalisations, or dogmatism of any kind are inappropriate.

In the present study, as many perspectives as possible, local and national, political and religious, philosophical and mathematical have been drawn in with a reluctance to neglect the smallest detail. Yet areas of darkness remain. That is perhaps, entirely as it should be. It is self-delusion to suppose that the historian has a right to know; or a duty to communicate all that he does know. However, careful analysis of Gassendi in relation to his environment—social and intellectual—has certainly yielded a rich harvest of insights into his character and motivation which no one could ever have hoped to glean from his academic treatises alone.

One such insight is that the appropriate place for discussing his motivation in general is not the chapter on the Church or on atomism but in the section on astronomy. This view is indirectly confirmed by the sheer weight of the material dealing directly with astronomy from a technical, historical and physical point of view in the *Opera Omnia*. It is not merely the largest single interest but bulks nearly as large as all his other interests put together. It
is confirmed by his remark to La Potherie that from childhood he had pounced on astronomical observations 'like a cat after mice'. In line with his tendency to assimilate animal to human intelligence, as in his image of the natural philosopher as a dog scenting out his quarry, the metaphor itself communicated a philosophical attitude. Gassendi viewed his interest in the heavens as an uncomplicated instinct, rather than a self-conscious methodology. Astronomy was very much the key to his interest in natural philosophy; and supplied, as we have seen, models for his methodology, epistemology and his concept of philosophical wisdom. Though generally reserved for his intimates and communicated sparsely in print, this last was of tremendous importance to his own character.

Two aspects of the traditional image of Gassendi, the Christian philosopher and the dedicated Epicurean, are opposites almost equally misleading. As far as we are able to tell, Gassendi had no belief whatever in the dogmatic, supernatural, biblical Christianity which was normative in his society. It was partly that he was unable to believe in it—some historians appear to suppose that a professed creed must fit like a tailored suit—and partly that, for intellectual as well as social reasons, he looked down upon it as barbarian superstition. He accepted the constraints which it imposed on his intellectual freedom; partly from institutional loyalty, partly from prudence but mainly from a feeling that religious tradition, however absurd, had a social and historical justification. As for Epicureanism, that was one component, although a very important one, in his attempt to reconstruct the history of pagan science and philosophy in the light of what he believed to be a consensus of the ancients in favour of some kind of pantheistic materialism; the quest for happiness in a balance of natural forces. Gassendi's own account of morality left little enough space for motivation. Humanity was
presented as a machine animated by pairs of opposing instincts (like sets of muscles). Decision making was a function of available data—an information-processing model, rather than a guilt-responsibility model. Milton appropriately attributed a Gassendist mode of reasoning to Satan, who chose between fighting and flight by the inclination of the 'balance' of the consequences of each in the constellation Libra.\(^1\) It was precisely because the anti-religious elements in Lucretius balanced what, to his mind, was the superstition of the day that Gassendi placed such emphasis on Epicureanism. From a purely scientific standpoint, as will be made clear in the next chapter, he made drastic modifications.

Gassendi himself would certainly have sympathised with the method of psychological analysis adopted in this thesis. Like Spinoza his was a behaviouralism tempered by élitism; the golden spirits were not such complete prisoners of 'the machine' of their sense impressions as the multitude, due to their superior knowledge. But like everyone else they had a central nervous system (or animal soul); as any other seed they adapted to the circumstances in which they fell. Let us assume, for the moment, that Gassendi found himself in the situation of Pascal's free-thinker, alone in a universe without a Creator. How did his attitude to astronomy help him to avoid the fear and despair which Pascal appeared to regard as inevitable? Gassendi's primary goal, following a strain in Renaissance scepticism, was to employ the idea of the infinity of space, the distances and material magnitude of the stars, the eternal succession of moments, to transcend his human consciousness. This perspective made possible a complete reversal of geocentric theology—what did the planet earth and its human cargo matter? What did the most cruel sufferings and torments of the individual ego—let alone its foolish fears and imaginary terrors—weigh in the total scheme?
Evidence that Gassendi thought in very much this way is provided by his frequent use of astronomical examples to stress the insignificance of wars, politics and human history against a cosmic backcloth. It is evident in his constant insistence that he was a pure spectator, not merely of social and political life but of the whole cosmic drama. He urged his disciples to picture the rest of humanity as if they were mere images in a mirror—an interesting anticipation of Versailles' Galerie des Glaces. This may help to illuminate his emotional, as opposed to his intellectual, rejection of astrology. Instead of viewing the heavens as created for the human race, and of interest only in so far as they could be shown to have a direct influence on wars, politics, weather and disease, it was as a yardstick for the total insignificance of humanity on the cosmic stage that Gassendi valued astronomical science. This attitude, which began with humanism, ended by transcending (or transhumanising) all homocentric values and perspectives.

There was nothing particularly original in this view, which Gassendi might have derived from meditation on ancients such as Seneca, whom he frequently cited in this context. Gassendi regarded this doctrine as the authentic credo of the astronomically minded élite in all ages. Far from treating it as a matter for cosmic despair, or retreat into fideism, it was the only realistic starting point for any morality which was not mere superstition, based on hopes and fears in the hereafter. Gassendi's admiration for Ptolemy, transcending their differences over geocentrism, did not merely stem from his verdict as a historian that Ptolemy was the 'authentic founder of the whole art and science of astronomy'. No one who reads Ptolemy attentively can doubt that he was deeply influenced by the sort of cosmic stoicism we have been discussing:

'With regard to virtuous conduct...this science of astronomy above all else can make men see clearly the constancy, order, symmetry and calm associated with the
divine. It makes its followers lovers of this divine beauty, remodelling and reforming their natures, as it were to a similar spiritual state. It is this love of the contemplation of the eternal and unchanging which we constantly strive to increase by studying first those parts of the sciences which have already been mastered by those who approached them in the genuine spirit of enquiry and by ourselves attempting to make as much advancement as the additional time between those people and ourselves has made possible.' (Almagest H8)

This passage is entirely in keeping with Gassendi's views, and the fact that it was written by an Aristotelean/Stoic who lived 1500 years previously should help to dissipate superficial misconceptions which tie science too closely to a seventeenth-century zeitgeist. Gassendi's expressed preference for the golden age of the Antonines, in which Ptolemy lived, shows the depth of the affinity which he recognised between his philosophy and theirs. Attempts to slap a Christian or a purely Epicurean label on Gassendi are, for this reason, a mistake. Although Ptolemy subscribed to the eternity of matter (on which Stoic, Epicurean and Aristotelean agreed), Ptolemy did not hesitate to write of the 'divine beauty' in the heavenly bodies. His assertion that this had moral effects was reiterated by Copernicus. But we must not make the mistake of supposing that wherever the words 'divine' or 'morality' occur in relation to science they are the direct result of some personal belief in Christianity. In the case of Ptolemy they reflect a well established tradition of intellectual paganism. When Gassendi criticised the ignorance of science of the biblical writers, he did not mean simply ignorance of fact or theory. Rather he meant this fundamental principle—first discovered by the astronomers—that physical laws are universal and unvarying even over immense periods of cosmic time. Gassendi's firm rejection of petitionary prayers, sacrifices and anything which purported to change God's mind, ran completely contrary to the whole direction of religion in his day. Apart from a few heretical mystics, like Malaval, it was alien to the Christian tradition. On the other.
hand, we find Gassendi's wish that the Gods be honoured not invoked, to have been the model prayer of Apollonius Tyana — the Pythagorean-Epicurean, whom Bishop Godeau ambiguously described as 'the ape of Christ', and celebrated as Christ's superior by the *Theophrastus Redivivus.*

Tyana's Pythagoreanism brings us back to the question of morality and astronomy, which was at the heart of the secret Pythagorean doctrine of harmony. Tyana, like Gassendi, abstained wholly from animal flesh. In Gassendi's own mind the collapse of the geocentric universe, the excitement (not terror) at the prospect of infinite space, and the transhuman succession of the unknown stellar masses, endorsed the rejection of meat-eating. Since there was no longer any evidence that humanity was the goal of the cosmos (or even that the cosmos had any purpose remotely imaginable to a human mind) to prey on other species could no longer be justifiable. Gassendi, who described man as an animal without any instinct—in the determinative sense of birds and bees—other than thought itself, was very conscious of morality as a principle of harmony or balance. The fact that the stars were not some remote fifth essence, but made of the same substance as ourselves, led to the possibility that our lives might be regulated by the same order. He was not being wholly frivolous when he described stars as states and planets as their citizens. But the true perspective for that order was not the spiritual lordship of creation in the purpose-built universe of the theologians. Gassendi's response to the stars, like his response to the structure of bodily tissues, was an _O Stupore_—wonder which stopped short of endorsing the presence of a geocentric, homocentric architect engaged in legislating morally, naturally and supernaturally for a humanity 'a little lower than the angels.' The order in Gassendi's universe flowed from the nature of matter itself. From the invisible workmen, who brought
the chaos of the elements into order; from the \textit{Itus Reditusque}, the regular wave-motion, determined by the interplay of conservation of motion and impressed force throughout the universe; from the codes of combination which were the arbiters of chance. (see next chapter). It was such a balance of elements, not a personal identity, which formed the harmony of the human soul.

All this did not necessarily rule out the divine, in some form. But it did rule out any divine intervention with the principles of time, space or matter. It ruled out, as we have seen, any divine preoccupation with humanity at the expense of other forms of matter. In this Gassendi seems to have been a close disciple of Bruno who accepted a divine principle innate in matter itself—not the steersman, or prime mover of the cosmos, but the timber fabric of the ship. In \textit{Apollonius of Tyana} the same identification between the cosmos and an ocean-going Egyptian galley was made by the Indian philosophers. Gassendi was sceptical that humanity would ever understand the divine nature philosophically or theologically. God, in our language could never be more than a \textit{Fimentum}, literally a construction or a fiction, warped to the dimensions of our own slender understanding. Astronomy seems to have furnished him with the hope of transcending these anthropomorphic limitations by an awareness of space which humanity could never put to any conceivable use; of innumerable suns, unimaginably vast alchemical furnaces, which might or might not have inhabited satellites; of a ceaseless flow of time as long as the eternity of the theologians. By placing humanity at the foot of this vast colonnade Gassendi found a perspective from which to view its moral and political problems with detachment. By demonstrating, through the science of observations, that the absence of a human scale or purpose did not mean absence of measurable order, Gassendi derived from astronomy the sort of mystical vision that
St. Thérèse of Avila or St. Thomas had derived from theology.

Gassendi was not a mystic in the usual sense of the word, but his emphasis on the unknowable character of God has figured in mystical doctrines. François Malaval's vision of the divine revealed in nature (rather than by churches, scriptures or theologians) captured this facet of Gassendi's thinking. But it is perhaps in Indian mysticism, rather than in western theism, that we come closest to the core of Gassendi's secret doctrine. Bernier's account of the Indian world-soul—a doctrine to which he alleges Gassendi to have been sympathetic, although it is presented in neutral terms in Syntagma I p. 287—is evidently coloured by these preconceptions. His account of an allegedly Hindu belief that God was a vast spider, who generated an orderly creation like a web, inspired Hume to argue that evidence for design in nature was not evidence for conscious design or a personal God. The spider was cited in the Syntagma as an example of creativity without conscious design, and the imagery of fibres or weaving was continually used by Gassendi to explain the evolving structure of everything from atoms to planets. 

I have not been able to trace by any evidence, independent of Hume and Bernier, that any such spider deity was ever worshipped in India. It is therefore at least possible that this was a conception originating with Gassendi himself. (See next chapter)

The book which comes closest to Gassendi's concept of matter, the anonymous Theophrastus Redivivus, discovered a common materialism in Aristotle, Epicurus and the Stoics, treating their philosophies as one. Force and matter were regarded as the sum total of nature and as the authentic divinity or world-soul. The stars, and our own sun, were emblems of this divinity because they were the most powerful concentrations of force and matter in existence. The author of this book, which may have been completed around the time of Gassendi's death, quoted all those anti-religious passages from Lucretius which
Gassendi carefully omitted from his own works. He referred to works by members of the Tetrad, and his ideas and language frequently echo that of Gassendi and his favourite classical authors; except that his use of them—the term Fignentum for example—is overtly atheistic.  

It is interesting that the term Redivivus was applied to Gassendi himself in an anonymous oration delivered at Oxford in 1655. This passage made a striking identification of Gassendi personally with divinity, the sun and the principle of gravitation. After his death (the previous month) Gassendi lived on—'redivivus'—not merely in his doctrines but at one with material nature. Apart from its blasphemous character, it is interesting to speculate on whether its author knew of the Parisian Theophrastus in linking the term Redivivus to Gassendi and how far his pantheistic image of gravity—'confounding God with matter' as Newton put it after reading Charlton's account of Gassendi—was based on a knowledge of some private teaching of Gassendi's, now inaccessible.  

The statement that Gassendi had located the Gods 'not in the heavens but as if in the stars' shows that this Oxford writer made the same deduction from Gassendi's writings as the writer of the Theophrastus. Once the supernatural had been removed, and God identified with the laws of conservation and combination of atoms, his essence was indistinguishable from matter and motion. But the stars were the largest concentrations of matter and motion in the cosmos. Therefore, although God was not exclusively in the stars he might be considered to be concentrated there. This would explain why the divine character was attributed by the Oxford writer to Gassendi personally, to the stars and to the force of material attraction itself.  

It would therefore seem that the motivation for Gassendi's astronomical research was that 'love of truth', which he professed early in his career. This was a passion going well beyond 'pure'
science and taking in the moral and spiritual need to accommodate his mind to inhabit a universe where traditional religion was still a social but no longer an intellectual necessity. It is unlikely, unless he was a second Apollonius of Tyana, that Gassendi stepped out of his cradle fully armed with such a programme. There is a fascinating tale, on which history remains silent, of how the peasant's son, an amateur astrologer destined for the priesthood, grew up to be the unbelieving doctor of theology whom St. Vincent met in Paris. Although his astronomical notebook was started in 1618, we know that his habits of observation went back at least to Kepler's grand conjunction of 1603 (aged 11). We might guess that his rejection of astrology immediately preceded the decision to begin the notebook, whose plan indicated a prior intention to confute weather-astrologers. How big an early influence was Wendelin—acquainted with sceptical circles in Italy and the Netherlands, and a dedicated astronomer? Or was it the patronage of Gaultier and other members of the parlement which was decisive at some point between 1607 and 1618 in turning him from astrology and scholastic theology towards what Matthew Arnold called 'the high white star of truth'? Although Gassendi's strongest personal objection to astrology, that it placed man in the centre of the cosmic stage, applied with equal force to theology, there is no clear evidence that unbelief in Christianity and rejection of astrology were chronologically or logically related.

Going back still further, to Gassendi's boyhood stargazing, the search for motive is more speculative still. Was it a lust for the power and fame bestowed on even the simplest peasant magus? Was there, as suggested earlier, an impulse to assist the local peasantry in their losing battle with the unusually unpredictable series of floods, freezing and drought which set in at the turn of the century? What is clear is that Gassendi's claims, in his astronomical lectures,
to be using astronomy as an instrument for the refutation of the sceptics and as a lantern-slide illustration of Catholic theology, were purely cosmetic. They were of a piece with his meticulous exposition, in the same lectures, of astrology, or the Ptolomaic and the Tychonian systems, without any hint of the real direction of his own researches over the previous twenty-five years. Because of the very nature of his true motives, this mask was unavoidable. Gassendi propounded to Descartes the old stoic paradox of the man in the mask. 'Do I know my father? Yes. But I do not know the identity of the masked man. Therefore the man in the mask cannot be my father.' The only way to know the man's identity is not by logical argument but by removing the mask. Then we find layer, upon layer spiralling towards infinity....
vi) Motive

1 **Paradise Lost** end of book one.

2 Almagest H8

3 Philostratus *Life of Apollonius of Tyana* Loeb I viii.

4 Bernier *Voyages* I p.202. It is clear that Bernier is talking about the process of emanation-return described by Gassendi in the neo-Platonic conclusion to the *Syntagma*. For Hume see *Dialogues Concerning Natural Religion* (Hafner ed.) vii p.51. These dialogues are soaked in Gassendist philosophy.


6 Cambridge Add. MS 4003-f.27 Newton gives a very full account of Gassendi's views of the relationship of mathematics to nature; space; body; rest; motion; the animus mundi; and adds 'No wonder atheists arise to confound God with matter.' The date of this MSS cannot be earlier than 1668 and might be as late as 1678.

7 B.M. MS 6193 add. f.996 oration to Gassendi delivered in 1655 in Christ Church Cathedral. This manifesto, attributed to the long-dead Gellibrand (who had had connections with Gassendi's work on the declination of the magnet) was clearly the work of a clandestine unbelieving group which regarded Gassendi as a god.
SECTION I

ATOMS AND INDIVISIBLES

1) The Debt to Antiquity
2) Originality and Eclecticism
3) Atoms and Indivisibles
4) Atoms and Christianity
5) Towards a Social Morphology of Atomism

Footnotes for each section numbered separately

'Contract yourself into the biggeness of an atom and you will enter Nature's doors more easily.'

Harriot to Kepler

'I was musing at supper, on the opinion of those philosophers who make chance the origin of all things. "Might not dishes, lettuce, eggs, salt, drops of oil, vinegar, flying about for eternity produce a salad entirely by chance?" "Aye, they might—but not as good as this one," replied my wife.'

Kepler
1) THE DEBT TO ANTIQUITY

The contribution of Renaissance humanism to modern science has not excited the scholarly interest which in recent years has been lavished on puritans and scholastics. Gassendi's work on ancient atomism, for example, is normally dismissed in a condescending sentence and the question of the relationship of his scholarship to creative science avoided. The phrase 'scientific revolution' has been applied to mean that a total break in continuity between Greek and modern science was the hallmark of the sixteenth and seventeenth centuries. Scholarly preoccupation with the Christian Middle Ages, or the Reformation, helps to explain why Gassendi's outlook has been so difficult to recapture. All too often a naive mental picture of Greek atomism as 'balls on sticks'—Dalton without any quantitative notation—guides the modern student of Gassendi. It is tedious to anatomise howlers. But what value can be placed on the judgements of those who confine Gassendi's studies of atomism to the margins of mainstream science and philosophy, when their knowledge of his classical sources is so slender?¹

It has been the fashion to belittle Gassendi's classical scholarship; as if it were not rather a matter for astonishment that an active priest, politician, astronomer, philosopher and experimental scientist, should have had time to master the several styles of Greek, from Homeric to Alexandrian, and pursue the discovery and restoration of original texts.² There are two further points to be made. Those scholars who have criticised Gassendi for faulty readings seem unaware that the standards of seventeenth-century classical linguistics fell short of those later attained in the nineteenth and twentieth centuries by
specialists with nothing to do but grind away at grammar and lexicography. Philology in Gassendi's day was part of the equipment of every learned person, including scientists and mathematicians. The emphasis was on the communication of ideas, rather than on the accuracy of syntax which led to the petrification of the Renaissance ideal in the European universities of the late-nineteenth century. If we take up Bailey's twentieth-century edition of Epicurus, it is clear that Gassendi's suggested emendations on the texts of Epicurus which he edited and translated are still taken seriously by the republic of letters. Where Gassendi could not make out the sense, he guessed on the basis of probability. Gassendi has been accused of taking little pains to establish the accuracy of his quotations from Lucretius by a collation of variant manuscripts. The truth is that he worked within a degree of accuracy suitable for his needs. Gassendi studied with Vossius and Golius in the Netherlands on the text of Epicurus. It was not until after the death of Vossius that the latter's son produced the more accurate manuscript of Lucretius which made the restoration of our modern text possible. Fortunately, we now possess a well-researched and authoritative study of Gassendi's work on Epicurus by Dr. Albert which entirely clears him of these smears of indifference or inaccuracy.

Such matters would be beneath the notice of serious historians, if they were not indicative of a general tendency to belittle or ignore Gassendi's work, which cannot be explained solely in terms of skills necessary to appreciate him fully. Atomism, for all its antiquarian pedigree, was a deeply emotive issue in the seventeenth century. The situation is not always so very different today. The Jesuit neo-scholastic of the 1930s and the Protestant evangelical of the 1970s are ecumenically at one in their determination to demonstrate that neither science nor religion has ever had anything to learn from
Marxist materialism originated directly in the study of Greek atomism; and Lenin regarded Gassendi as the equal of Descartes. This makes it all the more important that our analysis of the role of atomism in modern science be clinical and dispassionate. Religious antipathy to atheism and materialism, however laudable in itself, must not be allowed to distort the historical picture.

The accepted view of Gassendi's restoration of ancient atomism is that his pious thought was to baptise Epicurus, so that his authority might replace that of Aristotle in the Catholic universities of the future. It would be, so it is held, anachronistic to tar Gassendi with the brush of either Greek materialism or the nineteenth-century rejection of the supernatural. It will be evident to the reader that the historical Gassendi has little in common with the pious pedant created by modern commentators. Whilst there is no direct evidence to explain Gassendi's extraordinary obsession, either with the person of Epicurus or with classical atomism in general, it is suggested that both can best be understood in terms of what has been presented in the preceding chapters of this thesis. As a member of a sceptical and erudite élite, which was keenly aware of the link between civil disorder and religious fanaticism, Gassendi could not fail to have noticed the relevance of Lucretius' critique of religion and popular superstition. The fact that the passages containing this critique are the only sections of De Natura Rerum not cited in his discussions of atomism does not prove that he omitted them because he personally found them shocking. Contrary to the position which he publicly upheld—that Epicurus and Lucretius were deeply pious thinkers who posed no threat to Catholicism but only to pagan superstition—he must privately have been aware that these passages could be read as an attack on all religion. They were so understood by
some of his intimate friends, such as Gabriel Naudé.11

The account of Gassendi's relation to Christian beliefs, in the chapter on the Church, suggested that he was mentally a citizen of pagan Greece or Rome so far as his religion was concerned. His lukewarm enthusiasm for Christianity on the level of social ritual, or popular belief, was balanced by what can only be described as hostility—even contempt—on an intellectual plane. And this leads me to conclude that Gassendi's public admiration for Epicurus, like his carefully screened passion for Julian the Apostate, was part of his programme for secularising both science and scholarship, freeing them from the constraints which he believed Christian theology imposed.12

In order to understand Gassendi's grounds for pursuing the study of atomism we should turn to the writings of J. B. Morin. Although a colleague of Gassendi at the Collège Royal, and a friend in undergraduate days, Morin's views have been discounted by historians. Nevertheless his insistence that Gassendi's attempts to Christianise Epicurus are mere 'sophisms' ought to strike a chord in any reader, even without the context supplied in this thesis. His claim that there is no substantial difference between the real religion of Gassendi and that of any pagan Greek atomist could certainly not be justified from the text alone. But in the light of the evidence presented in GASSENDI AND THE CHURCH or GASSENDI ON LIFE AND SOULS it certainly does not appear extravagant or unlikely.13

The question of the timing and sources for Gassendi's interest in atomism have never been satisfactorily answered by scholars. All we know is that by 1628 he had already composed some Epicurean work. Scholars have no clear evidence that he was especially interested in science until after his visit to the Netherlands the following year. There had been an active interest in Lucretius' poem in France since
the sixteenth century; particularly among those scientific poets who had clustered round the French academies patronised by Charles IX, the grandfather of De Valois. Although Gassendi might have come to atomism through many sources, the most likely seems to be Peiresc, who also introduced him to scholarship. Peiresc's papers document his own conviction that atomism would be experimentally verified as the key to natural processes. It was to Peiresc that Gassendi sent the first plan of his projected Epicurean treatise. Peiresc was obsessed with discovering the clue to modern problems in the minute and scholarly reconstruction of antiquity. More important still, Peiresc had travelled. He had been in England in 1606, when the Harriot-Northumberland circle was tried for high treason, and later corresponded with some who had access to this circle in the Tower. The conjunction of atomism and atheism with science in this group has been played down by modern historians, doubtless for weighty reasons. However, there are certain anomalies in the tracery of influence which would be eased by the assumption that Peiresc was a link between this English circle and Provence. Lohne has drawn attention to an unexplained similarity between one of Harriot's unpublished diagrams on the law of fall—which he appears to have discovered independently of Galileo—and Gassendi's method of expounding Galileo in a treatise of 1645. Perhaps the fact that Peiresc had been with Galileo and Sarpi in Padua, discussing the as-yet-unpublished law of fall, immediately before his visit to England, is further indication of the channels traced by this subterranean convection of ideas. Another point of interest in this explanation is that, like Gassendi, the London circle appears to have linked Epicureanism with the elliptical orbit, new laws of force, research on ballistics and the new mathematics. The French tradition of Lucretian studies, though not without influence on exact science, was primarily sceptical,
literary, and humanistic. 18

The home of the Lucretian revival was Italy. But that particular brew of atomism, associated with Giordano Bruno and Vanini, was so heady that much of Gassendi's painful rewriting of his Epicurus involved the progressive elimination of the visible signs of Italian influence. Morin was quicker than most in spotting the inconsistencies which betrayed these oscillations between boldness and expediency. Why, he wanted to know, did Gassendi's writing against hermeticism exorcise the philosophy of Severino as destructive of true religion, when Severino's doctrine of the semina, or active matter, was praised in the Animadversiones and made the corner-stone of Gassendi's natural philosophy? 19 His letters to Galileo echoed Bruno's intoxication with the infinity of atomic space and the emancipation from fear of religion. 20 Yet this note is assiduously avoided in all his published studies of space and atomism, which are models of convoluted erudition and conventional pieties. Vanini is nowhere mentioned in Gassendi's work. Yet Peiresc admired his efforts to synthesise the new vitalism of Severino and Paracelsus with Greek atomism; and his interest in Lucretius marked him out as Gassendi's immediate precursor. Vanini's execution in 1619 may account for the need to keep the Epicurean project under wraps until 1627. The scandals associated with the Epicurean poet Théophile de Viau, executed in effigy after a spectacular blasphemy trial, confirm this interpretation. De Viau was a nature poet, who drew on the pantheism of Vanini and on literary Epicureanism. One of his associates, François Luillier, became a staunch friend and patron of Gassendi from 1627. Peiresc had made the introduction, and it was while travelling in Luillier's company that Gassendi sent Peiresc the first known plan of an Epicurean treatise on natural philosophy. 21

Although the exact lines of influence, or the details of
composition, must be regarded as speculative, there can be no doubt that Gassendi's interest in ancient atomism was not antiquarianism for its own sake. It was the spirit of sceptical paganism which he sought to recreate, maintaining a public support for the Catholic religion with due concern for his self-preservation. The sympathy of Gassendi and his whole circle with what has been described as crude reductionism, or 'nothing buttery', must be seen in the context of the religious fanaticism and popular dread of signs and prodigies with which they were daily confronted. In the seventeenth century, unlike the Age of Enlightenment, the educated classes and religious establishment were by no means emancipated from the fear of supernatural agencies. Viewed scientifically, Epicurus' physics amounts to little more than a reasoning by ostension—pointing to every conceivable state of affairs and saying: 'This is nothing but atoms in motion.' In the twentieth century it is difficult to recapture this lost world of the Epicurean rationalist; the excitement of Peiresc and his friends on finding a rain of blood to be the excrement of butterflies; or that a purple rain at Antwerp was caused by industrial pollution; or that the four suns which appeared at Rome in 1629 were caused by geometrical laws of refraction.

It is curious that, despite all the forests which have been laid waste in order to alert the world to the significance of Descartes, no-one has pointed out the profoundly Epicurean character of Cartesian reductionism. Even more than Gassendi, who avoids the crudities of 'nothing buttery' through his emphasis on the built-in limitations of all human science, Descartes recaptures the Lucretian spirit: 'Don't worry, it's all done by particles.' Despite his formidable offensive against Descartes' doctrine of God and the soul—which were scholastic—Gassendi never wrote any criticism of Descartes' natural philosophy. Shortly before Descartes' death,
the two met in Paris and staged a reconciliation.\(^{25}\) If we except the two major questions of the inertness of matter and the certainty of human sciences, the similarities in their physics are more striking than the differences. It is small wonder that lay patrons like Montmor and Cavendish, or even Boyle and Huygens, seem to have felt equally at home with both philosophers.\(^{26}\)

Another reason why Gassendi avoided the crudities of Lucretian reductionism, whilst preserving the principle of seeking natural rather than supernatural explanations, is the breadth of his classical scholarship. Gassendi was keen on Pythagorean and pre-Socratic atomism, with their mathematical bias towards explanations of nature. This enabled him to relate atomism to new mathematical developments in optics, astronomy, and the study of natural processes and motions. It took him a long way from the crude resolution of objects into particles which were no more than the objects of common sense made invisible. His study of neo-Platonism and Stoicism provided him with a more sophisticated image of material structure to supplement the hooks and eyes of Epicurus. This led naturally into new models, available from alchemists such as Paracelsus and Helmont, which emphasised the self-structuring germ. At the same time his studies of the Aristotelian critique of atomism, combined with the radical reinterpretation of Aristotle derived from Italy, made him aware of the intellectual limitations of any atomic theory in which discontinuity was crudely opposed to continuity by some arbitrary indivisible.\(^{27}\)

To summarise: Gassendi's interest in atomism was apparently secular and scientific. If there was a religious element, it lay in his conscious rejection of the medieval Christian tradition and his admiration for the secular, sceptical intellectuals of pagan antiquity. Gassendi's work provides a model for the relationship
between Renaissance humanism and science. Accurate restoration of the original texts was important, precisely because it might lead to new ideas capable of solving contemporary problems. Gassendi did not simply restate either Lucretius or Epicurus, but made a very broad study of pre-Christian theories of matter, outside a scholastic context, embracing Aristoteleans and Platonists, Pythagoreans and Stoics.
ATOMS AND INDIVISIBLES

1) The Debt to Antiquity

1 Professor Hall, in a lecture on John Dalton in 1966, referred to a huge work of 'three volumes in folio' into which, he alleged, Gassendi had 'blown up' Lucretius' writings on atomism. In his latest textbook he writes again of Gassendi's 'paraphrasing Lucretius'. I have not been able to identify the 3-vol. work to which he is referring. To describe Gassendi's philosophy as a 'paraphrase' of Lucretius ignores his debt to Epicurus, Aristotle, Plato and the Pythagoreans. In any case, Gassendi rarely paraphrases Lucretius, but quotes him in full.


Kargon confuses Gassendi's (Newtonian) theory of time with that of Epicurus and appears to rely on Charlton's English translation of Gassendi for all his generalisations about the latter. 'Charlton, Boyle and Epicurean Atomism in England' Isis 1964 p.191.

Fr. Barry Brundell is under the impression that Gassendi made Epicurus' deterministic atomism closer to the Christian concept of free will. The truth is the reverse. Epicurus was more concerned to secure the freedom of the human will than any other Greek writer. It was Gassendi who removed the main props to free will built into the Epicurean system.


Professor Rochot argued that Gassendi's Greek was quite inadequate to understand Epicurus in the original. As his example of error he quotes a passage where Gassendi has mistranslated an account of the evolution of human society as referring to the evolution of nature itself. My own analysis of this passage—which a Greek scholar has kindly confirmed—is that no grammatical error is involved. Gassendi misread the contextual clues in order to argue that Epicurus believed nature evolved through design. Gassendi knew very well that Epicureanism ruled out providential design in nature out of hand; on the other hand, conscious design was present in the evolution of human nature to the demands of its environment. Gassendi wished to mislead a Christian reader into thinking that Epicurus anticipated an argument from design.

2 Rochot op cit. p.109

For Gassendi's translation see U.0. (V)p.28; for modern translation see C. Bailey ed. Epicurus letter to Herodotus (75). The double meaning turns on the fact that physis can mean either nature or human nature, depending on context.

2 Rochot op cit. p.135. 163-4, Brundell op cit.

3 I am grateful to G. M. Lee (a compiler of the new Oxford Latin Dictionary) for discussion of this and other points of classical scholarship.


5 I am grateful to Dr Jones for private communication of his studies on Gassendi and Lucretius.
6 C. Bailey Titii Lucretii Carci De Rerum Natura (3 vols.) 1947 pp. 37-43

There is rather a mystery about the emergence of the two MSS 'O' and 'Q' in Amsterdam in 1690. In Gassendi's day a number of variant MSS were known, but all deriving from the original discovery 'in a distant place where few come' by Poggio in 1418.

7 Fr. Hoenen S. J. Cosmologia 1936 His book has been composed to demonstrate that the whole of science, including Dalton and Heisenberg, is 'potius Aristotelica quam Democritica'. He even takes the ultra-scholastic Duhem to task for daring to suggest that even medieval concepts of 'minima' were in any way influenced by Greek atomism, pp. 508-15.

D. Mackay The Clockwork Image 1974 pp. 40-7 stigmatise Epicurean science (which he describes without naming it) as 'dangerous ontological reductionism' alien to true science. This has been discovered only by biblical Christians 'born at a time when all men of learning were deeply religious.'

8 Marx Differenz der demokratischen un epikureischen Naturphilosophie Dokturdissertation Jena 1841

Lenin Works (45 vols) see index Gassendi and vols. 35, 38. This dependence of atheistic materialism on a philosophy created by a slave-owning agrarian society is soft-pedalled by Soviet analysts, since it clearly poses problems for their theory of class struggle.


10 Dr Jones' analysis shows how very striking is the omission of some 250 lines attacking religion—including some of the most famous passages in the poem. Out of an overall 7,500 lines Gassendi quoted 5,400 in his Syntagma alone. The other omissions are the description of the human sex act or purely poetic passages.

11 See GASSENDI AND ABSOLUTE MONARCHY

12 See GASSENDI AND THE CHURCH

13 V. Panurgii Epistola de Tribus Impostoribus 1654 p. 33

14 S. Fraisse Lucrèce en France au seizième siècle 1962

A. M. Schmidt La Poesie Scientifique en France au seizième siècle

15 Lettres de Peiresc IV pp. 249-52 28 April 1630. 1938

16 Henry, Earl of Northumberland 'the wizard Earl' was examined between November 1605 and June 1606. Not only are these the dates of Peiresc's English visit, but we know that he lied to James VI about being already a qualified barrister, in order to be able to participate with the king in a state trial before the council.

0.0. (V) pp. 263-4. His first mention of atomism comes in a letter written from England to Scaliger: 'I no longer marvel at the speed attributed to the ostrich, now that I have seen the English horses... I do not know why nothing in mathematical art seems able to place the planets on their right track: unless it is an overflow of minute particles scarcely intelligible to sense.' MS Aix Méjanès 1021 f. 66

See Atomism in England from Harriot to Newton 1966 Kargon pp. 18-30

Peiresc was a correspondent of Sir Robert Cotton (who had access to the Tower and helped Raleigh with his history) and of another friend of Raleigh, Seldon. B. M. Cotton MSS v. 46, 112, 117, 124, 134-49.
17 J. Lohne. 'Harriot's Collision: Theory' Archives for the History of Exact Sciences 20 1979 p.236. I am grateful to Dr Whiteside for drawing my attention to this article. The resemblance between Harriot's work in the 1600s and that of Fabri and Gassendi in the 1640s is closer than Lohne realises.

18 Peiresc's comment (n. 16) appears to point out the position which Gassendi did not publicly occupy until the 1630s and 1640s (over twenty years after).

19 Op cit n.12 p.50 Severino (1580-1656), like so many unorthodox thinkers of the day, came from Calabria, Southern Italy. He was connected with Telesio and Campanella and frequently in trouble with the Inquisition.

20 O.O. VI pp.4-6 Bruno's system had active matter at its centre La Bestia Trionfante ed. 1888 pp.21-39

21 For Vanini see Spink French Free Thought ... 1960 pp.30-42.

22 See D. Mackay op cit n.7.


24 It is certainly not coincidence which led Gassendi to use the term Vortex in his translation of Epicurus' Letter to Herodotus to describe the atomic generation of new worlds. O.O. (V) p.27. There is something rather poignant about the indignation with which E. Aiton The Vortex Theory of Planetary Motion 1972 pp.34, 58, 66. repudiates Gassendi's charge that Descartes' vortex derived directly from classical atomism. But even he cannot deny that Descartes' laws of motion owed something to Lucretius, p.251. See O.O. (I) pp.257-8.

25 Baillet Vie de Descartes pp.234-6. Fr. Fabri S.J. was their mutual friend from 1646.

26 See Biographical Dictionary of Scientists.

27 Gassendi's knowledge of the sources was so good that without familiarity with Kirk and Raven's collection The Pre-Socratic Philosophers 1964, W. Guthrie's History of Greek Philosophy 1962, especially volume I, or Plotinus Enneads and Aristotle's Physics, his reader will be largely in the dark. For Stoicism see Sambursky The World of Late Antiquity 1966.
ii) ORIGINALITY AND ECLECTICISM

Apart from the charge that he slavishly followed Lucretius, the most common accusation against Gassendi is that he pursued a convoluted path of erudite eclecticism, incomprehensible even to his contemporaries, from which no new ideas emerged. But although Gassendi failed to produce any definitive synthesis—an idea of the scientific process which he firmly rejected—his world was not a mere chaos of concepts from fragmented systems. To describe Gassendi as an atomist at all is misleading. The fact that this assumption is so general reveals the depth of misunderstanding in which his work is shrouded. Gassendi specifically denied that Epicurus, or anyone else, could definitely describe the ultimate constituents of things as atoms. Although he anticipated that the progress of science would produce new 'scalpels for matter' much sharper than the alchemical furnaces and instruments of vision many times more powerful than the microscope, he denied that the existence of atoms would ever be verified. To describe atoms at a theoretical level Gassendi preferred the more ambiguous term *principles.* Epicureanism, as understood by this sceptical empiricist, was merely the doctrine that matter was the only source of intelligible reality. It was materialism, not atomism, on which Gassendi's dispute with Descartes turned. Between Descartes' corpuscles and Gassendi's principles there was little to choose.

Although there were very many divergencies between Gassendi and Epicurus—some real, others fabricated to save the appearances for Christianity—the most fundamental was Gassendi's redefinition of the atom. This can be understood only if we put firmly to one side any idea that Gassendi saw his life-work as a crusade against Aristotelianism. For Aristotle himself, shorn of his Catholic theological trimmings and his concessions to Greek theism, Gassendi had nothing but admiration. This preoccupation
with the real or the historical Aristotle seems to have been general among Gassendi's intimate circle. Naude, Boulliau and La Mothe Le Vayer all refer to it as a matter well understood among the initiate. However, it seems to have been lost sight of since.

Gassendi's Aristotle, like his near-contemporary Epicurus, was a materialist whose prime matter was the foundation of the universe. The emphasis on friendship and pleasure as the supreme good in Aristotle's writing shows that in morality he concurred with Epicurus. The emphasis on sense in Aristotle's psychology shows that like Epicurus he was a good empiricist. These efforts to show a concordance of Aristotle and Epicurus involved the theory that the former taught two philosophies—a public and a private—publicly emphasising teleological metaphysics for prudential reasons, privately teaching a form of materialistic-empirical Platonism. This may seem a drastic departure from our textbook picture of Greek philosophy. But, given the dualism between their own professions of Christianity and their private hedonistic materialism, it is not difficult to see why Gassendi and his circle chose to portray Aristotle in this Machiavellian mode. But if the historical evidence is examined in the light of Gassendi's theory some textual support can be found.

To put the hypothesis at its very weakest, no Aristotelian scholar would now defend the view that we have either a consistent or a monolithic corpus of Aristotelian writings.

It is important to emphasise how closely the critical attitude to the analysis of texts, encouraged by Renaissance scholarship, was related to the Baconian attitude of comparison between recorded natural phenomena. Gassendi's approach to the competing Greek theories of matter was exactly the same as his attitude to the different observations of the unusual shape of Saturn. He was confident that one explanation would turn out, ultimately, to be
significantly better than the others. But he was content to proceed by accumulating evidence, rather than by reliance on authority or intuition.

Gassendi had meditated on Zeno's paradoxes of the continuum and read Aristotle's refutations of the existence of an indivisible minimum of matter; he accepted that they torpedoed conventional Greek atomic theory. It was not a mere gesture to tradition which placed Aristotelian logic side by side with Epicurean canons at the beginning of the Syntagma. Gassendi was equally fascinated by the Aristotelian concept of form, for which the Epicureans could substitute only the random swerve of the atoms. Despite his rejection of Aristotelian metaphysics—the philosophy of place, prime mover, four elements, potential/actual etc., discussed in earlier chapters—the Aristotelian concept of matter was fundamental to Gassendi's re-working of atomism to meet the needs of an experimental philosophy. Was not Aristotle's critique of atomism one of the finest examples of scepticism drawing limits to human intelligence in the whole of antiquity?

Gassendi's indifference to the Christian tradition is shown by his failure to fall back on the respectably medieval tradition of minima or Augustine's earlier location of atoms as seeds in the Divine Mind. Instead he characteristically put his ideas into the form of a commentary on the text of Epicurus himself. Seizing on a corrupt passage dealing with visible minima and whether an atom could contain an infinite number of points or not, Gassendi openly substituted his new sense for the unintelligible original. Just as there was a minimum angle, below which objects became invisibly small, so there was a minimum measure for extension. An atom was nature's natural minimum for extension. It was not simply a geometrical point materialised—that would be a logical impossibility, to have
mass without extension. It was not indivisible in the physical, Epicurean sense that it could not be cut. A geometrical point and a visible minimum formed two limiting cases for the atom. A point measured nothing, for it had no extension. On the other hand, a definite number—though not an infinity—of atoms composed a minimally visible point. The analogy which Gassendi had in mind was the Vernier scale on his astronomical radius. What registered as one unit, the smallest visible measure, was made up of a hundred units on the second scale in order to achieve precision well beyond the interval measurable by the naked eye. Leaving aside its actual value to science, this concept shows that Gassendi had clearly grasped the need to make atomism both logically consistent and quantitatively operational.

This acceptance of atomism as simply a theoretical model for the behaviour of lumps of matter enabled him to go on using 'billiard balls' or 'hooks and eyes' as mental pictures, if he wished. But it also set him free to explore the more sophisticated models of attraction and repulsion, applied in alchemy and biology. It enabled him to study electrical, magnetic or gravitational attraction without falling into the contradictory options of wave-particles or action-at-a-distance mechanism. Because of his theory of the minimal measure, Gassendi did not picture his particles as autonomous entities, as Epicurus did. This meant he had no difficulty in reducing the nervous system and brains of humans and animals to what he called 'fields' of particles, interacting in waves. (See GASSENDI ON LIFE AND SOULS). Light he envisaged as a wave-particle process, in which each colour in the spectrum was made up of undulating atoms with their own distinct 'measure'. Thirty years before Newton performed his famous experimentum crucis, Gassendi's own experiments with prisms had led him to the provisional conclusion that light was white from
the combined effects of the different waves. The deflection of the
colours at different angles in the prism was probably a visual measure
of the rate of vibration of their atoms. For the same reason the
sun appeared reddish on the horizon and yellow at mid-day, the
atmosphere acting like a sort of refracting prism.16

Gassendi pictured matter as possessing a mathematical form
which owed something to Platonism and something to Aristotelianism.
Unlike Plato he regarded the form as without independent existence in
its own right and, with Aristotle, closely related to matter itself.17
It was because of his originally Pythagorean conception of matter as
monads, or units, each flowing into the other, that he developed the
image of the wave in the wheat field. But organic matter required
more complex images; and the image of the semina—the form or workman
within matter itself, already discussed—was developed more powerfully
by Gassendi than any other seventeenth-century thinker. It implied
a materialism potentially far more sophisticated than the mechanical
reductionism which flourished in the nineteenth century. There are
traces of a similar idea in Newton and Boyle. Though in England the
idea of active matter was effectively purged of its subversive
implications for theology, the effect of Descartes' theory of passive
matter on creative scientists seems to have been exaggerated. It
was of more value to theologians devising credible apologias for a
Creator than to practical scientists. Isaac Newton seems a perfect
mirror of this dualism, vacillating between a Cartesian and a
Gassendist picture of matter in the first part of his career; finally
opting for a Gassendist picture in his science and a Cartesian
picture as a religious apologist.18

If recent research is to be credited, Gassendi's picture of
matter innately possessed of conservation of mass and motion,
endowed with properties of self-organization and hierarchic instinct,
dominated Restoration science. This is to be contrasted with the view of M. B. Hall, who in a recently reprinted work denounced Gassendi as a 'magnificent failure' published too late to have any practical importance. Because this was an age hypersensitive to the potential value of science to the unbeliever, the materialistic implications of Gassendi's world-picture were more evident to Newton, Locke, Boyle and Hobbes, or even lesser intellects like Digby, Evelyn, Charlton and Browne, than to most twentieth-century commentators. No-one suspected of unorthodoxy would wish to compound his problems by public association with Gassendi's materialism. No respectable writer would wish to incur the suspicion of being his disciple.

Gassendi's theory of time and space, which owed something both to Stoicism and to neo-Platonism, ought to be viewed in the context of his Aristotelian revision of atomism. Just as matter was not a collection of immutable entities bouncing against the walls of a concrete-mixer cosmos, so his concept of time and space eliminated the antithesis of the discrete and the continuum. Gassendi's space was without direction, substance or accident or qualitative boundaries. It was not merely infinite in extent, but also infinitely divisible. But, unlike the space of Epicurus, it was closely related to Gassendi's concept of matter. Although he did not go as far as Descartes, who identified matter with extension, Gassendi's material atom had no absolute existence; it existed objectively as the minimum measure of any substance capable of existing on its own. His sensible minimum was a measure of the threshold of perception. This crucial principle relativised the absolute character of Greek atomism. Just as the sensible minimum had no absolute measure, but might vary in size between individuals, animals
and men, or through improvements in optical technology, so the atom itself had no fixed size. The atom had parts. These points on the surface of the atoms could therefore be regarded as the smallest measure of similarity and difference imaginable between areas of space. They determined directionality left/right, up/down relative to their own co-ordinates. They may have suggested to Gassendi the principle of the identity of indiscernibles used by Leibniz.

Gassendi's theory of time abolished any idea that instants existed as entities parallel to Epicurean atoms, or as a sequence of Euclidean points. It rejected the Epicurean view that time was a mere accident of atomic motions, or that past/present/future were to be distinguished absolutely like cuts along a geometrical line. Gassendi's model for time was the flickering flow or flux of the candle flame. Time flowed through invisible pores in space, with a given direction, just as the flame rose upwards through the atmosphere. But the existence of a past, present or future moment—like the material atom—was subjective. All that we had was a continuous flow which might be used as a measure of other motions. The ideal instant, like the geometrical point, was a limiting case and had merely hypothetical or mental existence. We may imagine it as being approached by more and more precise clockwork mechanisms. But, like the ever-diminishing gap in the paradox of Zeno and the tortoise, it was forever just beyond the horizon. It would be natural to assume that the subtlety of these theories ensured that they remained without influence. But Gassendi had devised them not as philosophical fantasies, but as elucidations of the ancient paradoxes of Zeno in the
light of such modern problems as Galileo's law of fall or Kepler's discovery of unequal planetary speeds. And the similarity between Gassendi's principles and Newton's concept of time, space and quasi-instantaneous motion—as developed in the calculus—is so striking that we may suspect that one of his contemporaries at least realised what Gassendi was talking about. 26

No one who reads Gassendi carefully can avoid being struck by the contrast between the scepticism on such questions as the real nature of matter 'as it is itself' (which he refused to answer and treated as—what modern philosophers would call—a non-problem) and the universality with which such principles as he did formulate were applied. 27 At a time when contemporaries were still struggling with the necessity for a fifth element or the need to demonstrate the uniqueness and immortality of the soul, Gassendi stood quite unmoved by the crash of crumbling orthodoxies or the dust from fallen masonry. His theory of matter, agitated by definite measures of wave-particle motion, and following the laws of inertia and impact outlined in his De Motu were applied across the board—to the geological upheavals within the earth's crust, to the sun, to planetary motion, to the nervous systems in human and animals, to memory and understanding in the animal soul. An immortal soul was necessary to humans, in addition to the animal soul to discharge such vital functions as seeing oneself in a looking glass. 28 But the animal soul, which was coincident with the brain and nervous system, was a mere congeries of refined atoms similar to fire or a candle flame. Gassendi's determination to dispense with the idea of atoms as rigid indivisible lumps with definite boundaries differentiated this reductionism from that of Lucretius. The fire atoms which made up the soul of the earth or sun obeyed exactly the same physical laws as those governing electricity, magnetism, human perception, memory and sensation. It
was one of Gassendi's most characteristic analogies to compare the gravitational forces acting on the earth and moon, or the sun and planets, to the sequence of events in the mind of a boy attracted to plucking an apple by the effluvium of its decomposing particles passing through his nostrils. Such mechanistic reductionism would have been anathema to Newton—or at least no such analogy is to be found in his writings. Nor did he ever offer Gassendi's concept of matter as an explanation for 'action at a distance' in purely material terms.

Because of the revisions which he made in Greek atomism, Gassendi found it easy to accommodate the unorthodox perspective of alchemical thinkers like Van Helmont on gases, effluvia and action at a distance in his writing. It is likely that such problems occupied Gassendi and Kenelm Digby during their time in Paris together. Digby's work on atomism, along with Charlton's, was closely related to that of Gassendi. A good example of the way in which Gassendi applied atomic phenomena to practical explanation, along the lines suggested by Peiresc as early as 1606, was in his analysis of Kepler's laws. This will confirm Dr. Henry's point about the brittleness of the modern academic distinctions between occult, mechanistic and quantitative science, applied as a procrustean descriptive framework.

Kepler had suggested that the mathematical relationships embodied in his planetary observations were the result of unknown forces, internal to the sun, to which the planets responded through magnetic fibres. Gassendi, on the other hand, began from what he called first principles: 'These may be woven from atoms, or whatever you like, just as God wills.' This reference to God was not a mere device, so that Gassendi could theorise about atoms with impunity. The preceding analysis should make it clear that Gassendi's scepticism about atomism was perfectly serious. He wished to establish that the
first principles were plural and material, and not to waste time speculating about whether they were discrete, particulate, oblong, indivisible, etc. The next point, a reference to the key principle --ipsa Principia, the conservation of impressed force--shows that it was primarily the motion of matter, not its static nature, that interested Gassendi. Invoked to safeguard the laws of motion, as he had been to safeguard matter's existence, God now disappears from the argument. Fr. Sortais has noted how closely God and matter are associated in Gassendi's cosmology. He is needed to validate the existence, self-motion and laws of combination of matter. On the other hand, he seems to have little relationship to uncreated space or time. It is striking that Gassendi insists on the 'reality' of both. Whatever the force of his expression that time and space were 'real things or entities', this was denied to atoms, whose existence was merely 'probable'. The structure of the Syntagma

LOGIC/TIME-SPACE/PRINCIPLES OF MATTER/THE EFFICIENT PRINCIPLE (God): exactly mirrors the order of priorities sketched in this section.

The fact that he troubled to restate principles laid down at length at the beginning of the book is a measure of the importance which he attached to this use of atomism to resolve Kepler's laws. The argument involves considering each planet and the sun as a mass of particles. Gassendi argued, applying his law of inertia, that in ideal conditions each principle (set of particles) or each planet would move with uniform rectilinear motion. Within each sphere the rectilinear motion of each atom was impeded by its neighbours. This set up what he called 'interior machinery or fibres' which created what, in an earlier chapter, he had described as a sort of 'musculature' within the planet. It was the cause, as he reminded the reader, of the convection currents and volcanic eruptions which disturbed the centre of the earth and sun. The lines of configuration (or fibres:
"WAVES of GRAVITY and INERTIA"

my diagrams

2 forces acting on oscillating particles form a "fibre".

parallelogram of forces

inertia parallel segments

centres of force (coincide)

Kepler's diagram with Gassendi's explanation

particules in constant motion - ilus raduisique - inside earth

This is the resultant of two forces:
(a) directed at a tangent (rectilinear inertia)
(b) directed to centre (gravitational)

these forces are resolved into 2 sets of fibres, equally and oppositely directed (like pain of muscles)

- elliptical orbit

sun behaves in the same way as earth

resultant of inertial/gravitational "fibre" in conjunction measured by increase/decrease in vened cine
this was Kepler's word used non-magnetically) were parallel respectively to the axis and the diameter and acted equally and oppositely. There was a one-to-one coupling between the particles, which meant that the two sets of fibres exactly balanced. The fibres parallel to the axis were inertial—impelling the planet by rectilinear motion. Those parallel to the circumference were arranged around a centre of impressed force. The phenomena traced by Kepler, the acceleration and deceleration of the planet relative to the distance from the sun, and the measurement of area by the versed sine of the arc, were therefore accounted for. The balance between the inertial and the impressed force fibres was responsible for the libration of the planet according to the variation in distance from the sun and the elliptical orbit. Gassendi was quite clear about the universality of the principles; it would apply to Jupiter and its moons, or to the earth and the moon in exactly the same way. Elsewhere Gassendi applied the theory to comets.32

There is no direct evidence that Newton was indebted to these passages in Gassendi.33 However, Gassendi himself seems to have been in possession of this theory, at least as regards the earth and the moon, as early as the mid-1630s and, with assistance from Roberval and Fabri, had begun to work out how it related Galileo's law to the purely mathematical aspects of planetary motion. All this suggests that the importance of atomism in the evolution of a mathematical explanation of planetary motion has been greatly underrated. Especially if, as suggested earlier, there were secret links between the Harriot-Raleigh circle and Gassendi via Peiresc.34 Gassendi's theory leads to the most famous of Newton's predictions—the distortion of the earth's shape by gravity. Gassendi described how the horizontal fibres of impressed force bent in the direction of the sun; a distortion which was maximal along the equator.
As for occultism, a key feature of Gassendi's reasoning turns on the analogy between the fibres, or musculature in the planets, and those of an animal or human body. Elsewhere he outlined the mechanical relationship between bones and muscles to be a universal composition of forces employed in machinery and now known as the parallelogram of forces. At one end Gassendi's argument rested on this purely mathematical description of the relative parts of an isolated system. But at the other end it rested on the animistic principle that comets, the sun, planets and the earth itself are activated by consciousness. The earlier parallel of the boy : apple / sun : planet is now seen to be no empty analogy. Gravitation was an emission of matter; Gassendi regarded it as a process parallel to the decomposition of corpses or fermentation-releasing gases. Sensation and thought were seen as separate, but parallel, forms of action at a distance. Gravitation was, quite literally, pictured as communication between matter or thought. When the animal soul interacted with the muscles, it emitted a series of explosions which operated like pulses of light or gravity or sounds from plucked chords; so with the planetary and solar fibres. Newton's sober classicism tamed this Provencal exuberance. But traces of Gassendi's animistic conception are embedded in his writing like fossils.

Newton touched on the comparison of animals to illustrate the universality of the parallelogram of forces. But his mention is so brief as to be meaningless to someone who has not read Gassendi; and it has passed unnoticed by the commentators. Newton's subsequent application of the parallelogram of forces to particles, spheres and planets exactly follows Gassendi. In 1680 according to a letter to Burnet, Newton was toying with an alternative to Genesis in the form of Gassendi's theory that the structure of the earth was explained by the action of the laws in Gassendi's De Motu (later Newton's laws)
that formed the earth and directed the convection currents under its crust along paths determined by inertia and gravitation. It was not until some four years after this that Newton cracked the principle of applying the parallelogram of forces to the orbits of the planets. In 1680 he was still a believer in vortices.
1) "Originality and Eclectism"

1 See Mayo Epicurus in England 1934 p.2

2 0.0. (II) p.557b and (I) p.229 et seq. This section is entitled: De materiali principio sive materia prima rerum, p.266. After much debate, the atomic structure of matter is presented only as 'probable'.

3 Descartes Principia Philosophiae 1647 part II.

4 Deux Dialogues La Mothe Le Vayer ed. Tisserand 1922 p.98 Naudee Epistolae 1657 p.104.

5 The balance has been recently redressed by G. Tullio 'Aristotelismo e Libertinisme' in Aristotelismo Veneto e Scienza Moderna, ed. L. Olivier pp.279-97 1983.

6 0.0. (I) p.259 This was evidently an embarrassing point for the Judeo-Christian tradition. Both Epicurus and Aristotle agreed that matter was uncreated, eternal and the origin of everything else. See also 0.0.(V) p.71.

7 Gassendi was on solid ground here, as modern scholarship confirms: G. Taylor and J. Gosling The Greeks on Pleasure 1982 passim or P. Merlan Studies in Epicurus and Aristotle 1960.

8 This is now almost a platitude for modern scholars e.g. G.E.R.Lloyd Aristotle 1968 but in Gassendi's day this view was highly subversive—as in Galileo's prohibited Dialogues where he asserts that if Aristotle were alive he would be a Copernican.

9 See for example an analysis of Aristotle's doctrine on the very question that interested Gassendi most, indivisibles and the continuum: H. Waschkies Von Eudoxos zu Aristoteles 1977; Waschkies argues, persuasively, that Aristotle's reasoning on the nature of points was influenced by the mathematical-atomistic tradition of Democritus.


11 0.0. (I) pp.261b-262a.


13 0.0. (V) pp.21-3 and commentary p.76.

14 The Vernier scale was invented in the 1630s. Each division on the smaller scale is worth 1/100 of a unit on the first scale. Gassendi calibrated his radius himself, see 0.0. (IV) p.110.

15 0.0. (V) p.76 'They are not physical minima but only the smallest part of matter about which we may speak.'

16 0.0. (III) pp.470b-72a, 0.0. (II) pp.434-40. The first publication was in 1642—a book which was in the possession of the Cavendish family. Hobbes inserted a watered-down version into his Physica I Molesworth ed. pp.374-6, which omits the key points. The second was in the Opera of 1658.

17 0.0. (I) p.285a form = ipsa fons radixeque omnium. 0.0.(I)pp.254-6.

19 The Concept of Matter in Modern Philosophy ed. Macmullin 1978 p.78
The Halls had already been criticised by Kargon Atomism...1966 p.66, who gives a much more positive picture of Gassendi's influence in England. E. Grant Much Ado About Nothing 1982 is more positive still.

20 This is not true of everyone. Richard Baxter thought Gassendi a powerful and pious synthesis of science and religion. However, it must surely have been true of those who knew enough about the science—which Baxter of course did not.

21 For Boyle on Gassendi Works 1744 II pp.62-3, III p.358

22 Animadversiones I 220b-221a

23 0.0. (I) p.265.

24 0.0. (I) p.268a Gassendi had the new systems of locating points by co-ordinates in geometry in mind.

25 0.0. (I) p.220-3 'We might as well measure length with a pair of scales...as time by sequences of instants.'

26 Newton Mathematical Papers I 1967 ed. Whiteside p.91 Time and space presented as parallel. II p.223 uses Gassendi's example of surd roots in algebra as model for the use of infinite in physics, III p.77 Time 'aequabiliter fluentem' independent variables: time is numerator, space denominator of infinitesimally diminishing quantities.

27 This is what R. Popkin has attempted to describe as 'mitigated scepticism—a phrase which would have meant nothing to Gassendi who regarded all scepticism as mitigated by one thing or another. See my Introduction.

28 O. Bloch Philosophie de Gassendi p.402

29 0.0. (I) pp.234-6

30 0.0. (I) p.247 Digby's links with Gassendi—perhaps from the early 1620s—his links with libertinage in France and Italy (Pintard p.112), his double change of religion, and his relationship with Cromwell are ignored by those who seek to proclaim him as a link between the Counter-Reformation mentality and corpuscularism.

31 Op cit n.18

32 0.0. (I) p.639

33 Compare the method in Principia I section xii which generalises Gassendi's principles geometrically.

34 The idea that Harriot was a totally insular figure is clearly wrong. See The Mathematician's Apprenticeship M. Feingold 1984 pp.135-6 It would require immense labour to re-construct the skein of contacts. Camden, for example, who was a close correspondent of Peiresc and interested in astronomy, wrote an account of the gunpowder plot in 1607. In 1614 he writes to Peiresc BM Add. 6294 f.80 of his fond memories of Du Vair, who had visited England in 1581. There was therefore intellectual exchange between England and Provence in Elizabeth's reign. Peiresc was Du Vair's private secretary at the time of his 1600 visit and until 1621.
35 0.0. (II) p. 508.

36 *Principia* 3rd ed. pp. 15-17, 27 cf. Whiteside *Mathematical Papers* VI 'De Motu' e.g. I xii pp. 189-211.

37 *Correspondence of I. Newton* ed. Turnbull 2 1960 pp. 358-60.
iii) ATOMS, AND INDIVISIBLES

It has been argued that the generally accepted view that Gassendi was mathematically illiterate does not stand examination. A more accurate picture of Gassendi's relation to mathematical activity was provided by Sorbière:

'Like an old Amsterdam merchant who does not risk himself in exploring new worlds, but invests his capital in the voyage of those who do, so Gassendi profited from mathematicians... armed with Euclid alone he unlocked the secrets of physics.'

This influence of mathematical techniques is most marked in the area of infinitesimals. Because this lies on the borders of three kingdoms (Gassendi's term)—physics, mathematics and philosophy—the importance of his work in this area has passed unnoticed. However, Gassendi himself makes clear that the re-definition of Epicurean atomism in terms of Aristotelian logic, already mentioned, was closely related to contemporary mathematical developments. In addition to the Italian mathematicians, Cavalieri and Torricelli, whom Gassendi cites as examples, we know he was on close terms with a number of French mathematicians—Fabri, Roberval, Fermat and Pascal among others—who developed infinitesimal techniques. At the time the term indivisible was used; but, as Gassendi himself indicated, infinitesimal was more correct.

The problem was that Greek mathematics, following Aristotelian logic, did not accept that a geometrical point could be a magnitude; that is, could not feature in a ratio with other magnitudes. Gassendi quoted Aristotle's prediction that anyone who could treat a point as if it were a magnitude would drive a wedge through the whole of mathematics. Kepler, Cavalieri and Torricelli devised methods of comparing line magnitudes—straight and eventually curved—along point intervals. Since this was logically impossible, it was necessary to fudge it by arguing that the points to be compared were
points-in-flux: they were approximately a point in size but still had magnitude. A co-ordinate system was used to create a gauge to measure intervals between points. Whereas Torricelli and Cavalieri stayed closer to the Greek model, arguing through geometrical proportion, French mathematicians—notably Roberval—used more modern arithmetical methods. Cartesian co-ordinates and algebra transformed the comparison of infinitesimals into what is now modern mathematics. But the logical problems remained, despite the spectacular pace of analytical development. What was a geometrical point? This question was a subject of major debate, in which Gassendi was actively involved, in the 1630s. The mathematicians wanted to know how a point could be without extension and still be considered as an origin for a line; or a line be a part of a surface, or a surface part of a volume. These were technical necessities for the new infinitesimals and Gassendi's answer, that mathematics was a mental construction, in which a perfect fit with the physical world could not be expected, reveals his debt to Aristotle. The physicists, anxious to pursue a Cartesian direction of geometrising light and matter could not accept that Gassendi's 'shadow of conjecture' fell between all human artificium—even mathematics—and things themselves. This continued to give rise to bitter controversy into the 1660s.

Newton's delay in understanding that mathematical points, though merely geometrical centres, 'might be conceived as physical' was an obstacle in his calculating the total attraction of a sphere as if exerted from the centre alone, until the 1680s. Newton's philosophy of the relationship of mathematics to physical truth has puzzled scholars. But the oblique hints which he gives become comprehensible if we realize that it was, in all essentials, that of Gassendi.
doctrine of the limitations of mathematical explanations.

Gassendi’s atomism, in contrast to that of Epicurus, made an abstract idea of measurement, not sense experience, the mesh for dividing nature. Gassendi’s favourite image for matter was a woven fabric or net—both ideas originating with Plotinus.¹⁰ There were various gauges for measuring the intervals between the threads: the visible minimum (human sense), which might be just above or just below the concrete minimum (molecule or seed); the minimum piece of any given substance conceivable as existing (the atom); and the copula, or point-like component of the atom (the minimum measure of space). The geometrical point—location without extension—had no physical existence but was rather the limiting term of this series. The unreality of geometrical objects was not, as Gassendi’s critics have imagined, an appeal for abandoning mathematics for a purely sensory empiricism. The difficulties of the physicist in grappling with the principles—or things in themselves—through such concepts as molecules, atoms or the shadowy copula paralleled those of the mathematician. Even the astronomer employed hypotheses which were partly, or perhaps even largely, subjective. They were necessary for collecting observations and tables which would later become the basis for a sound objective approach to truth.¹¹ Mathematics, indispensable to the astronomer, was also indispensable to the physicist, not because reality was itself necessarily mathematical, but because human understanding was. Galileo’s principle that a God creates through geometry has been inverted; it is the human brain that needs to rescramble the sense-data into systems of measurement, if it is to relate to the truth even tangentially.¹² This is undoubtedly a form of Platonism but light-years away in sophistication from that of M. Koyré and his disciples.

Gassendi wrote that from the human standpoint nature stretched
down from the vast cosmos to material objects, so that the sensory minimum was the smallest term in the series; but in nature the sensory minimum was the largest term reaching down to the sub-atomic copula. It is worth pointing out—since logic knows no anachronisms—that modern particle-physicists have, at a very different level of complexity, re-fought some of this ground. The existence of particles with point extensions in space, but actually possessing mass, was a paradox unthinkingly adopted to solve certain observational problems. It posed similar conceptual difficulties to the problem of how atoms can be indivisible if extended. Gassendi’s solution, emphasising that all empirical investigation involves a coffer-dam of mental construction, was less ad hoc than it seems. The analogy which he used to explain this process, the use of irrational roots to solve algebraical equations (a method introduced in Gassendi’s day), was brought in to illustrate that a conceptual scheme might be useful, even if not only the nature, but the very existence, of its entities was problematic. The application of probability, rather than dogma to this question, further underlined the mathematical nature of Gassendi’s approach to science. Although the circumference and the diameter of the circle were incommensurable, mathematicians did not simply give up. Where the numbers did not exist, they invented them to close the gap between the limits of the ratio as accurately as their needs required. Again, it was Gassendi’s astronomical experience which was being applied. There was no sense in pursuing astronomical calculations to an accuracy of ten decimal places, as medieval scholars habitually did, when the instrument was not accurate even to one decimal place.

The concept of descending powers, which much exercised contemporary mathematicians, for example as a means of extracting roots in series, lay at the heart of Gassendi’s thinking.
Although it might seem, in strictly Aristotelian terms, that mathematics and physics were incommensurable, Gassendi saw a gulf over which atomism might engineer a bridge. It was the idea of different types of minima as families of related sets (aggeries) which made his solution strikingly original. The set of visible minima telescoped into the set of molecules, with the series converging down into atoms and ultimately points in space. There were additional sub-sets, in that the atoms, for example, varied in magnitude, though all possessed the same maximum inertial speed that was equal to that of light. In this concern to use light as a measure it would clearly be absurd to see any anticipation of Einstein. On the other hand, it exemplifies Gassendi's determination to turn physics into an art of measurement. Where human measure becomes useless some sort of natural minimum and maximum must be a yardstick. The geometrical origins of this approach are shown by Gassendi's use of the term angle (or cone-tip) to define a minimum in two or three dimensions. There is also his citation of Torricelli's use of co-ordinates based on the axis of an infinite solid to locate indivisibles. Gassendi saw Aristotle as providing a doctrine of the continuum which, though it closed the way to a material minimum or a geometrical minimum, opened the path to a mathematical analysis of matter through a more flexible theory of the nature of the interval.

The tendency to conflate atomism with Epicureanism and sensation must not blind us to the existence of an important classical school of mathematical atomism. Democritus, the most famous practitioner
of this method, employed indivisible means of comparing volumes and related the search for minima in matter to complex mathematical doctrines. A recent book argues plausibly that Aristotle's study of the continuous and the indivisible can be understood only in the light of a programme to continue the Democritan tradition.

Whatever the merits of this argument, it illustrates the soundness of Gassendi's instinct in re-working atomism through an Aristotelian critique in order to adapt it to the demands of an infinitesimal mathematics. It indicates that those who wish to present Gassendi as an unthinking and bigoted opponent of Aristotle, who sometimes used his name in order to placate conservative critics, are far from the mark.

Unfortunately, even more of Democritus' writings have been lost than the three hundred and fifty books of Epicurus. But another mathematician, whom the seventeenth century viewed as the greatest of them all—Archimedes—was squarely in the tradition of combining an interest in atomism with the use of new methods to calculate and compare areas and volumes. Gassendi fully shared the admiration of Galileo and Roberval for Archimedes, who was regarded as having been a supporter of heliocentricity. He quoted from his treatise the Sand-Reckoner to illustrate the possibilities of combining the concept of physical minima with the ascending powers of the mathematical calculation. The point was not the simplistic Platonism of his public lectures: 'God exercises geometry.' It was rather that the nature of the cosmos was unfolded through vast discontinuities in order of magnitude, which opened up chains of infinities incomprehensible to the limited measure (modulus) of the human intelligence. Only mathematics could depict an atom, an earth full of atoms, a solar system full of atoms, by an effortless manipulation of magnitudes. Even numbers had the additional advantage that they could be used to
push inaccuracies to the point where they become so astonishingly small as to be of no practical importance. Gassendi agreed with Plato that there was a pure pleasure in geometry. But that did not rule out 'accidental utility'—as when the problem of duplicating the cube was found to be the answer for the mason struggling to enlarge the Delian altar.20

Gassendi regarded himself as expounding the true meaning of the secret Pythagorean doctrine: 'all is number'. The Pythagoreans had been atomists, and Gassendi was at one with Cavalieri and Torricelli in regarding the use of infinitesimals as a mere re-discovery of this lost calculus. He used the Pythagorean term for atoms—monads.

Whether or not Gassendi was correct in his view that his theory of subjective atomism—'particles seen by the mind'—was authentic Pythagoreanism, this conclusion resulted from his study of available texts. The Pythagorean theory that the generation of numerical series was paralleled by the evolution of a line from a point, a surface from a line, a volume from a surface particularly interested Gassendi.21 Contemporary mathematicians, like his friend Roberval, used these Pythagorean series in calculating their summations of infinitesimals. This was the method which eventually led to calculus. It was particularly useful, because it could be applied to calculating the generation of areas—as in a planetary orbit or to chart the rate of acceleration of a moving point—as in Galileo's law of fall.22 Gassendi, Galileo and Torricelli all pondered the paradoxes of the point contained in the line in the surface etc. Gassendi had read Torricelli and carried on a long-standing correspondence with Galileo.23 Certain elements in Galileo's Two New Sciences suggest that he was working towards a solution not dissimilar to Gassendi's. There is the curious theory of point-vacua, advanced to account for the solidity of things.
The similarity lay in the context of a meditation on infinitesimals and different sets of infinities which commentators have understood in the context of the nineteenth-century set theory. This is clearly anachronistic. Gassendi and Galileo both meditated on paradoxes behind the one-to-one correspondence of infinitesimals belonging to sets of different magnitudes. Both related this to the mathematical concept of the difference between a set of ordinal numbers and a set of roots or irrationals. Both related it to infinitesimal forces, behind the structure of matter. Galileo's point-void is none other than the closest matter can approach to pure space; or, as Gassendi described it, 'the quasi-radix of all other magnitudes', 'the limit of human intelligence', 'the generator of dimensions'. Galileo's remarks may be understood only in the context of a set theory; but it is that of Gassendi rather than Cantor's.

Once it was understood that Gassendi's attacks on scholasticism were not personal to Aristotle (he always insisted they were not), but focused on the doctrine that the world was composed of real objects with knowable essential attributes, the mists began to dissolve. What are time and space, the only specifically real entities in the Gassendist universe, but sets of instants flowing into sets of duration; or sets of points flowing into dimension? Gassendi held that to talk of substances and accident in relation to either of these two entities was meaningless. Aristotle that atoms could not be real because an atom could be 1.
a specific point in space and a specific point in time, and points in space and time were incommensurable. Therefore, they could not share a location and atoms existed nowhere. Was this a starting point for Gassendi's meditations on time/space as it was for his re-structuring of Epicurean matter? Instead of breaking with Aristotle, he drew on his meditations on interval and continuity, as presented in the physics, to derive a picture of the universe which was neither mathematical nor sensual. Using the Cavalierian doctrine of magnitudes which were able to flow—in modern language: 'variables'—Gassendi transcended the picture of space/time as two distinct lines, made up of substantially different points. Nor was matter a set of colliding billiard balls, but a series of descending magnitudes whose true substance was beyond human thought to determine. With the copula, or measure of atomic size, points in matter approached as closely as conceivable to points in space. Through their inertial motion, or maximum speed, atoms approached the instantaneous—the limit of time's flux. Because the speed of light was the upper bound, and light was not instantaneous, they never coincided. The imagery which Gassendi used for time, the flow of particles in the flame of a candle, was chosen to illustrate this subtle affinity. If time was to be the measure of motion, its division net must be of an order of subtlety finer than the atoms; just as to measure the atom the copula must have a degree of subtlety falling just short of space itself.

This provided an answer to Aristotle's dilemma. Although Gassendi did not argue that space and time were the same substance, he did maintain that they had a parallel structure. Although he argued that they were real, he did not picture them as objects in terms of the anthropomorphic scale of our perceptions. Nor was matter. Although its nature must remain unknown, its essential
quality was to be variable, dependent on the scale of magnitude at which it was approached. Although an atom could not be divided by fire, or cut by a knife, it was necessary to conceive a still lower order of magnitude, if the idea of an atom was not to be confused with that of a physical point. In all this he drew freely on contemporary mathematics. The idea of using limits in order to overcome the paradoxes of the infinitesimal was being developed by Fermat at the time Gassendi was writing. Gassendi's interest in the concept of the tangent to the curve, in order to resolve the composition of planetary inertia with gravitational attraction, may well relate to his application of mathematical concepts to our understanding of matter. Aristotle used the example of tangents drawn to a curve to argue that there could never be a contact between two points; but only contact between a point and an extended line, however infinitesimal the line. Now, it was exactly when working on tangent problems in the 1630s and early 1640s that Fermat perfected his notion of adequality. This principle allowed him to treat two different sums, approximately equal to the same middle term, as almost equal. It also involved the search for a limiting value to an infinite sum. We know that Fermat communicated some of his results to Gassendi, which suggests that those historians of mathematics who have argued that Fermat was blindly using an empirical technique, with no sense of physical or philosophical implications, are mistaken. Fermat was extremely wary of communicating with anyone. Why should he form a connexion with Gassendi, whose interest in pure mathematics was nil, unless he was interested in generalising his idea beyond mere mathematical technique? As Gassendi wrote: 'Mathematics is a pure pleasure, but applications are discovered by accident, as even Plato found.'

This is not simply a question of Gassendi getting hold of some
half-baked philosophical idea of limit. The word 'limit' is not employed in this context by either Fermat or Gassendi. There is a genuine parallel between their conceptions, evident even at the technical level. For example, where Fermat sub-divided a parabola into infinite divisions, his method was to apply a decreasing proportion by inserting additional mean-proportionals between the segments. In modern terms, he took the square root of his existing magnitudes. This was an analogy which Gassendi employed in a number of different contexts: for example, the copula was called 'the root of matter' because it was of an order of magnitude below the atom. He compared the unknown character of the principles of matter to the irrational roots needed to solve algebraic equations. His concept of manipulating physical science in terms of unknown quantities (such as the organisation and nature of matter) might owe something to sceptical empiricism. But the confidence with which Gassendi assumed that physicists and astronomers would eventually get good results, if only they reconciled themselves to the fact that many of their theories rested on unknown, or unknowable, variables suggests that he had in mind the use of the unknown in algebraic equations.29

It is the ambiguity which Gassendi introduced into the structure of matter which accounts for the ease with which he implanted a wave-particle theory into his physics. A great deal has been written about the wave-particle theory in the twentieth century. It has been presented as an unthinkable paradox, which threatens the laws of logic. It has been argued that the idea is so absurd that only a long meditation on the truths of Christianity could have induced Niels Bohr to devise it. Others have maintained that only his rejection of western philosophy for eastern metaphysics led Bohr to make this incredible metaphysical break-through.30 Gassendi saw no paradox in a wave-particle theory, partly because of ignorance of the laws of
physics. It is not to be supposed that he was somehow short-circuiting three centuries of science. On the other hand, in purely logical terms, the perceptive reader will already have guessed that the paradox of the discontinuous point-particle and the continuous wave motion did not exist for Gassendi.

How did Gassendi apply his idea to sunlight, for example? Regarded as a stream of particles, compared to bullets, it was moving as a set in rectilinear motion, and reflecting or refracting through the 'pores' of different media, in accordance with Fermat's principle of least action. Like Descartes, Gassendi realised that this principle would account for Snell's law. But each particle also had an individual motion; though the axis of each light atom (conceived as spherical) inclined in the same direction. This was the 'line of impetus' outwards from the sun. But the individual particle followed not a geometrical line, but a band. Within this band each particle struggled to escape at a tangent. The resultant was a wave motion. Within any one beam of light there were the distinct colours of the spectrum. Although these travelled in the same 'set', they oscillated at different rates. A rectilinear beam of light could therefore be viewed, atomically, as a bundle of oscillating sets of particles. What the prism did was to separate out these different wave-lengths, which had to circumnavigate the pores of the glass at different angles, into sub-sets. This idea, unknown to Greek atomism, was generalised to sound, gravity and magnetism.

This indicates the thoroughness of Gassendi's determination to apply the principle of natural measurement to nature. He argued that the natural maximum inertial speed of any atom was the speed of light. But because light atoms had virtually no weight (quasi-pondus) they were in practice faster than others. All atoms had
equal capacity for speed, but since some atoms contained more copula than others they were heavier and slower. A concretion of atoms (res concretae) changed the direction of its component atoms but not their magnitude or velocity. In a sphere they oscillated around the centre of gravity. In a light-beam they were arranged along the line of momentum. Inertia, continuing to send out counter impulses to gravity, produced an effect which Gassendi compared to the pendulum. It was an itus reditusus: a continual oscillation, with a mathematically fixed period. Gassendi accounted for the oscillation of the light-waves, or the continual convection under the crust of the earth or sun, on this model. This was central to Gassendi's suggestion that the eccentricity of planetary motions, as measured by the versed sine, was compounded of inertia and gravitation. He saw another example of it in the predicted oscillation of a particle dropped into a hollow earth, which he discussed with Wendelin and Fabri.

Another model was the pebbles skimmed by the boys on the Rhône, whose rectilinear course was composed of successive itus reditusque due to continual impacts against the water surface. Fabri geometrised this model into the behaviour of two sets of polygons, whose lines became vanishingly small until they coincided, as time became vanishingly small, with a smooth curve. This was a clear anticipation of Newton's arguments. Fabri even used the notational system of placing the component of inertia over the component of gravitational attraction to express an evanescent quantity. Gassendi pictured both gravity and inertia as operating through equal, minute and successive impulses—like an ideal 'gunpowder'. The human nervous system was pictured as communicating by a series of explosions as fire atoms from the soul ignited a fluid secreted by the nerve fibres. It became possible to reduce astronomy to ballistics, by picturing the
moon as bombarded by gravitational wave-bullets, dragging it to the earth, and inertial wave-bullets taking it at a tangent. The resultant was the total sum of the collisions between all bullets at each instant. This was an idea developed by Thomas Harriot early in the century, and raises again the question of links between Harriot and Gassendi. What is not open to debate is the link between atomism and Gassendi's conviction that gravitation could be understood mathematically, through the fluxion of indivisibles and by the discovery of a measurement built into nature. The period of the pendulum provided an exact measure of gravitation on the surface of the earth. Mersenne used this fact to try and measure the proportion of gravitational descent to rectilinear acceleration in composing the trajectory of cannon balls. It was this same compound of motions which Fabri and Gassendi attributed to the moon and planets. This led Gassendi to choose the analogy of the pendulum to quantify the impulses of attraction exercised on the tides in relation to earth-moon, moon-sun, etc. Wendelin applied the same principle to a comet—compared to a bullet from a bombard inflected by the 'pendulums' of the sun and planets.

This model, which Gassendi claimed applied to the tides, the precession of equinoxes, the precession of the lunar nodes and the moon's nutation, has passed unnoticed. Unlike Newton, Gassendi did not set out to supply results—something which even Newton, who tackled all these problems, found exceedingly difficult. But, unlike Newton, who appears to have been following geometrical intuition, Gassendi had a coherent blue print for the mathematisation of nature through his concept of the universality of the wave-particle model for propagation. Using the ripples from a stone as a model of propagation, he regarded an inverse-square law of force and the speed of light as universal limits. The variable factor was the pendulum
effect: the limits for the vertical oscillation of each particle on the horizontal band. 39 Behind this theory was empirical observation of pendulums, experiments on sound and natural wave-motions. But its strength lay in its mathematical conception. Gassendi had in mind the grid of parallel lines, like those in music, which pre-Cartesian mathematicians, like Fabri, used as an equivalent of modern co-ordinates. The purpose of this grid was to locate infinitesimal lines, curves and areas for comparative analysis.

Gassendi's indifference to the paradox of wave-particle motion lay in meditation on the mathematical concept of comparing lines with curves; using the artificium of the grid to make each approximately equal to a point—not a Euclidean point, but a point magnitude in fluxion. 40 A more vivid example is the engraving of Mellan, who was trained by Peiresc at Rome and did the moon maps for Gassendi. Mellan, a friend of Galileo, Urban VIII and Poussin, devised a novel technique for engraving. The whole picture was composed of parallel lines. Every detail was created by varying the gauge, or distance between the lines, in order to create light and shade. Gassendi mentions this method as a model for his theory of light, in which colour was composed from sets of undulating lines. It is likely that Mellan's original idea came from the Italian mathematicians and their use of parallel co-ordinates to create solids out of points. The portraits of Gassendi, Peiresc, Montmor, drawn by Mellan from 1637-40, confirm that Gassendi's wave physics was articulated in the early 1630s. Gassendi is unique in having his conviction about the nature of material objects embodied in his own portrait. 41

Gravity, like light, proceeded discontinuously. A series of explosions among individual grains of gunpowder was concentrated along a single narrow beam, so that the effects appeared continuous. In crude analogies Gassendi compared it to blowing peas down a glass
"no curve can equal a line but a point can equal a point"

Gassendi's model for force versus gravitational pull

Galileo's discontinuous version
To illustrate formation of point vacua = missing lengths

Gassendi, Galileo, Fabri

Fabri's model for a trajectory of Δ's become a smooth curve over sufficiently small time intervals, in infinity.

Indivisible and the Continuum
tube or the syphon. But one of his strongest convictions was that certain simple principles applied to the coarsest as to the most subtle gradations of matter. It was the composition of forces between the inertia of the particles and the line of momentum of a wave which produced the pendulum oscillation with a regular period. One of Fabri's diagrams, illustrating the path followed by fixed points on two concentric circles in motion, describes wave patterns between parallel co-ordinates. It recalls the diagram of Aristotle's wheel, in Galileo's *Two New Systems*—a paradox discussed by Gassendi in his analysis of the relationship of points to atoms. Galileo's parti non quanti were Gassendi's copula—the minute points, almost indistinguishable from space, from which atoms derived their solidity. This makes Galileo's subsequent discussion of a series of experiments involving wave motions, vibrating strings and pendulums, totally comprehensible. Historians have been baffled as to Galileo's motive in describing these experiments, some of which, it is argued, were impossible. Elsewhere in this *Dialogue* Galileo provides a clue that he himself was a secret atomist. There is a strange reference to an accusation that Galileo was a disciple of an atomic philosopher—not named—who denied divine providence. Gassendi's idea, his foetua of Epicurean physics, may have been secretly passed on to Galileo by Diodati. Unfortunately Galileo's numerous letters to Gassendi have disappeared. But Galileo's atomism was mentioned as a possible issue at his trial—though in the end no reference was made to it. There is, however, no doubt that, for Gassendi, Galileo's law of acceleration was not just an improved impetus theory. Gassendi's diagram, published in 1645, arranged the increments of acceleration in triangular form, like a nest of quincunxes. This was the presentation normally adopted for the tetrad of Pythagoras. The tetrad stood for the shape
of the fire atoms, identified in Gassendi's circle with the soul common to humans, animals and planets. The soul was also synonymous with 'harmony'—the evolution of the cosmos, by the fluxion of a point, in the form of mathematical series, which determined the subsequent arrangement of atoms. This is the diagram, already mentioned, from which Harriot apparently anticipated Galileo.

The importance of the tetrad is crucial if we wish to understand the Pythagorean character of Gassendi's atomism. It has already been discussed in relation to Gassendi's Pythagorean society. Like the original order it seems to have been as interested in government as in science and left the vulgar guessing at its real beliefs. Gassendi's conviction that Galileo's law could provide the key to a universal physics, if understood in relation to the pendulum principle, now looks less like a lucky guess. He believed that Galileo's law was the great constant regulating the period of all natural oscillations.
Atoms and Indivisibles

1. O.O. (I) preface, not paginated.
3. Physics I 206a 14
5. See n.2.
   In 1660 a full scale punch-up occurred at a meeting of the Montmor Academy when Gassendi's old secretary, La Potherie, tried to strangle Desargues, the geometer, for arguing that geometrical points were real.
9. Principia Def. viii Koyre Newtonian Studies 1965 pp.152-3 finds Newton's idea 'unconvincing' because Newton had confused 'physical with mathematical concepts'. G. Buchdahl Changing Perspectives in the History of Science 1973 provides a much better solution by analysing Newton in Kantian terms. Although this would appear anachronistic, Gassendi's closeness to Kant makes this a plausible historical reconstruction.
10. Enneads IV 3 O.O. 285b Gassendi saw the cosmos as a vast spider's web.
13. O.O. (I) pp.263b-268a
14. O.O. (I) p.278 Descartes regarded light as instantaneous. Picard (Gassendi's pupil) measured it.
15. O.O. (I) p.273b: the Greek for a tip caused by two lines was tetron (used in surveying) cf. tetrad.
16. O.O. (V) p.301 and (I) p.263b Gassendi mention a specific problem in Torricelli in calculating the area of a cylinder round a hyperbola whose axis was infinite. Compare Torricelli Opere 1919 ed. I pp.191-221, where he does not use Cartesian co-ordinates but 'incredible as it may seem, I construct a cylinder with an infinitely extended axis from the sum of curved indivisible areas.'
17. See Metaphysics 985b A4, Generation and Corruption 316a-17a, Physics, 2231b, 15-18.
18. Greek Mathematical Works Loeb pp.228-231.
   Pre-Socratic Philosophers Kirk and Raven 1964 ch. xvii texts on early atomism concludes: 'Atomism is in many ways the crown of pre-Socratic Greek philosophy. It was in essence a new conception, skilfully applied by Democritus...and eventually gave a stimulus to the development of modern atomic theory—whose real nature and motives were utterly distinct.' p.426.
19. Von Eudoxos zu Aristoteles...H. J. Waschkies 1977; Physics V 111 and VI I are the passages of most interest to Waschkies and Gassendi.
20 O.O. (I) pp.265b
21 Compare Kirk and Raven (n.18) c.vii-ix with O.O. (I) p.254 seq.
23 O.O. (I) pp.262-5 draws on examples taken from Torricelli's work, such as his drawing tangents to the parabola Operæ 1919 II p.320-1.
26 Gassendi's principles, like Leibniz' monads, have location without precedence. Leibniz, who visited Paris in his youth, was originally a Gassendist. In modern mathematical language, Gassendi was discussing neither points nor objects but neighbourhoods. See B. Russell Leibniz 1900 pp.105-123 on points; on Gassendi's early influence p.70.
27 Aristotle Metaphysics 998a compare n.23.
If \( a \) is almost equal to \( b \) and \( c \) is almost equal to \( b \), then \( a = c \) whenever the difference \( a/c \) is less than any pre-assigned value. O.O. (I) p.265b and (VI) p.541.
30 F. Capra The Tao of Physics pp.155-66.
31 Op cit n.28 p.384 Fermat's calculation, defining a minimum in optics as economy of action in time, made perfect sense in terms of Gassendi's theory of time/light, whilst showing that Descartes had the right answer for the wrong reasons. O.O. (I) pp.428a-9b, 431.
32 O.O. (I) pp.428a-436a, (III) pp.470a-72b. Gassendi knew Kepler's work on optics and had also experimented with Peiresc.
33 O.O. (I) p.279a. This was determined: \( \text{intra augustissimos quidem fieri terminos} \) suggesting a relation with Fermat's principle of maxima and minima which had circulated in MSS since 1636. This method related the determination of tangents to curves and the sine law to the concept of adequality. (See n.28)
34 See section GRAVITATION
35 Fabri Philosophiae Tomus Primus 1646 Lyons pp.170-200 Fabri applies Fermat's method: max. omn. diff. \( x/y \) a good example of how Fabri to infinity applied the maths and Gassendi the physics. of O.O. (I) p.361.
36 The same theory in Physics 1669 I p.229 (Fabri) as in Gassendi, O.O. (II) pp. 508-9. J. Lohne A.H.E.S. 20 1979 'Harriot's Collision Theory' pp.214-55. He assumes that Fabri was sincere in rejecting Galileo's acceleration theory and therefore misses the link between Fabri and Gassendi's physics.
37 Novum Observationum... tomus III Paris 1647 ed. Mersenne pp.136-52. Ten years earlier Mersenne had speculated on whether it would be possible to fire a cannon ball into orbit.
38 Luminarcani Arcanorum Caelestium Lampas 1643 pp.17, 34. Wendelin and Gassendi worked closely together on a theory of mutually interfering pendulums to account both for Kepler's laws and a stone falling through the centre of the earth.
39 The pendulum was linked with the inverse-square law (see diagram). *Principia* II sect. viii contains a long analysis of wave motions. This has been supposed to be merely a refutation of Descartes' vortices.

40 Whiteside op cit n. 2 pp. 364-5
The rule that two figures are similar if unique points correspond may have inspired Gassendi's identity-of-indiscernibles principle. Roberval and Fermat greatly refined the technique of saursing.

41 See diagram: Bryn's *Dictionary of Engravers* 1927 C. Mellon.

42 Op cit n. 35 diagram 4.14a, 5.

D. P. Walker *Studies in Musical Theory in the Late Renaissance* 1973 p. 21-30
Gassendi's interest in music has been overlooked; e.g. O. O. (7) pp. 631-53.

44 Op cit n. 35 p. 72.

45 See GASSENDI AND ABSOLUTE MONARCHY (n. 5 The Clever Fellows)

46 J. Lohne. n. 36.

47 O. O. (VI) pp. 167-8 Gassendi's figure for the time taken for such an oscillation (40 minutes) is only two minutes short of the modern value; the difference arising from using Snell's measurement of the earth.
iv) ATOMS AND CHRISTIANITY

Most twentieth-century writers refer to Gassendi as 'having 'baptised' atomism, and emphasise the impossibility of conflict between science and religion in his day. Olivier Bloch, in his cautious and scholarly manner, offered no dogmatic generalisations about Gassendi's private beliefs. But his study clearly indicated that Gassendi's Syntagma juxtaposed atomism and Christianity, empiricism with the supernatural, experimental philosophy and scholasticism. There was no pretence at synthesis. Gassendi's attitude to the second term in each pair was consistently one of prudence rather than enthusiasm. In this respect it is interesting to note that Gassendi certainly did not succeed in making atomism respectable, if this was his aim, to theologians and the general public. Newton's reticence about atomism in his published writings merely reflected the attitude of the bench of bishops and the Royal Society itself. Nothing illustrates so well the fear that science must be productive of unbelief, because of its indirect association with Epicurean atomism, as the continual need to produce apologias proving either that science demonstrated the truth of religion, or that true religion did not need the supernatural.

Gassendi, on the whole, avoided both these expedients. Apart from his sympathy for nominalism and conciliarism there is no evidence that he was even a liberal Catholic. On the other hand, his efforts to spiritualise atomism were perfunctory in the extreme. A careful reading of his efforts in this direction suggests that, even if he meant exactly what he wrote, everything which treats of God as a cause would bear a double meaning. One of his favourite devices was to put an affirmation of faith in the form of a question: 'Who can doubt that God ... ?', etc. This conviction that no-one would doubt is all the more singular because so many of Gassendi's close friends are known to have been unbelievers. The crisis of belief, which sparked
off the apologetics, and the proofs of God and the soul in the writings of his friend Mersenne, left absolutely no mark on the writings of Gassendi. Only in his astronomical lectures did this question surface as a major topic. It is interesting that no one who heard these lectures would guess that he had spent the previous twenty years writing about atomism, or even that he was an atomist at all.

The closest he came to cementing atomism to Christianity by means of historical or scientific arguments, is the following:

1) No Greek philosopher, least of all Aristotle, believed the Greek creation myths. All regarded matter as an eternal substratum which could not be created; therefore, atomism is no more anti-Christian than any other philosophy.

2) There is order in nature, and this must have an efficient cause; therefore God or Nature or something is the source of order."

Such trimmings resemble the fig leaves with which the zeal of Counter-Reformation popes decorated the Vatican. They conceal only those parts of the argument which are most easily reconstructed in imagination. Granted the weight which Gassendi placed on the thesis of a lost ancient philosophy; the secret consensus of all the great thinkers of antiquity on such questions as the eternity of prime matter; it is hard to imagine that anyone could take (1) seriously. Is (1) not rather assimilating Genesis to other creation myths in what Gassendi called 'the poetic age of philosophy'? Julian the Apostate was scornfully emphatic about this, and we know Gassendi's secret sympathy for his position. As a defence of the Christianity of Epicurus, taken at face value, it is weak. But, taken as a concealed affirmation of the incompatibility of Christian dogmas with all science, it is very strong. It must be remembered that, for Gassendi, medieval science consisted largely of Arabs and Jews continuing a Greek tradition. All science was Greek.

Argument (2) contradicted Gassendi's repeated emphasis that form
was generated by matter itself and that matter had not only innate motion, but powers of self-organisation and the ability to think.

On these questions of a creation and a need for a designer it would appear that Gassendi was guided by prudence rather than sincerity. The tone of his language, despite its discreet obscurity, continually threw out shadows. Having made a sociological and anthropological analysis of the origins of religion, Gassendi abruptly concluded that none of this applied to the Old or New Testaments. This would be more convincing if he had not elsewhere argued that the authors of both Testaments had an anthropomorphic idea of God, based on their social origins and ignorance of science. When describing the emergence of the world from a concurrence of atoms, Gassendi described order as resulting from God's 'advice'—concilio. There is no doubt that Gassendi intended this expression to be viewed as a submission to biblical theism. But it is not necessary to compare it with Descartes' picture of a law-giver God to appreciate the lameness of a divine artificer confined to advising atoms. Another linguistic indicator is the insistence on describing God as 'efficient cause' throughout. This must be understood in terms of Aristotle's five-cause hierarchy. Aristotle's examples of efficient causes are: letters cause syllables, materials cause manufactures. Combine this with Gassendi's stated principle that any talk about causation must be regarded as at best speculation, and it will be seen just how low God's profile is, even in Gassendi's published work. God is here regarded as the raw material of creation. He is being logically identified with matter.

Epicurus did not dispense with the gods, but simply removed them from the chain of active being. They became images of the ideal of enlightened contemplation. Publicly baptising Epicurus, Gassendi privately Epicureanised Jehovah. He did so, not for any theological
reasons—this was a subject of no interest to Gassendi—but for easier
atomic engineering. He argued, like Lucretius, that there was a
parallel between the alphabet and the atoms, words and molecules.
Gassendi's innovation was to arithmetise this principle. The
formation of stable elements now depended on certain mathematical
combinations, written into the atoms and associated with the period
of inertial vibration with which atoms were endowed from the beginning.

Gassendi regarded the attraction and repulsion of atoms as
regulated by codes or blue prints.\textsuperscript{10} There is a clear connexion between
the examples Gassendi gives and the contemporary development of
combinatorial mathematics or the application of Pythagorean figurate
numbers to infinitesimals.\textsuperscript{11} There is evidence that Gassendi was on
solid ground in regarding this as true Pythagoreanism. The figurate
numbers were connected with an early form of atomism by Pythagoreans,
although the details remain obscure.\textsuperscript{12} There is no ambiguity about
what Gassendi was trying to do: he regarded the empirical evidence
from the regular geometrical development of salt and other crystalline
substances, or the shape of diamonds and snow crystals as confirmation
for a mathematical structure in matter itself.\textsuperscript{13}

This was presented as an argument for the existence of God in his
1645 astronomical lecture—a piece of pure Platonism, incorporating
a vindication of the Trinity.\textsuperscript{14} Although the Platonism was sincere
enough, it is arguable that the rest of this lecture was intended as
an oratorical device. Gassendi was already working towards, or
perhaps already possessed, a concept of probability which completely
transcended the framework of the old debate—unchanged since Cicero's
time—about whether the world was due to \textit{fortuna} or design.\textsuperscript{15}

In his discussion of elements, Gassendi actually employed a
contemporary cipher, using a line from Lucretius, to show how the
need for Epicurus' infinities of atoms disappears. A finite number
Tantum Elementa Queunt Permutato Ordin Solo
295232 79903 960 4140847 618609643 52000 0000
Cassendi’s Code for atoms I r471-6

area under
1) parabola divided infinitesimally
2) \( x = \sqrt{\text{mean proportional}} \)
of first set of divisions.

FERMAT’S PARABOLA

MATH I

Cavalieri c. 1630

20 figure = sum of lines
30 figure = sum of cross-sections
(cf. WAVES II: gravity waves)

Comparison of figure through infinitesimal segments

LYONS’ LOOM CHART circa 1620 for colour-coding

4 G F E D C

chords are suspended by weights and raised by a lever

\[
\begin{array}{ccccccc}
0 & 1 & 2 & \ldots & 9 & 10 \\
0 & 1 & 1 & 1 & 1 & 1 & 1 \\
1 & 1 & 2 & 3 & 4 & 5 & 6 \\
2 & 1 & 3 & 6 & 10 & 15 & 21 \\
\vdots & \vdots & \vdots & \vdots & \vdots & \vdots & \vdots \\
10 & 1 & 1 & 1 & 1 & 1 & 1 \\
\end{array}
\]

Matrix Code

Della Porta (1563): codes
Pascal (1650s): probability
Newton (1660s): calculus
will be quite sufficient for a mathematically accelerating series of possible combinations to explain everything in the world. Codes were in frequent use at the time by governments and secret societies. Harriot was asked to work for Burleigh. Peiresc's friend Giambaptista della Porta apparently devised codes for his own amusement; though in fact he was at the centre of a number of subversive societies based on southern Italy. He devised the matrix code, which is the one Gassendi chose as a paradigm of atomic combination. The Englishman Wallis, a correspondent of Gassendi, used similar codes on behalf of Cromwell. Wallis was also a master of the techniques developed by Roberval and Torricelli; and his work was of the greatest importance to Newton.

It is well known that modern probability theory in mathematics was sparked off by a correspondence between Fermat and Pascal in 1654. Gassendi's relationship with both, combined with his interest in the application of probability to physics, well before that date, suggests a possible connexion with this discovery. The problem to which Pascal and Fermat claimed they had first addressed themselves was the division of stakes between gamblers. It would be difficult to imagine anything more remote from creation and atomic physics, yet Gassendi himself, in a characteristic aside, introduced the imagery of dice-throwing into a discussion of the genesis of crystalline structure with tetrahedral faces. Like Kepler, Gassendi was fascinated by the geometry of perfect solids. Restoring them to their original Platonic context, he saw them as a foundation for a geometrisation of atomism. Did he picture the solids as dice, with numbered faces, thrown into a dicing table? His discussion of heredity, explaining why some characteristics were transmitted and others recessive followed the same logic.

A passage in Cyrano de Bergerac's *Voyage to the Moon* indicated...
Pascal Tree

of Probability

1654?

1st throw

2nd throw

3rd throw

1  1
1  2  1
1  3  3  1
1  4  6  4  1

unities = sum of Pythagorean numbers
natural triangular pyramidal

Pythagorean number = points = atoms
also used by Rebeval etc

to sum infinitisimals
This shows the TETRAD
an appropriate name for someone who had just broken the code of the universe and demonstrated the superfluity of supernatural intervention in its laws. Its laws were not like those of Descartes or of Moses, handed down from a mountain. They were simply the laws of chance. St. Vincent claimed that Gassendi's demon of unbelief, having taken over completely before his death, was driven out just as Gassendi died. But then it entered Vincent himself, who to combat his loss of faith tied his *credo* on a parchment round his neck. Pascal is said to have done exactly the same after his conversion in November 1654. If Gassendi confided his God-breaker argument to Vincent, it is understandable that even a saint's faith might have been badly shaken. The need to prevent this argument being publicised was evident. Only the faintest hints of it appear in Gassendi's text. He argued that God used chance in his creation, which is described as 'accident by design'—with God as a kind of consultant engineer—evolving through errors and imperfections to order. He linked the role of probability in the evolution of scientific theory with the evolution of the universe itself.

Gassendi was therefore able to answer the question which baffled Lucretius: if the spars, rowing benches and beams of a wrecked galley were scattered on the ocean, how could they ever come together again? If the atoms of the universe, like the parts of the French war galleys, were clearly numbered, they could be dismantled at the end of the campaigning season and then just as easily re-assembled. Once again, however, it must be stressed that the relationship of Gassendi's thought to that of Fermat does not rest on vague metaphors. The relationship between the so-called Pascal triangle, used in probability theory, the tabulation of a code matrix and Newton's binomial theorem is extremely close. One of the indispensable procedures for decoding was the context check: that is, the search for pattern by
looking for clues in terms of expectations and probabilities, rather than straightforward deduction or induction. The method of interpolating between known tabulated intervals was, on a more sophisticated level, a problem already familiar to Gassendi through astronomical tables. Gassendi saw the problem in physical as well as mathematical terms. Atoms had a desire to 'copulate' with others; they were the 'genitals' of nature. The need to mathematise did not necessitate a Cartesian castration.

Up to the eighteenth century probability meant merely that an opinion could be supported by at least one respectable authority. It was Gassendi who first developed its modern meaning—something which is not absolutely certain but admits a good expectation of certainty. This is a concept which is completely lacking in the ancient world, along with a mathematical theory of probability.

Was it the unique conjunction of scepticism with faith in seventeenth-century France that explains the spectacular eruption of probability theory into a European tradition from which it had been so conspicuously absent? Or was it primarily related to more utilitarian problems? The corruption and financial irregularity, discussed in the chapter on MENTALITIES, were not so much the result of a new cupidity as of the expansion of the royal finances outrunning the available machinery. Mathematicians, originating in the noblesse de robe, like Pascal and Fermat, realised the problem. The former sent Séguier his calculating machine, and the latter communicated to him a scheme for consolidating the community debt and paying off the creditors in order. Fermat was closely involved, in neighbouring Languedoc and Guyenne, in the administration of exactly the sort of financial problem which has been described for Provence. These were not minor questions of accounting, but fomented bitter rivalry and suspicion between different social groups. They were a central
issue in the Fronde. The emergence of probability-calculus almost immediately led to a drastic overhaul of annuities, public credit and local government finance in Holland, under the guidance of Huygens and De Witt. It was a question of great interest to Newton, whose patron played the key role in establishing the Bank of England. Insurance, which had begun in late medieval times and—unlike usury—was permitted by the Church, did not really come of age until the mathematics of probability had been created.

The development of the capitalist spirit itself, according to Braudel, was closely linked with the gambling mentality. But, because he was unaware what a dramatic transformation of economic life rationalistic probability-calculus achieved between 1660 and 1800, he failed to realise that the antithesis which he drew between rationality and gambling was false. Sombart was right to identify capitalism with rationality, precisely because the capitalist takes risks only where he believes he is assured of minimising his expectations of loss and maximising his expectations of profit. The capitalist, like Gassendi's God or Industrious Artificer, works to a blue print in which chance is allowed for and may even be turned to advantage in the design.
Gassendi describes the likelihood that the atoms were not self-moving from their own force, but that God instilled their motion, as merely 'probable'. Here he was using it, in the old sense, to mean an opinion which might be backed by precedent.

D. Kuhn *The Codebreakers* 1977 p.139.
Della Porta was an associate of Peiresc and Galileo. De Retz, another patron of Gassendi, used ciphers to further the anti-Mazarin cause in the *Fronde* p.157.

I. Hacking *The Emergence of Probability* 1978 p.58. Although the story is well known, Hacking points out that it contains, appropriately enough, some improbable features.

Gassendi links this with the principle of the identity of indiscernibles or the variation of leaves on the tree. In the *Mahabanta*, AD 400, the Irdians formulated a probability law, using the tree as an example. After Pascal the tree diagram was to become the classic illustration of probability. Is this another link between Gassendi and the East? See Hacking p.7.

See section ON LIFE AND SOULS

Pascal knew of Gassendi's wave-particle theory of matter and accepted it; p.149 'la nature agit par itus et reditus : le flux de la Mer et le soleil marchant ainsi.' Compare p.514 this chapter.

Op cit. n.18 p.61, Bell *Huygens* 1950 pp.200-1.

See section on LIFE AND SOULS

See section GASSENDI AND THE CHURCH

Gassendi seriously debates the possibility of pure chance creating the world. He rejects this in favour of 'industriae potius artificem quam temerarium fortunae manuum... si pictoris spongia in tabulan temere impacta equi spumam semel expressit'. The world shows evidence of industry, rather than the mere hand of chance and fortune. But he continues to speak of God as at best an 'adviser or architect', who regulates chance like a painter who produced foam on horses by throwing his sponge at the canvas.

D. T. Whiteside *Mathematical Thought in the Later Seventeenth Century* A.H.E.S. 1 1960-2 pp.236-44 gives examples of code matrix used by Wallis in the 1640s and 1650s, showing their relationship to Pascal's triangle on the one hand and Newton's binomial theorem on the other.

Gassendi was thoroughly versed in the Ptolemaic methods of locating planets through tabulation rather than geometry or multiple observation: *Almagest* ed. Toomer pp.545-54.

L. Daston *'Probabilistic Expectation and Rationality' Historia Mathematica* 7 1980 pp.234-59 puts a very strong case for the association of probability theory with purely prudential, rationalistic, commercial, legal and utilitarian habits. But she is thinking mainly of the eighteenth, rather than the seventeenth century.
32 Mahoney Mathematical Career of Pierre Fermat 1972 p.18
C. Henry Pierre de Fermat 1880 pp.2, 18
Pascal Oeuvres ed. du Seuil p.188

33 Op cit n. 18 pp.2-6

34 F. Braudel The Wheels of Commerce 1982 vol. 2 of his history
of capitalism. The title is meant to recall the roulette
wheel.

35 W. Sombart Das Wirtschaftsleben im Zeitalter der Hochkapitalismus
1927 p.80.
## A SOCIAL MORPHOLOGY OF ATOMISM

### ANCIENT ATOMISM

1. atoms: absolutely real, indivisible
2. dogmatic: nothing but atoms/space/gods exists
3. chance + infinite atoms = a world
4. contact: vision requires filmy simulacra; molecules formed by hooks and eyes; atoms must be perfectly solid, perfectly elastic
5. subjective: although atoms are invisible it is the sensual images of the individual which is paramount
6. chance, not time rules. Time is measured by the return of the atoms from chaos to world to chaos to world again.
7. mathematical atomism - eg Pythagorean - is unable to resolve the contradiction that a geometrical point may mark a number, but cannot be a location or extension for matter.

### ANCIENT SOCIETY

1. the property owning individual citizen was the unit of ancient democracy
2. the citizen's authority over his slaves and family was checked only by his piety or respect for the gods
3. although games of chance were common, there was little protection against chance in the form of insurance, banking, investment in annuities etc.
4. apart from slaves and family, social bonds were largely informal. Outside religion, which was not heavily institutionalised, the town was the only tie upon the citizen.
5. a citizen depended on owning enough land to keep his family. Those attracted to Epicureanism tended to be those with ample land for leisure and philosophy. Such men saw themselves as god-like. Their senses were an end in themselves
6. those engaged in manufactures were few and not wage-earning time is accidental in a rural society
TOWARDS A SOCIAL MORPHOLOGY OF ATOMISM

The essence of the preceding sections was distilled into a few lines by Spengler: 'The atoms of western physics resemble the figures and themes of music, their being or essence consisting not in individuation but in vibration and radiation. Those of the Greeks, on the other hand, were a multitude of confused individuals hunted by blind chance.' Spengler also wrote: 'Every atomic theory is a myth through which the culture reveals its inmost essence and self, through the contemplative-creative power of its great physicists.'

This is not an approach which has found favour since his time. The cultural analysis of science has been allowed to fall into the hands of left-wing analysts who use it as a political football. Now it is an idol, around which society must be remodelled; now it is a fallen idol, or scapegoat for man's inhumanity to man (or rather woman). These turns on the ideological gyroscope leave the historian unmoved. Though perhaps it would be over-optimistic to claim that the 'essence and self' of seventeenth-century western culture may be glimpsed through the interstices of Gassendi's atoms, seeds or principles, it is certainly true that those who refuse to look through the telescope of social context are denying themselves a spectacular view.

The conception of nature through indivisible or minute parts was fundamental to the approach of seventeenth-century intellectual elites—medical, mathematical and physical. In the Middle Ages, on the other hand, atomism was rare and actively discouraged by the Church. It was accessible chiefly through Aristotle's own refutations of it, on which even Gassendi drew heavily. Vague generalisations about the rise of mechanism or corpuscularity or such phrases as 'it was no accident that...'; 'he was a man of his time'; 'a transition figure'; 'he spoke for the century as a whole'; and 'he
was ahead of his time'—might serve as a substitute for explanation at this point. Can a consideration of social context take us any further? Certainly Spengler's pretension to dogmatic certainty was unwise. But let us turn his dogma into a question: What is the historical evidence which supports the notion that styles in atomism are related to changes in society?

To judge from the number of times he quoted it, Gassendi was particularly fascinated by the Greek analogy between the atom and a minute portion of land. Central to the Greek concept of the free citizen was property in land. This was a continuous theme from Solon to Aristotle. A citizen, without the minimum that would give subsistence to himself and family, was in continual danger of losing his political rights or of becoming a slave. As Aristotle indicated, any increase in number of the free citizen body, with division of land between children could not proceed beyond a certain point. This necessitated emigration. Epicurus was himself the son of an Athenian peasant colonist on Samos. One reason why this agrarian definition of the atom would have interested Gassendi was that it was actually closer to his own idea of a unit measure minimum than the atoms of Epicurus. There was no fixed area of land which would support an ideal citizen and nothing physically indivisible about such a unit. From what has already been said about French society, and Provence and Languedoc in particular, it will be remembered that the subdivision of land beyond what would safely support a family was a major issue. Although the policies of De Valois, and the sympathies of Gassendi, seem to have been directed to prevent the break-up of the peasant communities, powerful historical forces worked against them. The deteriorating weather, soil erosion, forest clearance, the mounting burden of debt on individuals and communities, plagues, government taxation, and the rise in population, combined to atomise
the holdings of the peasant subsistence-farmer.\(^5\)

It must not be forgotten that Gassendi's own father came from this class, and that he always showed a strong desire to protect not only his native village, but other communities in the region from the ravages of troops, rapacious or corrupt local government and taxation. Bernier, author of translations of Gassendi's works into Persian and French, was likewise a son of a peasant. In his writings he laid great emphasis on the social and political benefits of private property—as the concept had emerged from western feudalism. He warned Colbert that Turkish and oriental societies in which the peasant was part of a landless mass, at the mercy of the tax-farmer and the bailiffs of vast estates, were economically well below their real potential.\(^6\) Exactly the same philosophy emerges from Locke's travels in France—not surprisingly since he stayed with Bernier in Paris. The prosperity of the peasants in the untaxed papal states was contrasted with the misery in Provence.\(^7\) Locke shared Gassendi's view of the primacy of active minute material particles—which in order to avoid theological controversy he did not identify with Epicurus' atoms. Whether or not he derived this view directly from Gassendi, as seems likely, both made an objective connection of the concept of the minimum in matter with Locke's 'measure of property':

'...The measure of property in nature was well set by the extent of men's labour, and by the convenience of life... which measure did confine every man's possession to a moderate proportion.'

As in Gassendi's account of the contract, Locke sets up the laws and political society in order to preserve the security of this 'measure of property'.\(^8\) Both regarded society as a utilitarian construction. If the frame of government ceased to follow the measure of property, it might be broken.

It has been argued that Gassendi's vegetarianism and the
Epicurean doctrine of living on a minimum were related to the economic disasters of the times. There is clear evidence for this in his *Ethics*, where the efforts of the Emperor Julian the Apostate against grain speculators, is linked with the doctrine that if each would be content with a necessary minimum, everyone would have enough. The comparison of the efforts of the apostate Emperor with Louis de Valois in Provence is clear enough.\(^9\)

It would be interesting to know if the mathematician Roberval, the son of a Norman peasant, whose method of infinitesimals was so important in formulating Gassendi's analysis of gravitation, was guided by similar associations; or even Fermat, a member of the *parlement* in Languedoc, a province which was hit by a Malthusian catastrophe at exactly the same time that he was developing his methods of adequality and *maxima* and *minima*. We know that Fermat earned the distrust of his colleagues in the *parlement*, and of the government, for the integrity of his views on justice and taxation. Was the idea of the Greek atom as a field (*ager*) an aid to Gassendi's formulation of atoms and ideas as *aggeries* (*sets*)? Or did the idea of a field lead in naturally to the image of a wave (*seges*)—a cornfield of atoms in motion?

It is the differences between the context of these problems which explains why revivals are so often accompanied by modification, if not metamorphosis. Like a geometrical form transferred to a space of different dimension, a concept like atomism can be made to stretch like rubber. One of Gassendi's favourite images for atomic structure, which occurred rarely in Lucretius, was that of the weaver.\(^10\) *Texere*, *Contexere* were words which sprang continually from his pen. Differences in atomic structure were compared to the refinement of different types of cloth. The atoms which formed the soul were able to slip between the interstices of all other substances,
because of their exceptional fineness, and therefore moved with extraordnary speed.\textsuperscript{11} It is not difficult to see why Lucretius did not find this image so exciting. If atoms were conceived as solid particles, with hooks and eyes, to weave them—as Naudé jokingly remarked—would be an awesome task. But Gassendi's wave particles snaked into a textile metaphor naturally. Boyle's concept of atomic 'texture' derives from Gassendi.

Another reason lay in the modification of weaving technology. From the early seventeenth century, at Lyons, a new method of weaving had been introduced which foreshadowed the famous programmed loom, which gave Babbage the idea for the first nineteenth-century computer. Although it was not yet mechanised, the principle was the same. A grid reference, on a card or chart, recorded the different colours of warp and woof threads in the sequence needed for the pattern. The warps held in place by individual weights, could be raised and lowered by the operative at the precise moment when they matched the required woof. Interestingly enough, it was not Lucretius, but Aristotle who first compared matter in motion to the mode of operation of a handloom. But the originality of Gassendi lay in supplying his artisans—or workmen in matter—with programmed codes like the silk-weavers at Lyons.\textsuperscript{12} Such a code was exactly parallel to the co-ordinates being used for the weaving of infinitesimals into equations.

If we think back to Gassendi's use of atoms to account for Kepler's laws, the utility of the new concept may be more readily appreciated. The warp consisted of the atoms arranged along fibres of inertia, in circular infinitesimal sections along the polar axis. The woof consisted in the similar sections at right angles parallel to the axis and was the force impressed by gravity. The card read off by the planetary soul, gave the forces acting on each particle at any given moment; according to the distance of the sun, and whether...
the particle was inertial; that is, tangential to the impressed force; or gravitational and responsive to it. Solar gravity acted along the lines of impressed force, like threads of coloured cloth binding with the woof. Gassendi graphically described how this distortion twisted the woof lines in the direction of the sun, causing the planet to be distorted from the spherical, because the attraction acted at the circumference. Lyons was an obligatory stage for Gassendi on the road from Provence to Paris, and the home of one of his patrons, the Cardinal Archbishop. He made frequent stays there and mentioned certain rich merchants of the place in one of his letters, as favourable to De Valois' cause in the Fronde. Were these the silk manufacturers to whom Poussin sent a number of his paintings? Eli Diodati's Swiss cousin established a silk manufactory which became one of the largest in Europe.

The importance of images of manufacturing, architecture, boat-building and mass-production in Gassendi's concept of active matter has already been discussed. Their presence is to be explained by Gassendi's conviction that because the truth about the natural world was firmly sealed, the philosopher must use what imagery seemed helpful. His own histories of science showed his firm conviction that analogies, such as that between the cosmos and a room or building, however erroneous in absolute terms, were necessary bricks in the temple of knowledge. The social context of his atomism was determined on the one hand by the minimum of the subsistence farmer; on the other hand, by the subtleties of modern manufacture. Gassendi had written that early man 'ignorant of causes had applied what he could gather from observation, accommodating it as best he could to his mode of daily life, substituting myth for the discussion of causes.' This was partly a phase which humanity had outgrown; but the limits to human intelligence and to the sophistication of society
A Social Morphology of Atomism

Gassendi's Atomism

1) time/space/matter real
2) dogmatic: God, angels, devils, genesis
   scepticism: nature of first principles and their
   laws of growth and combination unknowable
3) probability, mathematical combination, coding
   makes a finite number of atoms possible
4) nature of first principles makes action at a distance
   through vapour (gas), waves, fields, combination according
   to like and unlike sets (codes), elements possible.
   Atoms are not indivisible and exist in groups, rather than
   in isolation. To isolate an atom all the others would have
   to be destroyed.
5) Although time/space is innate in the human mind, both are
   an objective framework locating matter in motion
6) Atomism and Mathematics are manufactured by the human
   mind as a framework for understanding the natural measures
   by which we can record our sense data.

Gassendi's France

1) a very complex arrangement of different sets of laws
   for both status and property
2) a very complex set of authorities in Church, State,
   province and community could check the individual's rights,
   exact taxes or impose financial and other penalties.
3) a very rapid growth of credit instruments, both local
   and national, as well as investment opportunities in the
   bureaucracy and the tax system.
4) massive institutionalisation: Catholic and protestant
   churches, universities, guilds, religious orders,
   communities, complicated bureaucracy, professions.
5) growth of world trade, manufactures, banks, separation
   of investment from involvement. Leisured rentiers whose
   income was not necessarily exclusively from land.
6) although the manufacturing sector was still limited
   it was wage-earning and time/motion had become an issue
   manufacturing had captured the imagination of statesmen
   as an area of potentially unlimited growth and
   export opportunity.
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were boundaries which conditioned all scientific change, not stages which had been surpassed.

A spiritual dimension was provided through the elusive nature of matter itself and the neo-Platonic image of the divine as a warp marrying the material woof, and weaving the mazes of the visible world between them. This ruled out any need for a divine craftsman or artificer: something which Gassendi, in deference to human ignorance, was happy to introduce, *ex machina*, as his work required. As with God the existence of a double soul in Gassendi's philosophy was not exactly a genuine conviction, nor a mere invention to satisfy his critics. The whole of Gassendi's vision is grounded in a denial of absolute entities of any kind. Even the various sub-visible entities are measures of matter, vibrations in space, rather than beings in an essential sense. It was relationship not being which existed, as Gassendi insisted in the course of his debate with Descartes. The idea that the human individual was some essential entity—like a personal soul—struck him as ludicrous in the extreme. Gassendi favoured the Greek definition of soul: harmony or number. It was merely the temporary locus of a number of vibrating atoms of different frequency. The noble soul was a neat way of denying human individuality, whilst preserving a religious language. He sympathised with Aristotle's view that human reason returned to a collective soul, as fire atoms ultimately gravitated to fire. But this was speculation, not hope or faith.

Werner Sombart has argued that the emergence of a God within Nature, in the course of the seventeenth century, paralleled important social and economic changes. The rejection of a supernatural, eternal, craftsman God who rested on the sabbath and cursed his botched handiwork was a sign of the decline of the individual craftsman and foreshadowed the more important methods of business organisation.
associated with manufactures. Gassendi's idea of an artisan immanent in matter, too remote to be understood in human terms, operating through inscrutable laws is, for Sombart, the God of bureaucracy, mass-production and the professional expert.\textsuperscript{18}

The insistence on God as the weaver, whose visible creation was his industria; and the semina, the invisible workmen—which He, himself, had manufactured—was not intended to be anthropomorphic. Gassendi insisted that the images of human manufacture were quite inadequate approximations for the atoms, just as all attempts at personification was a feigned divinity.\textsuperscript{19} It could be argued that the analogies with mass production or skilled craftsmanship (the diamond cutter, the mechanical coin press, the building labourer) are not specifically part of the structure of his atomism. Van Helmont, for example, was quite as enthusiastic for the idea of matter as a set of complex industrial processes as Gassendi.\textsuperscript{20} Pagel traces Helmont's moulds back to the Aristotelian forms, and a similar re-shaping of Aristotelianism can be traced in Gassendi. Aristotelianism, like atomism, could be stretched into some ingenious shapes. Renaissance Aristotelianism, whether unorthodox, as in Vanini, or publicly conformist, as in Harvey and Patin, grew into corpuscularism through its doctrine of forms encased in organic germs or seeds (hylomorphism).\textsuperscript{21} In view of the relations of Helmont and Gassendi, and the former's near-constant supervision by the Inquisition, the low profile of atomism in the writings of Helmont—as in the publications of Galileo—should not be regarded as a guide to real opinions. The configuration of Gassendi's theory of a primordial vortex of particles, radiating gravitation like a sort of vapour, with Helmont's theory of a chaos or primordial 'gas' was so close as to seem suspiciously preconcerted.\textsuperscript{22} It was for his views on action at a distance that Helmont first fell foul of the Inquisition. Kenelm Digby, who shared
Helmont's views in this matter, and was close to Gassendi, came out publicly in favour of atomism. Any rejection of a personal God for Nature was atheism in seventeenth-century terms. 23

It could be argued that Gassendi's rejection of the antithesis between materials/workmen, architect/labourers, ignored the hierarchical society of his day; and the whole element of command/obedience which justifies degree. The Chinese might abolish ranks in their army, but they could not manufacture Gassendi's ideal soldiers who knew perfectly each other's mind and were prepared for all eventualities of battle. Here Pythagorean Utopianism, rather than any contemporary social model, directed Gassendi's concept of matter. 24
Towards a Social Morphology of Atomism


2. Le grand mouvement de pensée qui soutient toute cette évolution des idées de 1550 à 1650 depuis le recul d'Aristotélisme jusqu'au triomphe du mécanisme c'est l'irrésistible renaissance de l'atomisme. Roger Les Sciences de la Vie ... 1971 p.153


5. R. Pillorget Les Mouvements Insurrectionnels ... 1975 notes three reasons why small peasants, close to subsistence, faced special difficulties in Provence from 1635-1647: p.501 seq.

   i. establishment of a gold standard 1640-1 and devaluation of non-precious metal coins in peasant hands;

   ii. high points of cereal prices in 1637-44, bringing famines;

   iii. outbreak of war and new taxes, etc.


7. Locke's Travels in France ed. Lough 1953 pp.70-76. He described Provence in the 1670s: '...more barren ground than fruitful. Five acres of poverty to one of riches.' p.80 He described the ruins of Peiresc's former gardens at Boisnegcy. He left a detailed account but suppressed Peiresc's name. He mentioned Bernier p.177 Bernier later visited him in England in 1685.


9. O.O. (II) pp.728-9 for Julian see Class Struggle in the Ancient World Ste Croix p.220 Like De Valois, in 1644, Julian was generally condemned for trying to fix prices. Op cit pp.320-21. Another example of combating grain hoarders comes from another vegetarian philosopher admired by Gassendi, Apollonius of Tyana 1 xv Loeb

10. See Bailey Lucretius III index.

11. I 262b Primis Principis, equibus semina texerentur are woven from ipsis seminibus, quae Deus ipsa texuerit. This image of God as a weaver recalls his use of the spider to refute Empedocles, Democritus and Epicurus: their image of creation as blind chance: Cum aranea certe fila primum tendit, quasi stamina; cum illa deinde subexit intervallis rarioibus; cum postea pertexit frequentioribus, ordine fila quaque compingens; cum circa centrum apparat, torrataque sibi domicilium in quo commodo delitescat; putas tum ARANEAM RESECRQUE QUID FACIAT: NON HABERE IN SE IDEAM SUI ILLIUS OPERIS? If this seems like an animal
intelligence argument which has slipped into an argument for God's existence, that is exactly right. Gassendi is glancing backwards at Augustine, who claimed that to study a spider's web too closely imperilled his immortal soul, and forwards to Hume. Hume's argument that God is a spider—or even a colony of spiders—seems to derive directly from this passage in Gassendi.

Dialogues Concerning Natural Religion D. Hume ed. 1972 p.51. A number of the arguments in these dialogues are to be found in Gassendi.

12 A History of Technology VIII 1957 p.111 This method was introduced by C. Danyon between 1605 to 1620; see diagram.

13 The threads—must of course be pictured as active waves, not strings on a frame.

14 O.O. (VI) pp.311-312 A. Blunt Poussin 1967 Poussin was in Lyons from 1618-20. His patrons among the silk merchants were Cerisier and Reynon. The former rates a mention in Libertinage Erudit Pintard. For the Diociati business, see Kamen The Iron Century Cardinal pp.95-7

15 O.O. (V) p.367.

16 This idea is fundamental to neo-Platonism. It is mirrored in the ratio of the golden section where the whole is to the greater part as the greater part to the lesser. This is mirrored in the nested pentagon and in the classical art of Poussin. (see p.551) O.O. III 389b

17 Of modern philosophers O. Quine, with his insistence that objects are logical cuts in an unknowable continuum comes closest to Gassendi on this point. See from a logical point of view, Word and Thing etc.

18 Sombart op cit n.35 pp.80-81. He writes of entgotterte Natur—a system of relationships replacing a transcendent God. He regards the pendulum, rather than Moses' tablets, as the measure of this new concept. The idea of a measure, of which the pendulum is the paradigm, is certainly the key to Gassendi's system.

19 O.O. (I) pp.122-3 Gassendi regards grammar, logic and mathematics as forms of manufactures. O.O. (II) 262-78, principia mechanicos spiritus scientia. Gassendi is not arguing that the world is a mechanism but that human science is itself a manufacturing process which can only know through images of manufacture.


21 Op cit p.42

22 Ortus Medicinae ... Helmont 1648 pp.40 and 111-117 archeus = workman Helmont's two semina = aurum flexibilem = organic life
- initium motus = things from things exactly corresponds to Gassendi's. Helmont even introduces atoms at this point—though he rejects materialism in Aristotle. He argues: 'The archeus is in the gas.'

23 Atheistical sentiments prefaced the play by Shadwell The Virtuoso 1676, dedicated to Gassendi's old friend the Duke of Newcastle. But they were kept in the original Latin. The play was based on the life of Peiresc by Gassendi, dedicated to Evelyn in 1657.

24 J. Evelyn Essay on the First Book of Lucretius 1656 quotes Gassendi 'no monarch rules the universe but chance and atoms makes this all in order democrotical where bodies freely run their course without design or fate or force.'
'The winner who excels in the pentathlon may triumph over all comers with ease, and yet still be beaten in each individual event by an athlete trained to run a given distance. So it is with scholars who range over all the sciences; they cannot match the expertise of the specialists in every discipline to which their curiosity inclines them.'

The heresiarch Photius (ninth century AD) from his Myrobiblion (found in Gassendi's study at his death)

'Genium meum perpetuo sequor, non invitus.'

Gassendi
One of the questions uppermost in the minds of those scholars who have been prepared to take Gassendi seriously is whether or not he should be classified with the ancients or the moderns. On the whole, the feeling has been that despite a number of modern elements the ancient predominated. Gassendi's alleged intellectual timidity turned him into, at best, a half-hearted revolutionary. There is remarkable unanimity on this point, as was recalled in the introduction, between scholars of all shades of ideological commitment or none. It would be tempting to dismiss their approach as anachronistic, a projection of modern views of what is progressive or reactionary into the seventeenth century, or an intrusion of political categories into science. But this would not be strictly fair, since the problem of ancients and moderns was well-known in Gassendi's own day.

Typical in this respect is Chapelain's comment on Gassendi's life of Peiresc. He could not understand why he should set aside his own philosophy to write at such length about a mere collector and antiquarian whose mind, however well stored, resembled 'one of those old shipwrecks from antiquity'. But there was a great deal of Peiresc embedded in Gassendi. Influence is too pale a term; Gassendi's own expression—archetypus—is more appropriate. For Gassendi and Peiresc antiquity meant far more than either mental training through study of the classics or curiosity about coins and artefacts. It was a sort of second identity: a mask behind which they might, paradoxically, give free expression to their real selves. Antiquity was a touchstone for both academic freedom and good government; as when Gassendi, expressing his impatience for the golden age to come, likened the France of Cardinal Mazarin to those open
sewers carrying carrying filth and rubbish down the streets of Provencal cities.

For Gassendi and his circle the contemplation of the golden age was no mere aristocratic day-dream, but a vision which enabled the philosopher to contemplate the crimes and follies of the present in the larger perspective of other possible worlds, both past and future. For this reason Gassendi regarded history as 'the certain light of life'. Nor did he see any essential differences between the prerequisites of the empirical scientist and the critical historian. In a seventeenth-century context, when Galileo's chosen confidant in matters scientific was a historian—Paolo Sarpi—and when Gassendi and Bacon wrote histories which are still consulted, or Sorbière was both Historiographer Royal and secretary of the Académie des Sciences, we cannot dismiss this view as mere idiosyncrasy. Gassendi's concept of Historia (literally description) was applied to knowledge of natural phenomena as well as to the past. Gassendi rejected the idea that the former offered any possibility of certain knowledge of the nature of things which was denied to the latter. He did not regard successful prediction as the unique criterion of congruence with the phenomena. This was the only logical position open to a convinced Copernican, aware of two millenia of successful geocentric astronomy. This scepticism was crucial to Gassendi's failure to present himself, and other moderns, as possessors of absolute truths that broke the continuity of human history with a force akin to supernatural revelation. There was a close relationship between the growth of secular-minded critical historiography and the autonomy of the new science from scholastic theology. The fact that Gassendi was secretly sceptical of Christianity as a trans-historical supernatural revelation, miraculously silencing the pagan oracles, was an important element in his refusal to allow either the
hermetic or the mathematical sciences to deck themselves in dogmatism stolen from theology. Just as Fr. Mersenne believed that God might delude the pagans with lies, if they were conducive to morality, Gassendi argued a science with undetected errors might still achieve a high degree of operational exactitude.

Chapelain's dispraise of Peiresc could be regarded as evidence for the thesis that ancients and moderns were at war during the seventeenth century and presented mutually exclusive modes of thought. Swift ranked Gassendi's atomism, which he identified with that of Epicurus, on the side of the ancients; opposed to Descartes' vortices among the army of moderns. Those histories of science which have tended to market the scientific revolution as primarily a break with Greek and Roman thinking have taken their cue from such late seventeenth-century journalism. Gassendi's first patron, Gaultier, struck a much more exact balance in 1630: 'We learn from the ancients, if not exactly the truth, then many things which seem to approach truth. I do not esteem those great men one jot the less for falling short, It is thanks to them that we have been put in the way of close observation of matters so noble and so far above us.' (Aix Méjanes MS 1023 f.272)

Seventeenth-century society had genuinely re-created, among a large and influential portion of its privileged classes, a paganised élite, whose cynicism and secular rationality had little or nothing in common with their official creed of Christianity. This explains the new admiration for Tacitus among historians as well as practical statesmen like De Valois, Paolo Sarpi or Cardinal de Retz. The same applies to the enthusiasm which led Hobbes to pour his novel political science into the mould of Thucydides, or Gassendi to present his materialism through the Greek atomists. The same Chapelain writing to Gassendi in 1633, when he threatened to
abandon his 'Epicurean philosophy' as a result of the trial of Galileo, was in no doubt about the originality of the threatened work: 'I am astonished that you now plan to give such a low profile to those fine ideas with which you have ravished our hearts. Did we not follow your track through the heavens and down to earth's centre, whilst you explained to us the cause of everything?' (Aix Méganes MS 1021 f.372). Chapelain certainly did not share the illusions of certain modern scholars that Gassendi had done no more than "blow up Lucretius' ideas into three huge in-folio volumes". But nor was the ancient philosophy merely a disguise enabling Gassendi to elaborate a modern physics in its shade. It was a key element in what has been termed the precession of the early modern world, at once both pagan and Christian, equally subject to influences from antiquity and the medieval west. It was this precession, a resultant of two conflicting forces—faith and reason—which led to a fundamental shift in the axis of scientific enquiry. Science was no longer the docile hand-maid of theology; but it would not bite the hand which fed it, either. Since so many scientists of the period were—like Gassendi—priests, this is no mere figure of speech; but, in Gassendi's case, this restraint was not the result of failure to imagine any possible conflict between science and religion. Rather the reverse: like his friend Naudé, he was unwilling to rock St. Peter's boat, precisely because he guessed that it was only on the threshold of 'revolutions in the sciences' (Naudé's term) that would be far more embarrassing to clerical-biblical authority than the case of Galileo. There is plenty of evidence of such restraint in Gassendi's published writings on geocentrism, gravitation, cosmic evolution, geology and fixity of species. It was not intellectual timidity, but a clear-sighted grasp of the social and ecclesiastical consequences, which bridled his hypotheses.
Gassendi incorporated the stimulus which his generation found in the ancients into a philosophy linking tradition with innovation in science: a philosophy which was itself not exactly original, but owed much to Ptolemy and Seneca. His argument was that scientific theories, whether true or false, were constructions, influenced by cultural elements, such as mythology, trade, the organisation of society, styles in architecture. On the other hand, the facts (or the phenomena) were commensurable between cultures: a universally viable seed-corn (germinas) for all hypothetical construction. This was much more favourable to scholarly study of the ancients than Cartesian rationalism. It prepared the way for the analysis of the past as a succession of cultures, each with a distinctive collective psychology, as in Voltaire or Vico.

Because science was a cumulative and progressive process, it was absurdly parochial to view one's own culture or period as intrinsically superior. Gassendi might have had a hint of this idea from a Provencal Jewish astronomer, Levi Ben Gerson, inventor of the astronomical radius.

Ptolemy himself had argued that it was the passage of time which had created his opportunity to improve on the ancients. In the philosophy of Seneca ancients and moderns were not absolute—but relative—terms, each civilisation occupying a dual role in relation to its precursors and successors. But Gassendi, like many sincere believers in progress, had no illusions about its inevitability, referring sarcastically to 'some who are dwarfs on the shoulders of giants and others [the astrologers] who are mere fleas under their armpits.' For Gassendi, the fate awaiting the whole cosmos was re-absorption into animus mundi; and human history was a totally insignificant wrinkle on the cosmos. His belief in (uneven) progress in the sciences was grounded on an instinctive law, like those which governed animals or matter itself. But his attitude remained relativistic. His view that material progress was often out of phase with human nature, took the familiar form of the contrast between the age of gold and the age of iron; less
commonplace was his realisation that technological progress for humanity might be retrogression for hunted animals.

This relativistic view was part of his attitude to science itself. Many seventeenth-century thinkers, scholastics and mechanists alike, saw it as pure truth driving out total error; or, as Fr. Mersenne in the 1620s professed to believe, a continuation of theological controversy by other means. For Gassendi progress lay in the unspectacular accumulation of facts, observations and seemingly unimportant details; or, at a theoretical level (to borrow a concept from astronomy), in the parallax of perspectives. Gassendi and his circle held that a new viewpoint was generated not by the internal contortions of Cartesian reason but simply by translation of an idea, or set of astronomical observations, originating in one civilisation into another. Apparent novelty may actually be a fusion of two different approaches to similar scientific problems; as when Copernicus borrowed a piece of medieval Arabic geometry known as the Tusi 'couple'. Or it may be an apparently trivial matter, as when a newly discovered Babylonian sighting of Halley's comet was used recently to calculate long-term gravitational alterations in the positions of the planets. One of the medieval Jewish manuscripts unearthed by Peiresc contained a new notation for irrational numbers and an early decimal system.

The limits of cultural pluralism in Gassendi's circle extended to medieval Jews, Arabs, troubadours and nominalists. There was a tendency to agree with Julian the Apostate that, without the Greek tradition, Christians would be incapable of either humanities or natural science, and that the Dark Age taught this by examples.

It is clear that the link made by Gassendi between ancient and modern science was inseparable from his sceptical epistemology. The repudiation of the ancients was characteristic of a doctrinaire and shallow rationalism, associated with certain would-be Baconians
or Cartesians. For the seventeenth-century intellectual the ancient world was not a heap of broken columns and dead inscriptions, haunted by shades in togas; it was a set of tools for constructing a 'do-it-yourself' golden age. No need to wait for Plato's millenium: if you imitated the Arcadians, even though living and dying in an age of iron, Gassendi and his circle believed that you acquired a sort of honorary citizenship of Utopias past and yet-to-come. This idea was less theological than it sounds. Through friendships with other golden spirits in this life, and 'burial' in their memories after death, the torch of a purely secular immortality was passed on. Gassendi dead became Gassendius Redivivus. The image was that of a personal presence now diffused throughout the cosmos. Hence the importance Gassendi attached to writing his lives of the astronomers, and to Peiresc's life in particular.

The hostility of humanism to science is partly an optical illusion, generated by an extremely narrow late nineteenth-and-twentieth-century idea of what science ought to be. In the case of Gassendi and his circle, modern scholars—unable to find their way through the rich classical undergrowth of allusions, citations and references—encounter that invisible curtain which cuts off the educated person of today from the preoccupations of antiquity. Leibniz, who found Descartes all but unreadable, praised Gassendi's writings: 'because, while containing some fine thoughts, they could be read right through without stopping, giving rise to all kinds of ideas which could be followed at fancy, and pursued as the spirit moved me... Provided it is understood to be a hypothesis, his work is sufficient foundation for mere physical science. It would make an admirable introduction to philosophy for young students.' (Philosophical Letters and Papers p.663 ed. Loemker 1969). Henry Stubbs made exactly the same suggestion to Richard Cromwell on behalf of the
SYNTAGMA PHILOSOPHICUM

As a Chateau (based on designs of Levaux of 1645 and 1656)

Gassendi frequently employs analogies drawn from architecture and the construction industry to describe not only his theory of the nature of things, but also his theory of how thought tries to construct a picture of a reality which it can never really understand. He was...a frequent guest at the chateaux of the aristocracy (that of the Duchess D'Aiguillon at Rueil or that of the Duc d'Angouleme at Grosbois) during the periods when he was working on the many drafts of his Syntagma in the 1640's. His method of working on these drafts, the re-arrangement of prefabricated sections and the insertion of pre-assembled quotations, suggests an architectonic rather than literary composition. Hence my idea of reducing this complicated and unwieldy work to its elementary principles in the form of a contemporary architect's drawing.
students at Oxford and Cambridge. Even in the nineteenth century scientists like Maxwell or writers on science like Bagehot were sufficiently educated to be able to read Lucretius as if he were their contemporary. A minister in Asquith's cabinet was able to quote Thucydides, after the failure at Gallipoli, without any sense of incongruity; much as Gassendi felt it natural to refer to Thucydides when describing the plague of Digne in 1629. It is arguable that the great revolution which severed us from ancient culture did not come in 1660 or even 1850. It was part of the historical process which initiated the technological barbarism of the First World War and which Spengler predicted would become the dominant theme in our culture.

Gassendi and his circle sometimes referred to Roman Catholicism as the 'ancient religion'. But this involved an element of word-play and deception. His Catholicism, like his humanism, can best be understood in terms of a mask. But antiquity was part of the scaffolding of his thoughts; a mask, like those used in the Greek theatre which served a prophetic function. Religion was a social convenience. It secured immunity from the ribaldry of the mob, like the masks in the great Provencal carnivals; it was a prophylactic against official persecution, like the incongruous bird-costume worn by Provencal doctors as a precaution against plague. Gassendi perhaps did see himself as a votary of the ancient religion; but although elements of this cult of nature might be recognizable in certain Catholic rituals (such as the communion service) or dogmas (such as the Trinity), it would be wrong to see this erudite pantheism as coinciding in Gassendi's mind with that of his profession. We can only guess at this distance (and only a few contemporaries shared the secret) what Gassendi actually believed about God, the nature of matter and the soul. But he claimed to trace his wisdom back to the Druids of Marseilles, through the dispersed Order of Pythagoras,
to sages from India and the far North (the Hyperboreans) who had flourished long before the Druids. Bernier, whilst pouring scorn on Jesuit efforts to discover elements of Christianity in Hindu legend, regarded the convergence of Gassendi's philosophy with the teachings of the yogis and theosophists as clear evidence for at least part of this pedigree.

Gassendi was a firm believer that true wisdom was moral as well as astronomical. As Ptolemy and other ancients taught, the passionate love of things eternal, and an understanding of regular motion, was the key to both. This philosophy was spread by oral tradition and secret signs rather than through books. This knowledge was common to Epicurus, Plato and Aristotle, but only indirectly mirrored in their public writings. As Milton put it, after his return from his trip to France and Italy, truth was like the limbs of the dismembered god (Orpheus or Osiris); a sort of crossword puzzle for the adept to unscramble into a unity, if he could. (Everyman ed. p.30) Although Gassendi encountered this theory in Greek authors like Plutarch or Porphyry, he had grown up with the procedures of the illiterate shepherds of Provence, who communicated secretly through arrangements of pebbles, just as the Pythagoreans are said to have done.

Walter Charlton—Gassendi's English translator—did not believe that Stonehenge was a temple, because like Newton he was convinced that the ancients had recognized the universe itself to be the true temple. All organised religion was a later corruption or imposture. Gassendi regarded science as a temple in course of construction in all ages. But this building could never be more than an antechamber to the true Temple, since the design of Nature was itself ultimately unknowable. Gassendi's Syntagma is a study of the relations between both temples; a history of science as well as a somewhat oblique summary of the most recent research. He himself compared his writings
to one of those cylindrical portraits, projected as a muddle of lines onto two dimensions, which made sense only when viewed through a cylindrical mirror. Although it may appear an antiquarian jumble, because it looks backward as much as forward, the Syntagma is a monument to Gassendi's vision that our picture of the world is a human construction; with the mark of a definite time and place. Each new generation performs its own mathematical integration, which is then added to the sum total of existing thinking. This is not to rule out change, but to explain it in terms of accumulating traditions. The resultant human science is an asymptotic curve, always converging on the phenomenal universe, always tangential to physical reality. It is ironic that Gassendi has been lampooned for his ignorance of mathematics; apart from Leibniz he was the only contemporary philosopher to incorporate the new mathematics into his epistemology. Hobbes, Descartes, Spinoza and the rest clung to a Euclidean image of epistemic certainty. Most of the libertins were sceptical, even about mathematics.

Seen in the context of his vision of a cumulative science, based on observations and careful recording of data, Gassendi's theory of an ancient wisdom appears as a vindication of both progress and tradition in science. For Gassendi these two values were not opposed but linked: to use his favourite image, the left foot goes forward only because the right foot, at rest, provides a fulcrum. Gassendi feared nothing so much as the sudden 'universal changes' which would follow the erosion of popular religious beliefs. Hence his antipathy to Protestantism; his casual dismissal of the Puritan sectaries, whose mentality continued to provoke wars and civil disorders. Protestant fanaticism provided a continuing argument for the Tridentine rigidities of the Counter-Reformation and had blocked the emergence of a liberal Erasmian Catholicism.

What is the difference between dogmatism and arguing from definite
principles; between the relativist and the intellectual anarchist? Anyone who can answer this question, without ambiguity, will be in a position to draw a ground-plan of Gassendi's thinking. He was a relativist, arguing from definite principles; though the ancient wisdom was not a creed or set of rules to be learned by rote. Each age, or each individual, might draw on the principles of the ancients; but these had to be applied afresh to each individual situation. The Tetrad agreed on this image of science as a craft-skill rather than as a set of absolute propositions. They extended the same principle to morality. Those modern scholars who have searched Hobbes' politics for a single, logically consistent system search in vain; but that does not mean he was not guided by definite principles. The same applies to Gassendi's science and gives the key to the intractable question: 'What was Molière's philosophy? Popkin's concept of 'mitigated scepticism' reflects the element of artificial balance in this quest for a consensus in science and morality, drawn from the common sense of an élite of ancients and moderns; but the phrase masks the widespread existence of an unmitigated scepticism about Christianity in private, generally mitigated to the point of extinction in public.

The primary purpose of this long study has not been to clarify the nature of scientific method or to score party points in the debate between internal and external methodologies of science. It has been the re-discovery of the historical Gassendi: an indecipherable ancient to us bright-eyed moderns. Cyrano de Bergerac described a machine, in use among the lunar inhabitants, resembling a clock combined with the adding machine of Pascal. If metal discs were inserted into the device, which could be strapped around the waist, it was possible to listen, through portable rings fastened to the ears, to any desired volume of a talking-book. Sometimes, particularly
towards the end of this research, I too have experienced the illusion of walking through the lunar gardens, listening to a cracked voice wheezing out incomprehensibly prolonged sentences in Latin, with an unmistakable Provencal accent. What I listen for, most eagerly, is not the literal meaning but the speaker's tone; the traces of sincerity, sarcasm or reserve. But it is the strident fanatical voice of Jean Baptist Morin which next assails me: 'The devil may be the father of lies but even he cannot compete with Gassendi in the sheer magnitude of his deception.' Suppose that this were true? Because of the historical nature of my approach to the evidence, this study would still capture something of Gassendi, the man, even if its subject were to out-do the deceiving demon imagined by Descartes.
APPENDIX I

GASSENDI'S SUICIDE

Gassendi made his attitude to euthanasia and suicide very clear in a confidential *Tetrad* discussion as early as 1630. (See ON LIFE AND SOULS). He could imagine 'nothing more horrible than what the people call *une belle mort* in bed from natural causes, surrounded by priests and doctors.' The sudden violent end of a soldier on active service was the ideal end. This view would be unusual, in a priest, since time to confess and repent sins was crucial to all Catholics in this, and other, ages. 'From a sudden and unprepared death deliver us O lord.' But Gassendi argued that the poor of Digne, in 1629-30, were better off without their priests (who fled) because plague was relatively swift and they were delivered from the 'mummery' of the death-bed. He argued that if the State authorised abortion, or euthanasia for the elderly, the over-population which caused natural checks like plagues to operate would be avoided.

Gassendi's own death, in 1655, has been cited as evidence for his Christianity. It was, outwardly at least, *une belle mort* from natural causes surrounded by all the rites of medicine and the Church. Several conflicting accounts of Gassendi's death exist but the purpose of them all is evidently to remove doubts about Gassendi's piety. However, in the curiously rambling archive—it was not intended for publication—of Fournier, Gassendi's astronomical assistant in Provence, we read the following entry: 'On the 22 October 1655 at 2.30 pm died Pierre Gassendi, philosopher. Il mourut en Socrate.' Unlike the other, minutely circumstantial accounts, no details are given. Yet this, I believe, is the only true account of Gassendi's death. The others were supplied to allay unpleasant rumours. To die the death of Socrates meant only two things in the seventeenth century: Socrates, though a pagan, had died a virtuous death, comparable to any Christian; Socrates took his own life by drinking poison—though he had an option
to survive—to escape his persecutors.

A letter from Gui Patin, Gassendi's intimate friend and physician, written in the summer of 1655, indicates that the decision to end his life had already been taken. Patin informed Gassendi that he might survive his illness for another year at most and that, although he was in no immediate danger, he faced a long and painful illness. Then follows a list of all the great men of antiquity, both Stoic and Epicurean, who had taken their own lives. He dwelt particularly on the case of the philosopher Seneca, recounted by Tacitus, who had taken his life by fasting, being bled copiously and then taking poison. His aim was to escape the tyranny of his former pupil Nero. Seneca was Gassendi's favourite among the Roman philosophers. Then followed a list of poisons obtainable 'from any Paracelsan mountebank in Paris'. We do not have the letter to which this was a reply. But to reconstruct it scarcely requires much imagination: 'How long have I got left? Am I going to suffer? Supposing I wish to apply the principle of euthanasia, which I have always preached in private, what means are available?'

This letter puts a new perspective on Sorbière's indignant claim that Gui Patin and the other doctors attending Gassendi had bled him so excessively, even by the Galenic rules, that they were effectively his murderers. It sheds a new light on the particularly strict fast which Gassendi had enjoined on himself—allegedly for reasons of religious austerity—though invalids were excused fasting in Lent. It recalls a bizarre ritual which, according to Cyrano de Bergerac, was practised by philosophers on the moon.

'All his friends take their farewell and the closest friend of all kisses him on the lips whilst stabbing him to the heart with a dagger. All the blood is then drained from his veins and bottled. During the next few days his body is cooked and his friends subsist on nothing but the flesh and blood of the philosopher. Throughout this time they keep company with young girls, none above fifteen, in the hope of getting them pregnant. They believe the soul of the philosopher may be reincarnated in the offspring.'
Cyrano wrote this before Gassendi's death, but perhaps only a year or so before. It is interesting that Cyrano died on 28 July 1655 and Patin's letter was dated 24 June 1655. Cyrano had died as a result of the unexpected fall of a beam from the roof of the house of his former patron, the Duc d'Arpajon — in the 1630s a comrade in arms of Louis de Valois and a leading champion of the Knights of Malta. When Cyrano's *Voyage to the Moon* was posthumously published, this passage and other blasphemous touches were removed.

If we liken Mazarin to Nero, there were sound political reasons for Gassendi's suicide. His patron, Louis de Valois, had died suddenly, in disgrace in November 1653. Some mystery surrounds his death. A document extant in the Archives Nationales (A.E.890 f.289-97) states that on September 10 1653 he resigned his governorship of Provence to Mazarin for 400,000 livres. There is no explanation for this sudden reversal of the view which he had expressed to Gassendi and to Mazarin's advisers, ever since he had been recalled from Provence: that he was governor of Provence for life and would not resign unless stripped of office for high treason; Mazarin had good reasons for avoiding public trials of his opponents. De Valois, with his special detestation of Mazarin, would have been most reluctant to approve this deal, which made Mazarin himself governor of Provence. The mystery is heightened by De Valois' funeral. Although he was buried in his family vault in the Minime Convent, there were no mourners and no funeral procession. Only, we are told, 'a few old family retainers.' Was Gassendi among them? Or did his health keep him at home? De Valois was exumed and reburied, with all the pomp which ought to attend a former Bishop of Agde, a prince of the blood, the Duke of Angoulême and last of the Valois, in his wife's family vault in Burgundy on 18 January 1654. In his oration the preacher mentioned that Gassendi had preferred the
prince's conversation above all the university professors.

Linked with the death of De Valois, whose exact circumstances may never be clarified, was Mazarin's personal campaign against Gassendi. J.B. Morin's two-pronged attack on Gassendi's secret Copernicanism and his secret unbelief had Mazarin's personal backing. Neither Gassendi nor his patron were innocent parties. Gassendi was actively plotting Mazarin's downfall as first minister from 1643, and continued to intrigue for De Valois' return as governor as late as 1653. An early Fronde pamphlet by Cyrano de Bergerac made a clear reference to Gassendi and Louis de Valois as the ideal protectors of France:

'We have princes who have not only the experience but the learning to rival the sages of Greece, we have sages whose wisdom might lead us to marvellous triumphs. For France will only be content when its kings are philosophers and its philosophers kings.'

The pamphlet applauded De Valois for not marrying his daughter to Mazarin's nephew and condemned Mazarin to the galleys for fraud and impiety. Mazarin, like Richelieu before him, was only countering a deep-laid and highly organised plot against his administration—a plot which aimed perhaps to put Louis de Valois, 'the sun of our time', as the Minime preacher expressed it at his second funeral, back on the throne of his ancestors.

The place of the Compagnie du Saint Sacrement in this plot is highly problematic. But Gassendi's last confessor was a leading member. So was the Duchess d'Aiguillon, whose daily gifts of specially cooked vegetarian food—which Gassendi always refused—seem all the more poignant if she knew Gassendi's real motives for fasting. So was Montmor, in whose house he died. Although suicide was permitted to Stoics, simply to avoid pain, Epicureans were made of sterner stuff. Only the possibility that you might betray your friends to a tyrant justified the death of Petronius and Cassius, the
most famous Epicurean politicians. In 1651 Cyrano turned coat and deserted Gassendi's party for that of Mazarin. How much did he know about Gassendi's secret teaching? After the publication of Morin's accusations, and the details about the threatened prosecution for atheism (which Mazarin had called off, he claimed, only because Gassendi's friends had removed the witnesses), Gassendi knew the heat was on. He was now a weak link in the chain of friendship securing the pagan inner circle of the Compagnie. Whatever means had been used to persuade Louis de Valois to sell Provence might be applied to Gassendi to betray his friends in the Compagnie.

As it was, Mazarin was not able to track down the Compagnie, despite his formidable network of underground agents, till 1659-60. By then the central committee had time to destroy or remove their archives, finances and membership lists.

'Do not weep for Gassendi, the death of a friend is like the fall of autumn leaves, and grief as ridiculous as it is unjust. Besides, he was in such an awkward situation, on account of the ill-will [mauvaise constitution] of a certain party we were speaking of only the other day, that I think we should now envy him his happiness rather than regret his loss. These are the days when the wisest men will slay each other, as did those who sprang up from the soil after the sowing of the dragons' teeth. Weep those whose bodies are in the grave; not those whose true sepulchre is in the heads of their friends. Gassendi's tomb was his fortress against disgrace', wrote La Mothe Le Vayer, the last of the Tetrad, to an unknown inquirer.
That Gassendi sprang from a family of poor but devout Roman Catholics has never been questioned. Yet the Latin of Sorbière, on which this deduction rests, is ambiguous. He wrote that Gassendi’s parents were faithful to the 'old religion'. This is taken to mean Catholicism as opposed to Protestantism. But other interpretations are possible. Digne was not a Protestant town but had, as Gassendi pointed out, been the centre for Jewish merchants in Gaul since Roman times. During the Middle Ages the intransigence of the Jewish population left the town frequently without a bishop. In the fifteenth century it was still one of the largest Jewish centres in Provence. The law courts had to keep records in Hebrew; and from the way Gassendi cites in full the oath which the courts imposed on Jewish witnesses (a crude equivalent of the Heron sworn among Jews themselves) it is clear that he derided the ignorance and anti-Semitism of those who had drawn it up. There is a very significant silence in Gassendi's history of Digne about the expulsion or forcible conversion of the Jewish community in the early sixteenth century — at the time of the union with the French Crown. Gassendi linked the collapse of the town’s prosperity with the wars of religion later in the century. But Marianne Calmann has shown that 'Digne' was a family name of certain prosperous Jewish families living in the Papal ghettos in the first half of the seventeenth century. Although Gassendi dared not write it openly, the disappearance of the Jews must have had a disastrous effect on the town's business community.

But whereas those with a profession or with capital fled, others remained. Digne had an unusually high proportion of Jewish peasants. Owners of flocks or vineyards, like their Biblical ancestors, they were prone to lapse into conformity or intermarry with their Catholic neighbours even before persecution. Could it be that Gassendi’s
grandparents or great grandparents belonged to this category? It would explain a number of eccentricities in Gassendi's behaviour. His vegetarianism, for example, would excuse him from ever having to eat improperly slaughtered meat. He used the quotation (in Hebrew) about the soul being in the blood of animals to defend his position. His patronage, by the eminent jurists of Provence, and their promotion of his interests, would cease to be surprising, since so many of them were of Jewish-convert descent. When Peiresc invited the Rabbi Solomon Azubi to stay in his house, to meet Gassendi and eat with them, there is no mention of how they arranged to meet the sensitivities about food-laws of an orthodox rabbi. Not only would he need Kosher meat; even vegetarian food would have to be prepared by an orthodox chef and be served on a specially reserved set of dishes. Whatever took place, the encounter itself—completely contrary to the laws governing relations of Jews and Catholics—was sufficiently remarkable.

In 1630, again in the house of Peiresc, Gassendi planned with Galup de Chasteuil to leave France for the Middle East. He had prepared himself for his departure by learning both Hebrew and Arabic. In the end, he did not go. But the Chasteuil family were descendants of converted Jews; and Chasteuil himself took up permanent residence in the Lebanon. Before he left, Peiresc, Gassendi and Chasteuil together had been studying the Samaritan Pentateuch. Their interest in this document, shared by Cardinal Francesco Barberini, who had made Gassendi Provost of Digne, suggests a still more novel turn to this question. The concept of God, developed by medieval Samaritan theologians, was very close to that of Gassendi. They rejected the anthropomorphic image of Jehovah and identified God instead with fire, the principle of force in all nature. Perhaps they were influenced by the Pythagoreanism which
Yaysan bas-alpin. La même clarté, la même terre et la même eau ont toujours connu les mêmes hommes. Photo Martin.
made Gassendi choose the fire atom—the tetrahedron—as the emblem of his movement. They rejected hell and heaven but looked forward to the return of a golden age. Antoninus Pius, the Roman Emperor who had ruled during what Gassendi regarded as the last golden age was claimed by them as a convert to Samaritan Judaism. Two other key phrases from the correspondence of Gassendi and Louis de Valois, sometimes written in Hebrew characters (mauled by the type-setter) were 'the finger of God' and 'the day of Vengeance.' These had special significance in the Samaritan theology. The elect were droplets of light—Gassendi's golden spirits—and the wicked were not damned but simply faded away. This seems to match Gassendi's own mixture of rationality and 61itism. Even Gassendi's doctrine of the primacy of wave-patterns in physics was paralleled in Samaria. They saw God as a sea, acting through waves as the human body does through muscles.

Why did De Valois respond to Gassendi's stilted and apparently pointless Hebrew phrases? Was it learned affectation? Louis may have been royal but his grandmother, mistress of the luckless Charles IX, was herself the grand-daughter of a pedlar and pharmacist from Eastern Europe—Toussasiev—whose son changed his name to Touchet, when he bought lands and office. Perhaps Louis' interest in science was inherited from this forgotten hawker of herbal remedies. There were prophecies, in Gassendi's circle, that a descendant of Charles IX would be a Messiah to both Jews and gentiles, uniting their religions into one and recover the Holy Land for the Jews. Gassendi's close links with La Peyrère, the first modern Zionist—himself of convert descent—suggests that he took a close interest in such matters.

La Peyrère was in the household of De Valois' cousin Condé, the 'helmsman' of the Fronde against Mazarin. Perhaps Gassendi's desire to travel to the Middle East in 1630 was not a purely antiquarian
impulse. If he and De Valois took the prophecies seriously, or in some sort of allegorical form, it would explain why their correspondence shows such persistent zeal for a crusade against the Turk. It would explain their enthusiasm for the war fought by the Knights of Malta—originally the Knights Hospitaller of Jerusalem and founded entirely by Provencal nobles—and their hostility to Mazarin for failing to unite Christendom in a new crusade.

Gassendi's last patron, publisher and literary executor, Montmor, was known to be of Jewish descent. Gassendi's Bible, in Latin and Hebrew, had no New Testament; and I cannot recollect that he ever cited a quotation from the four gospels anywhere. St. Vincent's doubting doctor, it will be remembered, had not only lost his faith, but actually experienced a revulsion from things religious so strong that even to have the names of Jesus or Mary on his lips was a torment. It is very easy to imagine that someone of Jewish descent, in Gassendi's position, might have felt like that. It seems that history is to blame.
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640, list of Peiresc’s library 1871-7 folios of Peiresc’s correspondents 1864 Observations de Diverses Merveilles de Nature 1774 Observations sur les yeux des hommes et divers animaux

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Méjanes, Aix-en-Provence

de Valois. A very important source, written by the son of an ensign in his regiment, never published and rarely mentioned by historians. 775,1790 anti-Semitic attacks on parlement.

The importance of this Jewish element in the parlement is not referred to, as far as I know, in any history of Provence. Marianne Calmann reports her own experiences, in her fascinating thesis (University of Warwick) on the carrière of Carpentras (Oxford University Press, 1984). She met the daughter of a rabbi, who claimed that her father had made her learn by heart, before he died, the genealogies of the Jewish families in Provence. But an oath of secrecy prevented the family revealing the names, even to a Jewish historian.

**Département des Bouches du Rhône**

Series B 33534 on community debt. The whole series B reveals many aspects of PARLEMENT activity.

**British Museum**

Add 6193 f.996 a funeral oration on Gassendi, attributed to Gellibrand, but apparently emanating from a hitherto undetected free-thinking Gassendist circle at Christ Church, Oxford in 1655. Locke, Henry Stubbe and Boyle (who had visited Provence and Paris in the 1640s) the mathematician Wallis, then a Professor at Oxford, Walter Charlton and the physiologist Thomas Willis are all possible associates. This document shows a deeper understanding of Gassendi's secret philosophy than could have been gleaned from his published works alone. It points to the existence of an organised Gassendist underground in protectorate England, which might explain the privileges accorded to the otherwise obscure Sorbière in the Royal Society and Gresham's College in 1663.


**University Library Cambridge**

F 164 c 42 collection of Fronde pamphlets. Add 3996,4003 Newton's notebooks.

Add 3965 (1B) a paper which Professor Westfall regards a first draft of Newton's De Motu. But it is dated March 1689/90 and is in the handwriting of John Locke's secretary, Brownlowe. Curious features of the language and method make this late date unlikely and it is therefore at least possible that it is as early as 1679/80 - though Whiteside has disputed this with Professor Herivel. It is therefore difficult to slot into the known sequence of drafts for the Principia. It deals with the crucial problem of composing planetary orbits, by infinitesimals, from a parallelogram of inertial and gravitational forces; an idea which, I have
proposed, was initiated by Gassendi and Fabri at some time between 1635 and 43. Both Locke and Halley resided in France, where they frequented known Gassendi circles: the former returning to England in 1679, the latter in 1682.

Chatsworth

Hobbes collection: letters from members of Gassendi’s circle to Hobbes: Du Verdus, Du Prat, Sorbière etc. which contain interesting details about Gassendi. For example, Fermat’s unpublished and important mathematical MS “On Porisms” reached Hobbes, in 1654, by the French ambassador Bordeaux, in the same diplomatic bag as three volumes of Gassendi’s philosophy.

Leningrad

By an accident of history some of the papers relating to Louis de Valois’ administration of Provence are in the Doubrowski archive. My inquiries to the Soviet Embassy in London and to the Soviet Academy of Sciences have failed to elicit any information about the accessibility of this archive or about the present state of Gassendi studies in Russia.

INDIA

Bernier’s lost translation (or rather paraphrase) of Gassendi into Persian could be a valuable test-case for my argument that Gassendi had a secret philosophy, imparted orally to Bernier and other intimates. Despite the assistance of Dr. Waley, my own research in the London School of Oriental Studies and inquiries made, on my behalf, by Gilbert Werner Pleuger on recent visits to the sub-continent, no trace of this work has been found. I did, however, discover that Bernier’s translations of the Upanishads were a key influence on the philosophy of Schopenhauer.

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Both Pintard and Bloch contain long and excellent bibliographies. The enthusiast is referred to these. Bloch contains also a useful date-chart.