The Use of *Materia* in Book I of Lucretius' *De Rerum Natura* and its Relevance to Modern Theories on the Mechanical Properties of Matter

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The Usage and Conception of *Materia* in Book I of Lucretius' *De Rerum Natura* and its Relevance to Modern Theories on the Mechanical Properties of Matter

The idea of matter and mass is an elementary physics concept that is found extensively throughout Lucretius' *De Rerum Natura*, and especially in his use of the word *materia*. The purpose of this project is to explicate Lucretius' use of the word *materia* in Book I of the *De Rerum Natura* and to understand the ancient conception of *materia* through modern-day scientific knowledge and rationale.

It is appropriate to begin with an overview of the Latin word *materia*. *Materia* comes from the same root *Ma-,* meaning *to make,* from which the Latin word *mater*, the Greek word *ματερ* or *μητερ,* as well as the English word *mother* are derived. The word *materia* thus implies the idea of a creator, something or someone that is capable of propagating physical existence, or possibly something created (Leclerc 122).

Aristotle was responsible for first using *hyle*, the Greek equivalent of *materia*. To him, ". . . *hyle* represented not only the idea of forests and woodlands, but the actual wood derived from these places in the construction and in the creation of things"[1] (Leclerc 122). While Latin had the word *silva*, which connoted the most literal meaning of *forests* or *woodlands* (Leclerc 122), there was nothing in *silva* that implied the creation associated with the material of the woodlands. Latin needed a word that implied the idea of something coming from another, the whole act of creation, and for this they chose the word *materia*[2], which not only represents this whole idea of creation, but can also be

[1] Leclerc, Ivor. *The Nature of Physical Existence*. George Allen & Unwin Ltd: London, 1972.
[2] For instances of materia being used in a context as "wood," refer to my notes on *materia* in the Appendix, Book VI, l.1061, and VL.1069-1071.

associated with the material of the *woodlands*, namely *wood*. In *De Rerum Natura* Lucretius applies a similar range of meaning to *materia* where the word is used in a variety of contexts dealing with creation.

As mentioned, the methodology of my project includes examining each instance of *materia* as it is used throughout Lucretius' *magnum opus* and collecting the attributes and characteristics of *materia* with the aim of then compiling a big picture of Lucretius' definition of *materia*, and how it compares to the modern conception of "matter." My hypothesis leads me to believe that Lucretius reinforces the definition of *materia* with characteristics that are consistent with the themes (and subheadings, which the Leonard-Smith edition provides so well) of each of the six Books.

In the proem of Book I, Lucretius begins *De Rerum Natura* with an invocation to Venus, and establishes some parameters of his great work: he clearly recognizes the addressee throughout the *De Rerum Natura* as Gaius Memmius (I 50-61), Epicurus (the founder of Epicureanism) must be praised for discovering the true philosophy (I 62-79), as it is a very worthy philosophy and there are many reasons why the Epicurean doctrine should be adopted by everyone (I 102-135), and the difficulties of properly treating Greek philosophy in Latin verse (I 136-145). The rest of Book I then serves two purposes: First, to give an introduction to atomic theory, which includes a list of characteristics attributable to atoms and matter: (1.) Substance (mass) is eternal (l. 146-328); (2.) that Void exists apart from matter as well as within it (l. 329-417); (3.) that substance (mass) and Void are the constituents of the Universe (l. 418-448); (4.) that all things exist as a result of either an essential reason or by some cosmic accident (l. 449-482); and (5.) that the *primordia corpora* ("first-bodies, atoms) are solid, indestructible, and indivisible (l.

483-634). The second part of Book I then contemplates the infiniteness of the Universe, which begins with an introduction to this topic, followed by a section on the apparent "boundlessness" of the Universe, and then characteristics of this "boundless" Universe.

Book I begins with a rather peculiar invocation to the goddess Venus as the *Aeneadum Genetrix* (I 1), "mother of Aeneas" [and his descendants]. It is interesting enough to note the irony Lucretius employs in this satiric invocation to a deity in whose existence he never really believed, but, for the sake of my study, it is even more interesting to understand why Lucretius attaches the Greek-derived epithet *genetrix* to Venus rather than *mater*. As I concluded in my introduction, *materia* can be understood as something or someone capable of propagating physical existence or as something created by this aforesaid propagator—the most basic substance of the Universe. I suggest that Lucretius employs double meaning in his use of *materia*, and so atheistically seeks to identify Venus not as a maternal figure and very-closely related source of human existence and continual propagator, but rather as a not-so-personal source of all of creation in general, and so is thus identified as the more impersonal *genetrix*, a feminine "origination" of all things, not only an *Aeneadum genetrix* (I 1), but an *omnium genetrix*.

The very first instance of materia in Lucretius De Rerum Natura comes at l.58, when Lucretius says

> *Nam tibi de summa caeli ratione deumque*
> *Disserere incipiam, et rerum primordia*
> *Unde omnis natura creet res auctet alatque*
> *Quove eadem rursum natura perempta resolvat*
> *Quae nos materiem et genitalia corpora rebus*
> *Reddunda in ratione vocare et semina rerum*
> *Appellare suemus et haec eadem usurpare*
> *Corpora prima, quod ex illis sunt omnia primis.*
> (1.54-61)

"For I shall begin to discuss for you on the highest order
of heaven and the gods, and the first-beginnings
of things from whence Nature creates all things
and increases [them] and nourishes [them]
and where the same Nature again reduces them
when they are dissolved, which, we are accustomed
to call matter, and the productive bodies of things
and the seeds of things, in ascribing reasoning, and to
name these same first-bodies, from these things
which all first-things are."

Lucretius sets the stage in these few lines for how we are to understand the constituents of matter. In discussing philosophy (*reddunda in ratione* L.59), we are to understand the highest of things, heaven (*caeli* L.54) and the gods (*deumque* L.54) in a context similar to the physical beginnings of things (*rerum primordia* L.55), the physical "building-blocks" of all things we can perceive. Lucretius lets the reader know that Nature is the one responsible for the creation, propagation, and nourishment of all things (*Unde omnis natura creet res auctet alatque* L.56). This is in direct contradiction to Lucretius' opening invocation to the goddess Venus, who is supposedly the giver of sexual energy to all species and allows them to propagate. Nature is clearly responsible for that role by l.56. *Materiem* is the object of the unified *primordia rerum* (atoms) and the general name for all matter that can be perceived by human senses.

Materia appears next in the De Rerum Natura as *materies* at l.169-171.

At nunc seminibus quia certis quaeque creantur,
Inde enascitur atque oras in luminis exit
Materies ubi inest cuiusque et corpora prima. . .

"But now because every kind is created from
Fixed seeds, there whence each thing is born
And comes into the borders of light
Where it is the matter and first-bodies of it."

Lucretius is informing the reader early in the text that what all creatures, human or not, come into the world with are bodies of matter (*materies* L.171), which are made up of the corpora prima, a term Lucretius used throughout *De Rerum Natura* to signify the atoms, constituents of matter. Every creature that enters and experiences the "borders of light" (*oras in luminis* L.170) is given matter (*materies* L.171), which is comprised of atoms (*corpora prima* L.171).

Another instance of *materia* in De Rerum Natura is found at Book I, lines 188-191, where Lucretius writes:

> *Quorum nihil fieri manifestum est, omnia quando*
> *paulatim crescent, ut par est, semine certo,*
> *crescentesque genus servant—ut noscere possis*
> *quicque sua de materia grandescere alique.*
>
> "These of which nothing is clear, when all things
> grow little-by-little, as is suitable, from a certain seed
> and so growing, [all things] preserve their kind—as you can learn
> each thing from its own matter grows"

It is noteworthy that Lucretius uses the word *grandescere*, as this term generally deals primarily with agriculture and with the growth of crops from soil. In this case, though, Lucretius employs *grandescere* to give the reader a mental picture of the "crops of mass" growing from seeds, or the atoms. Each living (and non-living) organism has the power to grow only to the extent that its atoms, the most basic elements that compose its body, will allow it. Modern science would agree with Lucretius' assertion to a certain extent. What Lucretius calls "atoms" here are actually the cells that we understand today as being the "building-blocks of life." "Mitosis," derived from the Greek *mitos*, meaning "thread," is the process of cell-reproduction in which the cells of living organisms divide exponentially, which in turn cause the living organism to grow. Lucretius attributed this

phenomenon to the idea that all living things can only grow from their own initial and definite material elements (*crescunt. . .semine certo,* "they grow from a fixed seed", I 189).

Lucretius of course had no idea of the role that genetics plays in the growth and change of all living things. It is not the "building-blocks of life" that limit an organism's traits and characteristics, but the genetics contained within these cells, the strands ("threads") of DNA contained within each cell's nucleus that really determines each of the qualities that are later attributed to an organism.

At l.203-204, Lucretius discusses the limitations that are set upon what exactly can be created from the "fixed seeds" (*seminibus. . .certis* l.169).

> *. . .si non, materies quia rebus reddita certast*
> *gignundis, e qua quid possit oriri?*
>
> "If not, since it is certain that matter is produced
> From things already made, what could arise from
> What?"

Lucretius backs up his earlier assertion that "nothing could come from nothing"—not even by "divine power" (*nullam rem e nilo gigni divinitus umquam* L.150). Earlier, at line 199-201, Lucretius informed the reader as to why it is that men cannot be made so vast in size that they could "wade through the deep sea" (*pedibus qui pontum per vada possent/transire* L.200-201). He says that this cannot be so, as the reader should clearly be able to see, since "nothing can come from nothing." Since all things must have a material source, as that material source must have an innate limit as to its size, so then must there be limits to *materia* that derive from that source, especially a limit on the *materia* of all things that come from the *materies* (L.203), translated here with the *reddita* (L.203) as "fixed material."

At L.238-240, Lucretius attempts to disprove the idea that all material things can be reduced to absolute nothingness.

Denique res omnis eadem vis causaque volgo
Conficeret, nisi materies aeterna teneret
Inter se nexus minus aut magis indupedita;

"Again the same force and cause would
Kill all things, unless eternal matter
Held them among each other, tangled
More or less in their bonds."

Again, Lucretius is observing another point in question if nothing could indeed come from nothing. If this were so, then all of matter, without any type of distinction (*volgo* L.238) could be utterly destroyed by the same exact force (*eadem vis* L.238), the same exact blow. Matter, Lucretius says, is most necessary, in that, being "eternal" (*aeterna* L.239), it is responsible for holding [all things] (*se* L.240) together (*inter* L.240). If the physical bodies of matter (atoms) did not exist, there would be no bonds (nexus L.240) that could hold physical existences together. If something could come from nothing, then it would indubitable have to have characteristics similar to "nothing." If anything could come from nothing, it would not take much to break it apart by the touch of anything, since there would not be any matter with which to hold it together. In this way, all things must have matter, and matter cannot come from nothing.

The very next instance of *materies* occurs only a few lines later, at l.244-247.

At nunc, inter se quia nexus principiorum
Dissimiles constant aeternaque materies est,
Incolumi remanent res corpore, dum satis acris
Vis obeat pro textura cuiusque reperta

"But now, because the bonds among of the first bodies (elements)
Are unlike and because matter is eternal,
The things remain in the unscathed body, until
Whose texture a force sharp enough to affect the

Texture is found."

Lucretius recognizes for the reader at this point that there are different types of bonds created by different types of elements (*inter se quia nexus principiorum/dissimiles constant* L.244-245). There are different degrees of strength between each bond of different elements, and Lucretius understands this concept. Because different strengths of bonds exist, and because matter is eternal (*aeternaque materies est* L.245), a physical entity (*corpore* L.246) can remain intact (*incolumi* L.246) when certain forces attempt to destroy the physical structure of the body--it takes various forces to destroy various bodies of matter.

Modern chemistry shares (albeit at a more advanced level) Lucretius' idea of the *inter se. . .principiorum/dissimiles constant*. In modern chemistry, there are three different types of chemical bonds, all with varying strengths. It is important to note that all chemical bonds are created as a result of the atomic structure (the sharing of electrons) of the different elements of The Periodic Table of the Elements.

First off, there is the covalent bond. The covalent bond is the strongest of all the bonds and it occurs when only two atoms can perfectly share electrons. One of the most important examples of this which we see in nature is water, chemically called H2O. The next strongest bond (moderate bond) is the ionic bond, which occurs when there is an attractive force from two oppositely-charged ions. The weakest (and probably most complicated) chemical bond of all is the hydrogen bond, which is "formed between oppositely-charged portions of covalently-bonded hydrogen atoms."[3]

Lucretius understood that different materials will have different characteristic strengths—that different forces would be necessary to break them apart. Modern

chemistry supports this theory in that it realizes that the different elements known today have different atomic structures, which in turn cause different outcomes when they interact with other atomic structures of other elements. The varying elements all have varying strengths, according to their atomic compositions, and can all bond to form other compositions with varying degrees of durability.

Lucretius first introduces the reader to the concept of Void at L.330. By l.345, Lucretius once again gives the reader some characteristics of matter by openly disproving the fact that Void cannot exist in matter and in everyday life. For, Lucretius claims, if Void did not exist, then all of matter would be clumped together in one solid mass (. . *.materies quoniam stipata quiesset* L.345). Without Void, without the absence of matter in some areas, things of matter could not move back and forth, but as it is, we can perceive so many things physically moving throughout life (*multa modis multis varia ratione moveri cernimus ante oculos* L.341-342). For matter to be able to move, there has to be Void, an anti-matter of sort.

By L.540, Lucretius has been giving reasons as to why body and void are mutually exclusive. Lucretius writes

> *Praeterea nisi materies aeterna fuisset,*
> *Antehac ad nilum penitus res quaeque redissent,*
> *De niloque renata forent quaecumque videmus.*
>
> "Besides, unless matter had been eternal,
> each thing would have returned utterly to nothing
> by now, and whatever we see would have been
> born from nothing."

Lucretius is again allowing the reader to understand why it is necessary that Void exists. For if there was no difference between definite matte and Void, all things would have

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[3] Information from http://www.bmb.psu.edu/courses/bisci004a/chemtutor/bonding.htm

eventually come to absolute nothing, and from nothing be renewed. Mass has to be eternal, for without such, all things would have returned to nothingness by now.

A few more lines down, Lucretius emphasizes the importance of the role which matter takes in the "renewal" of all things. At l.547. Lucretius states that . . .*materies ut suppeditet rebus reparandis*—"that matter may be used for the restoring of things." There is a cycle that we are to understand here, that for anything to come into existence, there must be enough matter in the world for it to be so. We are to understand the necessity placed upon matter in ours, as well as all things', creation. Without the restorative powers of *materia*, no one could be alive today.

At l.591, Lucretius describes another characteristic of the atoms that constitute all matter:

> . . .*immutabil' materiae quoque corpus habere*
> *debent nimirum.*
>
> "No doubt they ought have a body of unchangeable matter
> (constituent particles) too."

Lucretius here describes matter as being *immutabil*(*is*), that is, "unchangeable, and uses *corpus materiae* to refer to the collective of atoms that compose the body of each living thing in the Universe. By saying that these atoms are *immutabil*(*is*), Lucretius is stating that the most basic element, the "primary seeds" from which all living organisms of a single type come, must indeed be unchangeable in their form and content. Lucretius uses the law of deduction to arrive at the conclusion that all of matter, which comprises the bodies of humans and animals alike, is created of immutable (unfaltering) matter, since there happens to be a limit fixed for the growth of all things (*reddita finis crescendo rebus*, I 584-585), since Nature gives the laws of what each thing may and

may not do (*quid quaeque queant per foedera naturai, quid porro nequeant*, I 586), and since nothing changes (*nec commutatur quicquam,* I 588). Thus these seeds can bring forth a race of creatures with similar characteristics that will never change over time in each individual member's lifetime. Indeed, if the "first bodies"—as Lucretius applies to the atoms of any organism—could simply change at any moment, and at any whim, no one could possibly begin to know what types of strange creatures or even non-living entities could spring forth from the seeds of some other thing. Hippopotami could be birthed by humans, pterodactyls from cats. Sound strange? It did then and it still does now. It all reverts back to the genetic makeup of all creatures. It is the genes (collectively known as the "genome") that give members of a certain species their traits and allow them to look as they do and to utilize their body in their environment as is necessary for their survival. A hippopotamus could never be birthed by a human because the genomes of the two are completely different. Each species has its own vast collection of genes called the genome, and it is impossible for humans to ever have their genome mutate as to become anything like that of the hippopotaml. Although slight mutations can occur in any species' genome (l.e. hippopotami born with lighter/darker-hued skin, and the multiplicity of differences of the human's exterior surface), the genomes of the human and the hippo could never coincide enough for a member of one species to call the other its progeny. So Lucretius' immutable matter (*immutabilis corpus materiae*) confirms the modern biological concept of set cells.

At lines 225-229, Lucretius presents to the reader an if-clause as to the effect that time (*aetas*, I 225) has on all matter (*materiem omnem*, I 226).

> *Praeterea quaecumque vetustate amovet aetas*
> *Si penitus peremit consumens materiem omnem*

Unde animale genus generatim in lumina vitae
Redducit Venus, aut redductum daedala tellus
Unde alit atque auget generatim pabula praebens?

"Besides if time, consuming all matter, destroys from
deep within whatever it removes by age, from where
does Venus restore a living race in terms of species into the
light of life? Or from where does the artistic earth
nourish that which is revived and increases the species, offering
nourishment?"

Lucretius challenges the reader to ponder the source from which Venus is able to restore all animal life (unde *animale genus generatim in lumina vitae. . .redducit Venus*, I 227-228) if time (*aetas*, age) has the potential to utterly destroy all matter on account of age (*vetustate*), and to remove all things from our very sight (*amovet* [*ex oculis*], I 225).

It is interesting to note the third-person usage of Venus. According to the editors William Ellery Leonard and Stanley Barney Smith, Venus again is simply the personification of "sexual energies."[4] This slight reference to Venus as the source of desire for all creatures to ensure their species' survival is then coupled, and almost overshadowed, by the claim that the earth, itself personified as an "artist" (*daedala tellus* I 228) is really the one responsible for the continual nourishment, and increasing of the species. So again, I argue that the goddess Venus is distanced from the whole creative process, not the one responsible for the propagation of *materia*, but that the *tellus* is in fact the real increaser of all species, *daedala tellus. . .auget generatim.*

Lucretius goes on to give several rhetorical questions as to where the sources of certain phenomena exist: from where does the "artistic" earth (*daedala tellus* I 227) supply all creatures (once they are brought back to existence by Venus) with nourishment and make them grow (. . *aut redductum daedala tellus. . .unde alit atque auget generatim*

[4] Leonard, William Ellery and Stanley Barney Smith, eds. De Rerum Natura. The University of Wisconsin

pabula praebens, I 228-229), from where are the seas supplied by the springs within and by the rivers without (*unde mare ingenuei fontes externaque longe flumina suppeditant*, I 230-231)? Lucretius leads the reader into another conclusion using the law of deduction as his reasoning. He states that if things were indeed of a perishable body and if things of the same species or nature still exist today, then those that exist today must surely have their source in the constant recycling of the primary elements from those things have long been "dead." Indeed, by his claim at lines 234-236 in Book I, must their matter (nature) as a whole be imperishable:

> *Quod si in eo spatio atque anteacta aetate fuere*
> *E quibus haec rerum consistit summa refecta,*
> *Inmortali sunt natura praedita certe*
>
> "But if within space and time already having been driven away
> were things from which the sum of things, being made again,
> is set, certainly their nature is eternal."

At I, 248-249, Lucretius applies to *materia* a basic principle of physics, namely the Law of the Conservation of Matter, which states that "matter can be neither created nor destroyed":

> *. . .sed omnes*
> *discidio redeunt in corpora material.*
>
> ". . .but all things
> return into bodies of matter by their breaking-up"

Here Lucretius implies that all mass in existence (in the entirety of the Universe) is constantly being used and reused in the life and death of all things. The bodies of matter (*corpora materiai*) that make-up all of life are constantly decaying (l.e. "when they break apart, *discidio*) and then returning into other bodies of matter (*in corpora materiai* I 249). Even as creatures and people begin to get older, they shrink and look less and less healthy

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Press: Madison, 1965. pp. 197, 228.

because the very constituents of their bodies begin to decay and, having left their body, find another organism elsewhere. With the phrase *discidio redeunt*, Lucretius refers to the pre- and post-mortem decay of the atoms of a living thing's body. The atoms seem to simply leave the dead thing's body, and travel through whatever medium till eventually reaching the source of existence for another thing. The constant reuse of atoms by all living things is a testament to the fact that from death springs life and vice-versa. That matter does decay into the most indivisible constituents is a basic principle of life. These constituents are then mixed with the soil or whatever medium and matter goes back the way it came--from the soil, to the soil. The atoms of our bodies can then be used by the soil, can help to fertilize soil so that plants may grow and supply the air with more oxygen, which humans and all other creatures of earth of course need to live. For Lucretius, then, matter is not only *immutabilis* but is also constantly recycled, with atoms moving from one body to the next.

The editors Leonard and Smith demarcate lines 483-634 as supporting Lucretius' assertion that "primordial bodies are solid, indestructible, and indivisible."[5] In the next several instances of *materia*, which fall in between these lines, Lucretius demonstrates to his readers that solidity, indestructibility, and indivisibility are indeed three more attributes associated with *materia*.

Lucretius discusses this "solidity" of *materia* at L.511-512 and L.516-519, when he describes the actual union of all the primary bodies that form the sum total of a body:

> Praeterea quoniam genitis in rebus inanest,
> Materiem circum solidam constare necessest.
>
> "Moreover, since there is void in created things
> it is necessary that solid matter be around it."

5

(l.511-512)

id porro nihil esse potest nisi materiai
concilium, quod inane queat rerum cohibere.
Materies igitur, solido quae corpore constat,
Esse aeterna potest, cum cetera dissolvantur.

"Nothing is able to be anything unless it
Is a union of matter, which in turn is able to hide the
Void of all things. Therefore matter, which in solid
Body, is able to be everlasting, when other things
Are dissolved."

(l.516-519)

Lucretius introduces here the concept of void (*inane*)--the polar opposite of matter. He claims that there must be void, or emptiness, to some degree in almost all things. For there to be a void in objects, there must also be atoms without void surrounding the void (*inane. . .cohibere*) in these objects. And, with the existence of void, it must be understood that, again, mass must be "everlasting" (*aeterna* L.519), even when all other such objects dissolve away into nothingness (*cum cetera dissolvantur* L.519). A bit further in Book I, under the subheading of *De Molli Natura Aqua Aere Et Ceteris*, or "On the Nature of Softness in Water, Air, and Other Things," Lucretius lends even further support the solidity of the atoms which comprise the four elements of air, water, land, and warmth.

Huc accedit uti, solidissima materiai
Corpora cum constant, possint tamen omnia reddi
Mollia quae fiunt—aer aqua terra vapores—
Quo pacto fiant et qua vi quaeque gerantur
Atmixtum quoniam semel est in rebus inane.

(I 565-569)

"Furthermore, while bodies of matter are most solid,
nevertheless may all things be restored [as things]
which are soft—air, water, earth, heat—in this way
they may become and are born by what force

since void is ever mixed in [these] things."

Lucretius admits here that the atoms (*materiai corpora*) are completely solid (*solidissima*) and that the things which are soft (*mollia*), such as *aer*, *aqua*, *terra*, and *vapores*, are indeed so because of the void that is intermixed within the solid physical entities (*atmixtum quoniam est in rebus inane* I 569).

This is how Lucretius describes the four phases of physical matter in his *De Rerum Natura*—namely solid (much denser *concilium materiai* I 516-517), liquid (much less-dense *concilium materiai* I 516-517), gas (little to no *concilium materiai* I 516-517), and plasma, which he knew nothing about. Solids would obviously contain less of this void because not just anything can penetrate the walls of a solid. In liquid, there exists a greater amount of void between the atoms, but motion in liquid can still be restricted to a greater reduction in speed, since the atoms of liquid are still close together and it still takes some strength to push through them. Gases on the other hand, still have mass, but the atoms are so far between, that practically any moveable object can go through a gas unhindered. Lucretius also wants his readers to understand that all atoms that compose matter contain this characteristic solidity to them. Liquid is not made of softer atoms, and gas of even lighter atoms than water, but these two media just contain a "larger" amount of *inane*, which is clearly distinguishable according to Lucretius (. . .*sunt ergo corpora certa/quae spatium pleno possint distinguere inane* I 526-527).

Of course scientists today know a bit more about the properties of phase changes than Lucretius did. Any website or physics textbook will point out the four phases in which matter can be transformed. We understand today that the properties of the phase changes are based on varying amounts of energy. Solid materials are known to contain

the least of amount of energy. With such a small amount of energy, the particles that make up the solid cannot move fast at all and one particle cannot "push" past another. Plus, in a solid, the particles are packed so close together, that they have virtually no movement at all, but resemble more of a vibration. There is more energy within liquids, and so particles have enough "power" to bump into each other and push other particles farther away. It is precisely this motion that gives liquid the quality to flow. Gas and plasma have the highest amounts of energy. In both of these states of matter, the particles have so much energy, that when they collide, they can push each other so far apart that the attraction between each particle is lost, and so the gas or plasma completely diffuses. Plasma is a little more complicated than gas because it has the highest amount of energy over all. In plasma, the collisions of the particles are so extreme that the electrons are actually knocked off of the atoms, resulting in a gaseous-like state that consists of positive ions and electrons—the basic constituents of atoms, instead of the whole atoms that comprise gases.

Lucretius had no idea of the complexities of atoms—all the protons, neutrons, electrons, quarks, and the energy produced by atoms, atomic energy. All of physics for Lucretius had to be *ob oculo nudo*—naked-eye physics. He understood the fact that all matter was composed of different materials, which we today recognize as the elements from the Periodic Table of the Elements and we can also understand the idea of compounds, which are the combinations of these elements. Lucretius could never describe water as having two atoms of hydrogen and one atom of oxygen, but he knew that he could put his hand in it and move it around unlike solids, which he could not put his hand through at all. Lucretius obviously understood the dichotomy between *materia*

and *inane*, which is his predominant word for "void," and the fact that he could indeed put his hand in water probably led him to think that there must be a certain degree of this *inane* present in water because, although he could put his hand in water, he probably noticed the slight resistance against its movement and so described this resistance in terms of the same particles which make a solid hard, but with a fewer number of these particles. He probably also observed gas at some point in time, and noticed the rather free motion he could have within a gas, and again, using the dichotic formula of mass and void, he described gas as having yet fewer particles than liquid, and many more less than a solid.

At I, 551-555, Lucretius gives the reader proof by deduction that mass can be broken down into particles that are divisible only so far:

> *denique si nullam finem Natura parasset*
> *frangendis rebus, iam corpora materiai*
> *usque redacta forent aevo frangente priore*
> *ut nihil ex illis a certo tempore posset*
> *conceptum ad summum aetatis pervadere finem.*
>
> "In short, if Nature has prepared no limit
> to the breaking of things, already the bodies of
> Matter would be reduced by breaking continuously
> From ages past, so that nothing conceived out of from these things
> These things is able to arrive at the pinnacle of age by a certain time"

Here, he suggests that there is a natural limit (*finem*) to the breakdown of matter (*frangendis rebus*). If these particles of mass could be broken down indefinitely, then, he argues, nothing could possibly be brought into full-maturity of life (*ad summum aetatis. . .finem*) because the particles would be overly degenerated (*usque redacta*). As Lucretius claims at lines 556-557, atoms seem to dissolve from an object "faster" (citius I 556) than to restoring that object again:

nam quidvis citius dissolui posse videmus
quam rursus reficl.

"For what we see is able to be dissolved
more quickly than to be Restored."

If particles were indefinitely divisible, the ever-disjoining particles would continue to dissolve, so two sufficiently developed particles, capable of giving life to an organism, could never meet. *Nihil ex illis. . .posset. . .ad summum aetatis pervadere finem (554-555)*—"nothing could ever achieve the full maturity of life," Lucretius says. How could life propagate when things never mature enough to procreate? All life of flora and fauna would be on a decline if this was the way the constituents of matter function. William Ellery Leonard and Stanley Barney Smith recognize this particular section as being a direct attack on the position of the Eleatics, who believed and taught that all of matter was composed of infinitely divisible particles and that void did not exist, since object was "full" (Leonard/Smith l.551-564 256).

At l.635-637, Lucretius attacks the Heraclitian theory that the constituents of all matter consist of the same elements as fire.

Quapropter qui materiem rerum esse putarunt
Ignem atque ex igni summam consistere solo,
Magno opere a vera lapsi ratione videntur.

"Therefore, whoever thought that the material
Of things is fire and that the whole sum consists
of fire alone, seem to have slipped from true reasoning
from a great work."

Lucretius openly berates all of those people who adhered to Heraclitus' belief that the very elementary particles that constitute matter are made of fire (. . .*materiem rerum esse. . .ignem atque ex igni summam consistere solo* L.635-636). He argues throughout l.635-

704 for several reasons as to why fire in and of itself cannot possibly be the very material substance from which all things are created. Fire cannot (1.) produce anything else except for fire—it has no generative bodies, (2.) Heraclitus denies the very existence of void, in which case fire could not possibly be as dynamic as it is without it, (3.) fire ultimately changes into other forms, such as heat, in which case it is then used up and destroyed and so, if all things were composed of fire, all things would change into nothing and then from nothing would all things be created—since this is not true, things cannot be made of fire, (4.) some things must be permanent (unlike fire) or else all things will be reduced to nothingness, and lastly, that (5.) this theory completely defies sense perception, which in Lucretius' time, was really the only way to discover the truth.

Lucretius clearly explains for the reader why basic elements found in nature could not possible have their atoms as the standard atom from which all of matter is derived at l.628-634.

> *Denique si minimas in partis cuncta resolvi*
> *Cogere consuesset rerum natura creatrix,*
> *Iam nil ex illis eadem reparare valeret*
> *Propterea quia, quae nullis sunt partibus aucta,*
> *Non possunt ea quae debet genitalis habere*
> *Materies, varios conexus pondera plagas*
> *Concursus motus, per quae res quaeque geruntur.*
>
> "Finally, if nature the maker of things was accustomed
> To force all things, to be resolved into the smallest
> Parts, already nothing would be strong enough to
> Restore itself from these [elements]. Therefore, because
> Things which are increased from no parts, are not able
> To have the matter what generative matter ought to—
> The variations, connections, weights, blows, combinations,
> Motions, through which things are born."

The most basic unit of matter, the atom, must be capable of propagating its own existence, and atoms of such natural elements like water, fire, air, et cetera do not have

the necessary qualities for doing thus—variations (*varios* L.633), connections (*conexus* L.633), weights (*pondera* L.633), blows (*plagas* L.633), unions (*concursus* L.634), and motions (*motus* L.634).

First off, he claims that things which seem so complex in their nature could not possibly come from a substance whose very nature seems so "pure and simple."

> *Nam cur tam variae res possent esse requiro,*
> *Ex uno si sunt igni puroque creatae.*
> (l.645-646)
>
> "For I would like to know how things can be
> different, if they were created from fire sole and pure."

This first argument is in defense of the *varios* of l.633 that are necessary for the propagation of any type of matter. For if fire, being a natural element, is so pure (*puroque* L.646), and single (*uno* L.646), then there could be no possible way it could generate (propagate) more of itself, as it is breaking the first necessity of any generative substance.

The second argument Lucretius uses against Heraclitus and his followers' belief that fire is the elementary substance of all things has to do with the containment of void. Lucretius already demonstrated to the readers at l.565-569 of his poem that void (*inane*), which he uses again here at l.655, must be contained within all things—especially fire, which would be much denser and solid-like. Lucretius captures this point sarcastically at l.655-656:

> *Id quoque, si faciant admixtum rebus inane,*
> *Denseri poterunt ignes rarique relinqui*
>
> "There is this too, if they should make it that

Void is mixed within things, fires
Would be able to be dense, and to
Remain rare."

Nec rursum cernunt exempto rebus inani
Omnia denseri fierique ex omnibus unum
Corpus . . .

"Nor do they perceive again that when void
Has been taken from things, all things become
Condensed, one body from all [bodies]."
(L.660-662)

Lucretius aims to break Heraclitus' credibility, but illustrating this point to the readers. For who has ever seen a fire with the same characteristics as a solid? *Denseri poterunt ignes rarique relinqui* (L.656) Lucretius says, and since it IS in fact not possible, void must exist in fire, as it does in most all things.

Lucretius next attempts to defy Heraclitian logic at l.665-669 by stating that if fire changes into something else, it is completely destroyed.

. . .potesse
ignis in coetu stingui mutareque corpus
scilicet ex nulla facere id si parte reparcent,
occidet ad nilum nimirum funditus ardor
omnis et e nilo fient quaecumque creantur.
". . .fires can be extinguished in their union
and change their body (mass) if they evidently
spare to do it from no part, all heat will utterly
fade into nothing no doubt and out of nothing will
be made all things that are created."

Lucretius is no doubt referring to the idea that, when flames rise and give off heat, the heat can only last so long. In this way, the particles of heat fade away, and the very nature of fire is overly dynamic in this aspect—how can planets, people, all of matter, be made of a substance which has the capacity to fade away into pure energy the near-

second it is created, into heat, the same of which is never to exist again? Lucretius was correct when he "all heat [emitted by a fire] will utterly fade into nothing" (L.668-669).

First of all, all fires can be described as a continual and rapid process of oxidation, which in turn is the chemical process of combining oxygen with a material. When a fire is burning anywhere or anything, it is constantly absorbing oxygen from the air, which it needs in order to remain burning. As the temperature of a fire increases, so does the rate of oxidation and the heat of the fire. Pyrolysis is the name given to the process of the chemical decomposition of the matter or material that occurs with the heat generated by the fire. It is during pyrolysis that smoke, filled with various chemicals, depending on the material, is released.[6]

Modern science certainly recognizes the complexity involved in the physics of fire. Even today, we still have much to learn about the very mechanics involved with the creation and process of fire. An experiment by physicist Paul Ronney aimed to study the nature of fire by placing it in the context of space. His experiment took place in an aluminum cylinder about one-foot across in orbit and containing gas (five-percent hydrogen). What he discovered in this gravity-less atmosphere were tiny, perfect spheres of fire about one-third inch in diameter and just floating sporadically around the chamber. Neither Ronney nor any of his physicist comrades could fully describe this newly-discovered phenomenon, but if they can fully understand what Ronney calls "the simplest possible flame," they hope to eventually develop leaner-burning and less-polluting internal combustion engines.[7]

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[6] Basic information from www.usace.army.mil/publications/ armytm/tm5-315/chap3.pdf. Information seems to be arranged in a textbook format.

[7] Kunzig, Robert. *The Physics of Fire: Infernal Combusion.* Discover Vol. 22, No. 1 (January 2001). Information found at http://www.discover.com/jan_01/featphysics.html

If Heraclitus is correct in his theory that fire underlies all matter in the Universe, then he has disproved one of the grand credos of the *De Rerum Natura*—that nothing can come from nothing (. . .*et e nilo fient quaecumque creantur* L.669). Since all heat that is produced from fire fades too rapidly, then all things that are produced must come from nothing, since matter has to first exist before it can bring about existence. Heraclitus' theory would undermine all of existence as Epicureanism (and infallible logic) understand it, and thus Lucretius has no problems in demonstrating the fallacy of Heraclitus' theory.

The very next instance of *materia* in Book I comes at l.705-706, where Lucretius transcribes verbatim l.635: *Quapropter qui materiem rerum esse putarunt/ignem atque ex igni summam consistere posse. . .*—"therefore, those who thought that fire is the material of all things of that the sum [of all things] can be from fire. . ." For this instance, Lucretius has more in mind then just negating that fire is the underlying substance of all matter. Lucretius argues now that all elementary substances, including fire, air (*aera* L.707), water (*umorem* L.708), or earth (*terramve* L.709), cannot be the basis for all matter in the Universe, nor can any of these elementary substances be coupled or placed all together to form the basis for all matter:

> *Magno opera a vero longe derrasse videntur. . .*
> *. . .qui conduplicant primordia rerum,*
> *Aera iungentes igni terramque liquori,*
> *Et qui quattuor ex rebus posse omnia rentur*
> *Ex igni terra atque anima procrescere et imbrl.*
>
> "They are seen to have deviated far from the truth. . .
> . . .whoever couple the first-beginnings,
> Joining air with fire or earth with water,
> Or those who think that all senses can be produced from
> From the four elements, from fire, land, and also liquid"

Lucretius now attacks the views of Empedocles, who holds that all matter was indeed created from all four of the elements. Lucretius argues with the same logic that he utilized against Heroclitus. Lucretius argues that Empedocles and his followers deny the existence of void (*exempto. . .inani* L.742), place no limit on the number of divisions that the *primordia rerum* can undergo (. . .*finem non esse secandis corporibus faciunt* L.746-747), they do not attribute the atoms of things as being solid, but rather "soft" (*primordia rerum mollia* constituent L.753-754), their atoms (elements) are mutually destructive, warring with and canceling each other out (. . .*inimica modis multis sunt atque veneno ipsa sibi inter se* L.759-760), and if each of the four elements can remain in harmony in their union, they would not be able to produce anything, since anything produced would have characteristics of each element, and all would be mutually contradicting.

The next instance of *materia* is at line 916, when Lucretius uses *corpora materiai* in his methodical literary devices, the *reductio ad absurdum,* which is best translated as "restoration towards something silly."

> . . .*si fieri non posse putas, quin materiai*
> *corpora consimili natura praedita fingas. . .*
>
> "If you don't think [this] can be, without supposing
> that bodies are endowed with a nature of similar matter. . ."

In this instance, *materiai* is used with corpora to denote the total system of atoms that consists of some physical entity. I believe that we are to understand *putas* (I 916) and *fingas* (I 917) as appositional statements addressed to Memmius. At line 916, Lucretius

points out that Memmius "falsly" (Leonard/Smith l. 917 288) imagines that atoms are "endowed with a similar nature," especially when he does not think it possible after Lucretius has explained it through the example of wood and fire.

At I, 984-987, Lucretius uses *copia materiai* to again refer to the complete mass of atoms in the Universe in his defense of the Universe's infiniteness.

> *praeterea spatium summai totius omne*
> *undique si inclusum certis consisteret oris*
> *finitumque foret, iam copia materiai*
> *undique ponderibus solidis confluxet ad imum. . .*
>
> "Besides if all space of Universe would stand enclosed
> On all sides by certain boundaries and was limited,
> By now the entirety of matter would flow together
> To the bottom with solid weights on all sides."

In this argument, Lucretius creates a finite, box-like Universe. He explains to the reader that the vast store of mass (*copia materiai*) would have run together from all sides (*undique* I 985) of this Universe. Because of its sheer weight (*ponderibus solidis* I 987), it would have already collected on the bottom (*confluxet ad imum* I 987) and engulfed all of earth and sky. This would of course happen only if the Universe was finite (*finitumque foret* L.986). He explains this further at L.988-991:

> *. . .nec res ulla geri sub caeli tegmine posset,*
> *nec foret omnino caelum neque lumina solis,*
> *quippe ubi materies omnis cumulata iaceret*
> *ex infinito iam tempore subsidendo*
>
> ". . .Nor could any thing under the roof of heaven be
> managed and neither would the sky altogether be nor
> the light of the sun, where all matter would naturally
> be lying, having accumulated already, having sunk
> down from infinity."

Nothing could exist, not even the *lumina solis* because everything would be completely meshed together. As it is, though, space is infinitely vast, and the bodies of "first-beginnings" must be in continual motion and matter must be supplied from the bottom of the infinite Universe, as nothing is obviously collecting at the bottom and anything released upwards into the air is bound to come down.

These passages in Book I thus reflect Lucretius' general understanding of how gravity works—a concept the poet develops more in Book II . Lucretius seems to apply this "what-goes-up-must-come-down" understanding of gravity to the enigmatic workings of the deep Universe. Since all the matter that is simply "out there" does not come and smother us all, it must be that the atoms themselves are in constant motion, are constantly being thrown up and around, so as to never come down.

Lucretius' image of the "elements of matter" being supplied from beneath (bottom of the Universe) suggests to me a "water-fountain-like" analogy. Lucretius seems to have in mind some type of fountain, in which water is shot into the air by some force, only to come crashing down to the earth again. I propose that Lucretius is imagining a jet-stream of matter's elements being propelled upwards from infinity into the "higher" regions of the Universe. However, because these elements never come crashing down to the bottom of the "box," there must be some incessant motion characteristic of them.

> *semper in adsiduo motu res quaeque geruntur*
> *partibus e cunctis, infernaque suppeditantur*
> *ex infinito cita corpora materiai*
> (I, 995-997)

> "Some things are always born in constant motion
> From all parts, and the bodies are supplied, rushing
> From infinity."

Lucretius explains that the Universe is plagued with constant motion *ex infinito*,—within the infinitely deep recesses of space, and postulates even further, claiming that space must be infinite since the elements do not come crashing down.

As living humans in the age of space exploration, we may find it easy to identify the errors in Lucretius' thinking. We know that it is not the actual motion of the objects (I'll call them this because we know single atoms are not just flying about by themselves) that seems to be keeping them aloft, but rather a force Lucretius knew little about called "gravity." It is the force of gravity that is able to keep all the celestial bodies in place or in motion. The planets, stars, meteors all get their motion and stay in perfect balance because of the force of gravity—a force that sort of holds the entire Universe together. Of course, there are oddities in space that Lucretius could never have dreamed of, and that we can only begin to fathom with our modern tools for space exploration. Only now are we beginning to grasp the concept of enigmas like black holes and quasars, but we're still extremely limited in our knowledge. We know for a fact that no space-shuttle of any sort will be able to study the inner workings of a black hole, lest the gravitational force of the black hole drag it into its dark oblivion.

At I, 1014-1020, Lucretius further explains why *copia materiai* could not be finite:

> *nec mare nec tellus neque caeli lucida templa*
> *nec mortale genus nec divum corpora sancta*
> *exiguum possent horai sistere tempus.*
> *nam dispulsa suo de coetu materiai*
> *copia ferretur magnum per inane soluta,*
> *sive adeo potius numquam concreta creasset*
> *ullam rem, quoniam cogi disiecta nequisset.*

"Neither sea, nor earth, nor light-filled regions

of the sky, nor mortal kind nor sacred bodies
of the gods can stand the small time of an hour.
For the sum of matter is born, dispersed from
Its own union, dissolving through the great
Void, or nothing, having been so compounded,
Would ably create any thing, since, having been
Dispersed, it could not be gathered."

Many scholars, including Leonard and Smith[8], suggest that a lacuna before line 1014 contained an "if"-clause in which Lucretius questioned the finite nature of matter. "If matter was indeed finite", Lucretius argues, no entity on land, sea or sky (I 1014) could last for any length of time (*exiguum...tempus,* I, 1015). The atoms necessary for the production and existence of any body would, after breaking away from its initial union and body by its own motion (*dispulsa suo de coetu*, I, 1017) rush throughout space (*materiai copia ferretur*, I, 1017-1018), disintegrating (*solvata*, I, 552) [to nothingness]. Basically, Lucretius is stating that the atoms from one entity's body could never be reused by another's, since the atoms, being finite, would simply disappear through the infinite abyss (*magnum per inane*, I, 418), never to seen or heard of again.

As far as we know today, there is as much matter in the Universe today as there ever was, because neither matter nor energy (which Einstein later proved were synonymous) can neither be created nor destroyed. Matter can change its physical properties, but there will always be the same quantity in the end. There are of course some exotic theories that may violate this theory, but as far as all of humanity knows and as far as the general theories of physics today are concerned, this holds true. To the human mind, matter is infinite because space seems not only infinite in size now, but we

[8] Leonard, William E. and Stanley Barney Smith, eds. *T. Lucreti Carl. De Rerum Natura*. Madison, Wisc.: The University of Wisconsin Press, 1965, pg. 296-297.

have learned that it is constantly expanding. How far exactly will space expand, we can only begin to hypothesize. We just do not know.

At line I, 1021-1037, Lucretius discourses on the beginning of the Universe and how it is that the atoms function as they do. He views the first-beginnings (*primordia rerum*, I, 1021) of all particles of the Universe as on an evolution-track, perhaps similar to flora, fauna, and humans. The Universe began as random and chaotic, which is suggested in the following quote, from I, 1021-1025:

> *nam certe neque consilio primordia rerum*
> *ordine se quo quaeque sagaci mente locarunt*
> *nec quos quaeque darent motus pepigere profecto,*
> *sed quia multa modis multis mutata per omne*
> *ex infinito vexantur percita plagis*
>
> "For certainly the first-beginnings of things
> placed not themselves in a useful union nor order
> with a sagacious mind, nor did they produce
> to stipulate what motions, but because many things
> having been changed in many ways were being
> tossed about, having been provoked by blows
> throughout the All, from infinity."

Here, Lucretius says that the very beginnings of things (*primordia rerum*, I, 1021) never positioned themselves with any type of plan (*consilio*, I, 1021)) or in any order (*ordine*, I, 1022) with the utilization of a "wise mind" (*sagaci mente*, I, 1022). All particles in the very beginning never had a cosmic law by which they functioned, but rather, without the use of a *sagaci mente*, moved about until they just "fell" into the current arrangements of which our Universe now consists.

> *Omne motus et coetus experiundo*
> *. . .tandem deveniunt in talis disposituras*
> *qualibus haec rerum consistit summa creata. . .*
> (I, 1026-1028)
>
> "By experiencing all motions and unions
> . . .finally they fall into such positions

this sum of things having been formed
remains among such kinds."

After every motion (*omne. . .motus* I 1026) and every combination (*omne. . .coetus* I 1026) of each particle in the Universe had been made, each particle began to find and prefer "such placements" (*in talis disposituras* I 1027) and combinations which eventually led to the seemingly perfect balance of the Cosmos. This is very similar to Chaos Theory that we might have heard of today.

Manus J. Donahue III, a former student at Duke University wrote an award-winning essay in the Fall of 1997 that discusses the elementary mathematical basis for Chaos Theory. This essay defined Chaos Theory as "the qualitative study of unstable, aperiodic behavior in deterministic nonlinear dynamical systems."[9] Chaos theorists today tend to use computer-generated charts in examining the behavior of many things in nature that occur aperiodically—that is, natural systems and occurrences that are impossible to predict. Today, we can recognize innumerable natural systems that are of particular interest to the Chaos theorist. Such systems can include weather patterns, snowflake structure (of all the billions/trillions of snowflakes that have fallen throughout the world and throughout history, not one of them is said to have the same, identical structure as another), the stock market, fluid dynamics, et cetera.

We recognize Chaos Theory today as having a role in the creation of our Universe, during the pre-big bang "time." Perhaps the point of singularity that was the primeval atom from which the "big bang" occurred was created from what we can only call "chaos." Perhaps all the motions of the planets, stars and every other celestial body or non-body are governed by that initial chaos. Perhaps chaos is the answer to why the

Universe is as it is, unless individuals substitute chaos with God, or whatever religious figure they feel better explains the meaning of universal existence. What Lucretius postulates here to be true, that the initial particles had to first try *omne motus* and *omne coetus* before they could arrive at a perfect system we now know as the Cosmos is, in fact, comparable to the Chaos Theory of today.

Though Lucretius does not go into depth, the idea of particles randomly trying every type of motion possible, as well as every combination with every other particle gives the reader a feeling of the instabilities between them and the "chaos" found in nature at the very beginning of time. We have collected a lot of data using the most modern advances in scientific equipment. Satellites have been used as cosmic x-ray detectors outside of our atmosphere and studies in the detection of the red-shift in wavelength of cosmic rays have given us greater evidence of the big-bang theory of creation, which states that a point of singularity, no bigger than an atom, exploded out of what can only be imagined as "Chaos." Of all the possible outcomes that could have resulted from the initial Chaos, Lucretius' *primordia rerum*, the seeds of a great Universe were created near-instantaneously. The reasons for this have been the brunt of many scientific debates, and have usually been attributed to God. Though we do have much scientific evidence to lend great support to the big-bang theory (and its chaotic source), much of the theory still lies in pure speculation and imagination. We have most certainly begun to solve the mystery of the creation of humanity and the Universe, but by no means are we completely there yet.

I will now give a more in-depth account of the theory underlying the "big bang." First of all, the big bang theory understands the Universe as being the size of an atom

[9] From the Duke University Web Site, http://www.duke.edu/~mjd/chaos.html

initially, which then suddenly "exploded" from chaos (mentioned earlier) and with this explosion came the tiniest, most indivisible particles that we can identify (or theorize of) today such as electrons, protons, quarks, etc. From the expanding and eventual cooling of the "baby" Universe, came the enabled combinations of these indivisible particles into the more complicated atoms of hydrogen and helium. Gravity brought together massive amounts of hydrogen and helium atoms to form the beginnings of galaxies and also brought together smaller amounts of hydrogen and helium to form the first stars. It is not until the death and decay of the first stars that we see the introduction of the heavier elements, which are necessary for all forms of complex life, into existence.

Perhaps everything did happen randomly in the beginning to eventually lead to the creation of all physical entities and their physical properties today. It is the perfect balance of the non-living Universe that not only gave rise to the ever-evolving human race as well as all flora and fauna, but is also responsible for their continued existence. Lucretius does not seem to ever postulate how these "first-beginnings" (*primordia,* I, 1021*)* came into existence. He never theorizes about a "big-bang-like" explosion of life, but in Book V, discusses the construction of all that we know as earth and sky as simply an "assemblage of matter"—*coniectus materiai*, V.416. For the sake of order and simplicity, I will discuss this in greater detail later. For now, in Book I, Lucretius simply refers to the very first indivisible bodies, *primordia*, as the "first-beginnings" of bodies with their own will to attempt every kind of motion and every combination with other particles and from which descend the entire *copia materiai* of the Universe.

At lines 1031-1036, Lucretius discourses on life as being continuously renewed and given to all types of flora and fauna, because the apparently infinite store of matter from deep within the infinite Universe:

> *Efficit ut largis avidum mare fluminis undis*
> *Integrent amnes et solis terra vapore*
> *Fota novet fetus, summissaque gens animantum*
> *Floreat, et vivant labentis aetheris ignes.*
> *Quod nullo facerent pacto, nisi materiai*
> *Ex infinito suboriri quopia posset*
>
> "It happens that the rivers renew the greedy
> sea with waves of the stream and the earth,
> nourished by the heat of the sun, renews its
> produce, and a stock of animals rises and flourishes,
> and the slipping fires of the ether live.
> But that do [these things] in no way, unless
> The sum of matter can rise from infinity."

Lucretius presents certain creations of this Universe that would not otherwise be unless there existed an infinite store of matter that could arise from deep in the Universe (*nisi materiai/ex infinito suboriri quopia posset* I 1035-1036). Rivers could not replenish the greedy sea (. . .*avidum mare fluminis undis integrent amnes* I 1031-1032), the heat of the sun could not keep being reused to replenish the earth (. . .*solis terra vapore fota novet fetus* I 1032-1033), a humble race of living things (. . .*summissaque gens animantum* I 1033), and the fires living in the "slipping aether" (. . .*vivant labentis aetheris ignes* I 1034). According to Lucretius, not one of these entities—the flowing rivers, or any living thing—could exist without the *materiai ex infinito suboriri quopia posset* of I 1036. Matter must somehow "arise" (*suboriri* I 1036) from deep within Infinity and must be used in order to propagate all of life, as well as natural phenomena such as flowing rivers. Lucretius' use of suboriri seems to contradict his earlier phrase in Book I, lines 155-156 that . . .*nil posse creari de nilo*—that "nothing is able to be created from

nothing." Lucretius is well aware of this concept he argued earlier--since nothing can be created from nothing, and since there is a constant need of replenishment for all flora, fauna, and natural phenomena in the world, that there can be no other way than for the *quopia materiai* to be infinite.

Lucretius furthers this argument at lines 1039-1041, when he claims that there would be no way things, living or not, could have continued existence if matter [*ex infinito*] was no longer replenishing them.

> *. . . sic omnia debent*
> *dissoluei simul ac defecit suppeditare*
> *materies aliqua ratione aversa viai*
>
> "Thus all things ought to dissolve
> As soon as matter, turned from the path
> For some reason
> Is ceased to be supplied."

All matter is composed of atoms which are constantly being shot throughout space and constantly form unions to form matter. Otherwise, if atoms are no longer supplied from the "infinite stores," if they can no longer form unions, then all things will eventually decay, as they are wont to do naturally, as Lucretius mentions in 1039-1040: *sic omnia debent/dissoluel.* . L.1039-1040.

Lucretius imagines these "stores" of the infinite amount of matter at lines 1049-1051:

> *Quare etiam atque etiam suboriri multa necessest*
> *Et tamen ut plagae quoque possint suppetere ipsae*
> *Infinita opus est vis undique materiai*
>
> "Therefore again and again, it is necessary that
> They rise, being many in number, indeed
> That in order for those blows to be able to be supplied
> It is necessary that there is an infinite store of matter
> On all sides [of earth]."

The editors Leonard and Smith tell us that the *multa* of line 1049 is to understood as modifying an omitted *primordia*.[10] Lucretius parallels this passage with his earlier argument at line 1036 when he claims that "it is necessary that the sum of matter arises [*ex infinito*]." Lucretius employs two different grammatical models in lines 1049 and 1051 to give the reader a feeling of necessity for how the actual existence of atoms "arise (*suboriri multa [primordia] necessest* L.1049) and the need for the *primordia* to be infinite in number (*infinita opus est vis undique materiai* L.1051) on all sides of the planet in order to comprehend the number of atomic collisions (*plagae* L.1050) that are supplied (*suppetere* L.1050). Lucretius identifies here that the store of matter must be infinite. The word that Lucretius uses as the modifier "store" for *materiai* is *vis*, which is quite interesting in lieu of the multiplicity of definitions for *vis*. By using *vis*, Lucretius identifies *materia* not as just being infinite in terms of its number, or quantity, but this word also implies an infiniteness of the power, strength, influence, and force of *materia*. The force of *materia*, the very innate power (and number) of *materia*—especially on all sides of the planet (*undique* L.1051) is here the very binding force which holds the planet and life together. As Lucretius mentioned earlier, without *materia* and the constant supply of, all things would dissolve [into nothingness] and life, as we know it, would cease.

Lucretius also claims in L.1051 that the stores of matter which are "on all sides" (*undique*) of the planet must be infinite, that the number of atoms which pelt the world and form unions of matter are continuous. To understand this more clearly, we must examine lines 1042-1048:

Nec plagae possunt extrinsecus undique summam
Conservare omnem, quaecumque est conciliata.
Cudere enim crebro possunt partemque morari
Dum veniant aliae ac suppleri summa queatur.
Interdum resilire tamen coguntur et una
Principiis rerum spatium tempusque fugai
Largiri, ut possint a coetu libera ferrl.

"Nor can the blows on the outside preserve
The whole thing, which is has been formed
[By unions]. For they are frequently able to
pound and delay part while others come
and so the whole thing can be supplied.
Meanwhile however they are forced
To recoil and so are able to grant the beginnings
Of things space and time to escape so that
They can be born, free from their union."

Lucretius uses this argument to confirm his view at lines 1049-1051. Indeed, simply supplying matter from all sides would not be enough to hold any word together (*nec plagae possunt. . .undique summam conservare omnem. . .*L.1042-1043). Indeed, even during a "continual" (*crebro* L.1044) onslaught of atoms, one part of the surface area of the world might experience a delay (*partemque morari* L.1044), and so give the "first beginnings of things (*principiis rerum* L.1047), which are already united in a union to form *materia*, the time and space (*spatium tempusque* L.1047) to escape (*fugai* L.1047). Since everything is clearly replenished constantly, this cannot be true, and so other atoms (*aliae* L.1045) must come (*veniant* L.1045) and thus can supply the whole of the world (*suppleri summa queatur* L.1045). This is the very logic Lucretius utilizes to prove to his reader that the "quantities," or "stores" of matter of l.1051must be infinite.

[10] Leonard, William E., Stanley Barney Smith, eds. T. Lucreti Cari, De Rerum Natura. The University of Wisconsin Press: Madison, 1965, pg. 300

The very last occurrence of *materia* in Book I occurs at lines 1111-1113, when Lucretius says

> *Nam quacumque prius de parti corpora desse*
> *Constitutes, haec rebus erit pars ianua Leti:*
> *Hac se turba foras dabit omnis material.*
>
> "For in whatever part you assume the bodies
> to fall short previously, this direction will be
> the door of ruin of things."

At this point, Lucretius has used his logic to disprove two theories: (1.) matter does not tend toward the center and (2.) matter does not disperse on all sides, completely away from the center. Lucretius employs lines 1111-1113 as the concluding statement on the invalidation of this second theory. He stated earlier, at lines 1102-1104 that, if matter was to disperse on all sides,

> *Ne volucri ritu flammarum moenia mundi*
> *Diffugiant subito magnum per inane soluta*
> *Et ne cetera consimili ratione sequantur. . .*
>
> "[If fire and air have a tendency to move upward][11]
> not even the walls the of world would disperse
> dissolved throughout the great Void
> as in the manner of flames and the rest follow
> in a similar procedure."

Lucretius uses the earth as his example for why this second theory cannot stand. If matter was really to tend to disperse right away (*subito* L.1112), then the earth, which Lucretius has proved a plethora of times to be composed of atoms, the very basic constituents of matter, would have dispersed long ago, upon its creation. Since humans

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[11] Lucretius, Titus Carus. De Rerum Natura. trans. W.H.D. Rouse. The Loeb Classical Library: Harvard University Press: Cambridge, 1975. pp. 90-91. The brackets of my English translation denote the lacuna of l.1101, of which there are eight lines total (l.1094-1101). The translation in the bracket comes directly from the translation of W.H.D. Rouse in the Loeb Classical Library edition of Lucretius' *De Rerum Natura*.

and all living creatures exist, is proof enough that matter does not disperse once in contact with other matter. The fact remains that the "walls of the world" (*moenia mundi* L.1102) are nothing like the flames (*flammarum* L.1102), in that the earth is held together, because the constituents of matter are solid (*solidissima materiai* L.565) and also form unions (*concilium* L.517).

Lucretius had set himself to the task in Book I to prove several different theories of the mechanical properties of matter, each theory dealing with rather broad and dichotomous concepts of matter. He wanted to demonstrate for his readers that (1.) Substance (mass) is eternal (l. 146-328); (2.) that Void exists apart from matter as well as within it (l. 329-417); (3.) that substance (mass) and Void are the constituents of the Universe (l. 418-448); (4.) that all things exist as a result of either an essential reason or by some cosmic accident (l. 449-482); and (5.) that the *primordia corpora* ("first-bodies, atoms) are solid, indestructible, and indivisible (l. 483-634). Lucretius littered his *magnum opus* with everyday, commonsense logic that he could only obtain empirically in order to prove these concepts attributed to "substance" and delivered his ideas in a poetic format.

But how relevant is Lucretius' concept of *materia* in Book I to modern theories on the mechanical properties of matter? After examining every instance of *materia* in Book I of the *De Rerum Natura* and how Lucretius' ideas on the mechanics of matter and the very constituents of matter work, I feel that Lucretius was on a similar wavelength as modern science in many ways. None of his statements about *materia* in Book I blatantly contradict modern scientific theories, although his poetry often lacks the true empirical data, which is, of course, so important to modern scientists. Lucretius did not know

about cells and cell-reproduction, but he still attributed what we now know as cells to simply "bodies of matter," which seem to then grow (*grandescere*, I, 191), such as plants from the ground. He had an intuition that the Universe and the mass contained therein were infinite and that mass was kept aloft in space. He knew that different materials found in everyday life had to be destroyed with varying forces—the same force needed to tear a papyrus would do nothing in breaking a shield or sword.

For Lucretius—and those who adhered to Epicureanism (and logic)—*materia* is the substance of which all things are made and is endowed with characteristics that are conducive for the existence of all things. Matter must be eternal—if matter was not eternal, then everything as we know it—all that we can perceive with our senses--could not exist as it is. Lucretius entrusts the readers to realize that, contradictory to what other prominent scientists/philosophers have thought of in the past, Void (*inane*) does exist—it is the absence of *materia*, and is most necessary for *materia* to function. Thus, the Universe is composed of nothing but *materia* and *inane*, the dichotomy of existence. One cannot exist without the other.

Between L.483-634, Lucretius gives several defining characteristics of *materia*. *Materia* (being composed of *primordia rerum* l.483) is solid (*solido. . .corpore* l.486) and indestructible (*nulla potest vis/stinguere* l.485-486). Here Lucretius also tells us that all *materia*, the whole "sum of things" is created (*unde omnis rerum. . .summa creata* l.502) from *materia*, also known as the "seeds of things" (*semina. . .rerum* l.501) and the "first-beginnings" (*primordiaque* l.501).

Lucretius has also proven to that the Universe is boundless in respect to its size. For, is space were finite, all matter would have collected on the bottom, and would have

smothered the world out of existence. Space must be infinite in size, as matter itself is also infinite. Creation would have been impossible if matter was finite, since the *copia materiai*, which makes up all of creation—even of the sacred bodies of the gods (*divum corpora sancta* l.1015)—would never compact enough to form anything (*numquam concreta creasset ullam rem* l.1019-1020). For this, an infinite store of matter is needed to preserve the world and the Universe.

Lucretius' *materia* has a lot in common with our concept of matter today: it was indivisible at some point, as we surely believe quarks (the tiniest unit of mass known) are, it was indestructible (conservation of mass), and it was infinite (though we do think that there is a set amount of energy (and thus mass) in the Universe, in terms of our puny understanding, it IS infinite), and mass was eternal. For without matter, there can be no reality--all things must be composed of matter. That is how the infallible laws of physics and existence work.

While modern scientists may be quick to dismiss his scientific reasoning, Lucretius' thought patterns and logic can still be appreciated today in scientific as well as poetic contexts. Although his theories cannot entirely be accepted as fact today, we can still praise his extraordinary and uncannily perceptive understanding of the nature of matter.

Appendix:

Brief Study of Each Instance of *Materia* Throughout the *De Rerum Natura*

Materia, Materie

Book I, l. 191
". . .Quidque sua de materia grandescere alique. . ."

Materia is in the ablative here, used with the preposition "de," best translated as "from" in this case. Lucretius is describing the phenomenon in this instance in which whatever "something" has the power to grow or "increase in size" (grandescere) from its own **material** elements, or matter. "Materia is here used as a collective noun standing for "primordia," or "beginning/first things" (elements). Therefore, materia is reminiscent of solid matter consisting of elements and atoms, consistent with scientific viewpoint today. Grandescere is also a word used in terms of agriculture, specifically in terms of the growing of crops.

Materiae

Book I, l. 591
". . .immutabili' materiae quoque corpus habere. . ."

The "materiae" of this line is used in the Genitive case, and is modified by the adjective "immutabili'. The use of the Genitive indicates a quality of the body (corpus) described, it being a "body of unchangeable matter." Lucretius is using immutabili' to reach an understanding with his audience that all creatures of the same type of species is going to be composed of the same type of elements, or matter. The viewpoint that materia is a collective of "primordia," a collective of these "first" elements is again applicable here. Thus, immutabili' is an adjective given to materia to understand that materia is one of Nature's constants, something that cannot be simply changed.

Book II, l. 425
". . .non aliquo sine materiae squalore repertast."

Here materia is once again accounted for in terms of the total constituency of atoms composing whatever material object. In this context, Lucretius is making the assertion that whatever is found in Nature to be rough or harsh is "not without this same characteristic roughness in its material elements."

Book II, l. 550
". . .materiae tanto in pelago turbaque aliena?"

Materiae is here used in the Genitive singular and is modifying the "pelago." The image being conveyed here is whether there be a possibility for an object to be made completely

unique, the only one of its kind, and thus formed from any and all the matter in a chaotic, sea-like existence.

Materiai

Book I, l. 249
". . .discidio redeunt in corpora materiai."

Leonard and Smith claim that the technical definition for "discidium" needs to be employed here, that is "breaking up." Lucretius is again denoting the elements that make the materialistic world as being composed of "corpora materiai." Here, he is referring to the eventual decaying of everything, stating that any object with super complex atomic formations will eventually "return" to its basic elements, its corpora materiai.

Book I, l. 516
". . .id porro nil esse potest nisi materiai [concilium]"

The "concilium" is actually the first word found in the next line (l. 517). This is a general word for "council" or "meeting," but we're told in Leonard and Smith's commentary that we should use the technical meaning, which is "union." This is another statement used by Lucretius to add reasoning to his assertion that only bodies of solid "matter" could possibly hold any "void." For there to be void in something and for something to conceal this void, there must be something without void surrounding the void, some "union of matter."

Book I, l. 552
". . .fragendis rebus, iam corpora materiai. . ."

The antecedent of "fragendis rebus" is ". . .si nullam finem Natura parasset. . ." (l. 551). Lucretius is creating a hypothetical situation for us here. He claims that if Nature had no limit to the capacity in which some object could be broken up, then nothing (no body of matter) could ever really reach its full maturity because everything would be continually breaking down, including past ages.

Book I, l. 565-566
"huc accedit uti, solidissima materiai
corpora cum constant. . ."

Here Lucretius talks about how the elements (atoms) of matter are always solid, no matter whether the complex physical entity is soft or not—whether they be air, water, land, or some gas, their physical elements are going to have a characteristic solidity to them.

Book I, l. 916
"si fieri non posse putas, quin materiai. . ."

This is the beginning line of another example of Lucretius' "reductio ad absurdum." Again, the materiai here is just serving to modify the "corpora" in the next line and is used again to denote the very elements of physical, visible matter.

Book I, l. 951
". . .sed quoniam docui solidissima materiai. . ."

Lucretius refers back to what he's "already taught." By now, and in this instance, he's saying once again that the elements of matter are "perfectly solid."

Book I, l. 986
". . .finitumque foret, iam copia materiai. . ."

In this instance, Lucretius employs the word "copia" to describe the entire count of mass in the Universe. Lucretius is setting up a picture for us of a very limited, almost box-like heaven in which all sides are fixed, with very definite limitations. With this line, Lucretius is illustrating how by now ("iam") the entire collection ("copia") of mass in the Universe would be enough to burst the sides of this box, to indeed run "to the bottom," collect "at the bottom" and thus (earth being underneath this box) would cause no room for the heavens as earthlings know it or for earthlings for that matter.

Book I, l. 997
". . .ex infinito cita corpora materiai. . ."

Lucretius postulates here that space is not finite, that the constituents of matter aren't collecting at the bottom of some cosmic box, but that the Universe is instead plagued with the constant motion of these atoms, and that the "bodies/elements of matter" are moving constantly from the deepest recesses of space, from "infinity."

Book I, l. 1017-1018
"nam dispulsa suo de coetu materiai
copia ferretur magnum per inane solute. . ."

In this instance, every element of matter flies through space on account of being "wrenched apart" from each union it makes with every other element of matter and so flies through the Void untied ("soluta," l. 1018).

Book I, l. 1035-1036
"quod nullo facerent pacto, nisi materiai
ex infinito suboriri quopia posset. . ."

This whole thought is supposing that infinite matter is needed to preserve the world and the Universe as they are. Because infinite matter is needed, it must come from somewhere, from the space incomprehensible to the human mind which humans deem "infinity." All bodies ("quopia" here = "copia") proceed from the great Infinite.

Book I, l. 1051
". . .infinita opus est vis undique materiai"

"Vis" means "quantity" here. Lucretius is stressing here that in order for the world to be supplied with the infinite matter, there must be "stores" of infinite matter on all sides of the earth, on all sides of anything created from matter, thus on all things.

Book I, l. 1113
". . .hac se turba foras dabit omnis materiai."

By this point, Lucretius has disproved two theories: One, that matter does not tend toward the center and two, that matter does not disperse on all sides, away from the center. This is Lucretius' concluding statement on the invalidation of this second theory, stating that if all of matter simply tended toward the outside, dispersed all at once upon contact, this would surely lead towards the death of everything and the existence of nothing.

Book II, l. 62-63
"nunc age, quo motu genitalia materiai
corpora res varias gignant genitasque resolvant. . ."

Lucretius now talks about the actual motion that moves the "productive" elements to form the things that they do.

Book II, l. 89-90
"et quo iactari magis omnia materiai
corpora pervideas, reminiscere totius imum. . ."

Here the atoms are perhaps regarded as "little boats tossed about on a great sea of void" (Leonard, Smith 321). A dominant theme regarding matter in general in the DRN is the whole "sea" analogy, with all matter and void in the Universe collectively making up a great "sea" of mass in the Universe. Here, Lucretius is keeping to that theme, making it that each little corpora materiai is a tiny boat on the vast sea of matter and void, constantly being "tossed about" as Lucretius has shown the reader.

Book II, l. 126-128
"corpora quae in solis radiis turbare videntur
quod tales turbae motus quoque materiai
significant clandestinos caecosque subesse."

Lucretius is talking about the phenomenon of the dust particles (matter) that can be seen when one looks at the sunlight that streams through windows and such. He claims that there is turmoil ("turba") between the matter one sees floating about and the actual rays of the sun itself. He then deduces that there exist both seen and unseen motions alike which are characteristically innate in matter in general.

Book II, l. 142-143
"nunc quae mobilitas sit reddita materiai
corporibus, paucis licet hinc cognoscere, Memmi. . ."

Lucretius' opening statement of another topic dealing with the attributes of matter. Here he addresses Memmius and tells him that he may understand the mobility, quickness, swiftness, motion attributed to the bodies of matter if he listens "to the few words" that follow in this next section.

Book II, l. 167
"at quidam contra haec, ignari materiai. . ."

This seems to be an attack on other schools of thought that lend more to a belief of a creative force beyond the reaches of Nature. As an added insult, Lucretius says that those types of people are "ignari materiai," or "ignorant of matter," which seems to be used here as what Lucretius believes should almost be a commonly accepted scientific truth.

Book II, l. 266
"omnis enim totum per corpus materiai. . ."

Lucretius here connects the atoms of the body with the functions of the mind, with intelligence itself. It is the stirring of all the atoms throughout the whole body that causes the gears of the mind to begin their churning and for intelligence to be generated.

Book II, l. 281-282
"cuius ad arbitrium quoque copia materiai
cogitur interdum flecti per membra per artus. . ."

I think Lucretius is actually talking about the movement of the body here. The "arbitrium" refers to the mind's will to move the whole collection of mass, whether it be arms, legs, etc., to wherever it needs to go. "Copia" of course refers to the whole mass of matter that makes up this limbs, "membra."

Book II, l. 294-295
"nec stipata magis fuit umquam materiai
copia nec porro maioribus intervallis."

Lucretius is describing here the force by which the atoms that make-up any physical entity are packed together. The point he eventually arrives at in this section is that the laws of motion as well as of mass in Nature are constant—that all things will behave in these terms as their "seeds" dictate and that there is no power which can change the sum total of things (the Universe) nor any power which can change the motion of things.

Book II, l. 304-307

"nam neque, quo possit genus ullum materiai
effugere ex omni, quicquam est, neque rursus in omnest
unde coorta queat nova vis inrumpere et omnem
naturam rerum mutare et vertere motus."

This is a continuation of the text used above. Lucretius points out that there is absolutely no point to where any type of matter ("genus ullum materiai") can leak out of the Universe (described as simply "the All"). He then illustrates that no "new power" could be created from nothing and then burst into the Universe, consequently changing the whole nature of things or the motion which accompanies each thing.

Book II, l. 525-528
". . .etenim distantia cum sit
formarum finita, necesse est, quae similes sint,
esse infinitas aut summam materiai
finitam constare—id quod non esse probavi. . ."

This is a very confusing idea, but I think what Lucretius is trying to say is that because the number of differently-shaped atoms is finite, it goes to show that because the sum of matter is infinite (and he claims to already have proved this), the number of atoms of the same shape must be infinite.

Book II, l. 529-531
"versibus ostendam, corpuscula materiai
ex infinito summam rerum usque tenere,
undique protelo plagarum continuato."

This is one of few instances where Lucretius places the word "corpus" (which he's been using all along to describe the atoms) in the diminutive form, "corpuscula." This way, he's placing more emphasis on the minuteness of the tiny bodies which in turn hold the entire Universe together, ad infinitam. He also brings in his idea of the swerve ("clinamen") of the atoms that are constantly battering against the side of an object, which in turn holds the object together. There is an "uninterrupted succession of blows on all sides."

Book II, l. 544
"infinita tamen nisi erit vis materiai. . ."

What Lucretius has been deeming as "summam" before, he now uses the word "vis," which can be used as an amount, but can also denote the power and strength of the sum total of mass in the Universe. In this context, Lucretius is talking about the necessity of an infinite store of appropriate atoms to support a life-form that is solely unique to all other life-forms.

Book II, l. 559-563
"sic tibi si finita semel primordia quaedam

constitues, aevom debebunt sparsa per omnem
disiectare aestus diversi materiai,
numquam in concilium ut possint compulsa coire
nec remorari in concilio nec crescere adavacta."

Lucretius again employs the sea analogy here. He's talking again of first-beginnings (primordia) and how, being dispersed throughout all of time and "tossed about" on the "tides" of matter, they could never be driven and combine together and consequently, they could never serve to increase the properties of an individual or thing together.

Book II, l. 667-668
"tanta est in quovis genere herbae materiai
dissimilis ratio, tanta est in flumine quoque."

This is Lucretius' vocative statement telling the reader of the great "diversity" of physical make-up to be found in every little and great entity alike—from the tiny blade of grass to the great rushing river. Lucretius uses two words (dissimilis ratio) to denote the idea of "diversity," or literally "different relation, connection."

Book II, l. 735-736
". . .propterea gerere hunc credas, quod materiai
corpora consimili sint eius tincta colore."

Lucretius associates the atoms of matter with the color that they project. He states that the atoms themselves have no color, but that the mind is able to associate things without the need of color, for even the blind man who has never beheld color can identify objects through the use of his other senses.

Book II, l. 737-738
"nullus enim color est omnino materiai
corporibus, neque par rebus neque denique dispar."

Another continuation of the text above, this again states Lucretius' belief that the constituents of matter do not have any color, like or unlike the things that we humans can witness in Nature.

Book II, l. 899-901
". . .vermiculos pariunt, quia corpora materiai
antiquis ex ordinibus permota nova re
conciliantur ita ut debent animalia gigni."

Lucretius is giving the reader an example of the things that can happen when the "ancient arrangement" of matter is altered. Here, he says that the rotting of things post mortem or by rain as such, the eventual altering of their physical make-up, of their atoms has the potentiality to bring forth "little worms" (maggots), because bodies of matter that have been moved from their original arrangement combine in a way which new things and

animals are produced. Lucretius believes that maggots appear out of nowhere on dead and/or rotting things because of the different combinations of the constituents of matter in each case, but of course we all know that maggots come from the eggs that flies lay in these environments.

Book II, l. 963-965
"praeterea, quoniam dolor est, ubi materiai
corpora vi quadam per viscera viva per artus
sollicitata suis trepidant in sedibus intus. . ."

Lucretius talks about the aspect of pain experienced when the constituents of matter are attacked and thus moved "out of place." When bodies are attacked, the constituents are moved out of place and cause pain, but a soothing delight comes during the whole healing process when the atoms move back into their original position. Because of this fact, Lucretius goes on to claim that there is no way that first-beginnings could have been afflicted at any time with pain and could not take pleasure in the healing process since they are not composed of bodies or elements themselves. All in all, they cannot experience any sensation whatsoever because of this idea.

Book II, l. 1002-1003
"nec sic interemit mors res ut materiai
corpora conficiat, sed coetum dissupat ollis."

Lucretius describes the role death has in the forming and scattering of the constituents of matter. He claims that matter is not wholly annihilated after death, but that the constituents of matter are simply dispersed and made to combine in other ways to bring the light of existence to other things.

Book II, l. 1019
"sic ipsis in rebus item iam materiai. . ."

Lucretius wants us to turn our attention to the things in real life whose nature completely changes if its combinations of matter, motions, order, position, or shape are changed.

Book II, l. 1057
"nil agere illa foris tot corpora materiai. . ."

This is Lucretius' imperative to the reader to disbelieve that all the bodies (atoms) of matter beyond the earth as we know it do nothing, that because of the chaos of all those atoms flying around and about, other "assemblages" must have occurred, other planets and other great entities beyond our fathoming formed.

Book II, l. 1064-1066
". . .quare etiam atque etiam talis fateare necesse est
esse alios alibi congressus materiai
qualis hic est, avido complexu quem tenet aether."

Again, here is Lucretius' claim that there must be other great physical entities comparable to our earth that has been formed beyond our reaching. It is interesting to note the phrase that Lucretius' uses to describe our planet, a place which "the upper air holds in a greedy embrace."

Book III
l. 193-195
"haerit enim inter se magis omnis materiai
copia, nimirum quia non tam levibus extat
corporibus neque tam suptilibus atque rutundis."

Lucretius is describing the chemical makeup of honey in this example. He says that honey, unlike the mind, is not made up of smooth atoms, but rather atoms "not so smooth, delicate, or round." Because of the rather jagged makeup of honey's atoms, there exists more cohesion of the atoms, which, sticking together, inadvertently causes the whole of the substance to move more slowly.

Book III, l. 806-810
"praeterea quaecumque manent aeterna necessest
aut, quia sunt solido cum corpore, respuere ictus
nec penetrare pati sibi quicquam quod quead artas
dissociare intus parteis, ut materiai
corpora sunt, quorum naturam ostendimus ante. . ."

These are the qualities of which any entity must have if it is to be eternally lasting. Being of solid structure, it must be able to "reject all blows and never allow anything to penetrate it and thus sever the bonds that hold it together."

Book III, l. 854-856
"nam cum respicias inmensi temporis omne
praeteritum spatium, tum motus materiai
multimodis quam sint, facile hoc adcredere possis. . ."

Lucretius entreats the reader to look back on the whole expanse of past time and to realize that surely the current arrangements of the motions of matter have surely been duplicated in the past, for the number of arrangements are finite, yet the expanse of time already passed is most likely infinite.

Book III, l. 928-929
"maior enim turbae disiectus materiai
consequitur leto, nec quisquam expergitus exstat. . ."

Lucretius is talking about the great dispersion of atoms of a person's body post mortem.

Book V

l. 67-70
"et quibus ille modis congressus materiai
fundarit terram caelum mare sidera solem
lunaique globum. . ."

Lucretius gives examples of how the "congregations of matter (atoms)" are responsible for the existence of the earth, sky, sea, stars, sun and "the ball of the moon."

Book V, l. 353-354
"nec penetrare pati sibi quicquam quod quead artas
dissociare intus partis, ut materiai. . ."

Here is a near-verbatim occurrence of lines 808-809 of Book III, this is again giving the conditions needed of an object to be able to have eternal existence. This again states that an object must "reject all blows and allow nothing to sever the bonds of its constituent elements."

Book V, l. 407-408
"ignis enim superare potest ubi materiai
ex infinito sunt corpora plura coorta."

Lucretius is talking about the fluctuating strength of the elements, namely fire and water, and the ongoing war between them. In these verses, Lucretius talks about the potentiality of the atoms of fire to grow more than usual in number out of the Infinite and overcome the Universe, but is mysteriously beaten back by some other force—this is why the whole Universe is not one big scorched entity.

Book V, l. 416-418
"sed quibus ille modis coniectus materiai
fundarit terram et caelum pontique profunda,
solis lunai cursus, ex ordine ponam."

Here Lucretius plans on informing the reader how the "assemblages" ("coniectus") of matter helped to establish the earth, sky, ocean, sun and moon respectively.

<u>Materiam</u>

Book IV
l. 147-149
". . .sed ubi aspera saxa
aut in materiam ligni pervenit, ibi iam
scinditur, ut nullum simulacrum reddere possit."

Here, Lucretius uses "materiam" with the "ligni" to mean "lumber." It is not just "mass," but particularly the "mass" of wood.

Materiem

Book I
l. 58
". . .quae nos materiem et genitalia corpora rebus. . ."

Lucretius here is pointing out the similarities in meanings between such phrases as "materiem," "genitalia corpora rebus," "semina rerum," and "corpora prima." The idea behind all of these names is that they all have to do with the very constituents of what we can only think of as mass today.

Book I, l. 226
". . .si penitus peremit consumens materiem omnem. . ."

This is Lucretius' thought on the method of aging in any physical entity. The inner constituents of matter are slowly "consumed" by old age, which in turn slowly destroys the physical being.

Book I, l. 512
". . .materiem circum solidam constare necessest."

This is the idea that if any object is going to contain some type of Void, this Void will have to be surrounded by solid matter, else Void would prevail, and there would be, well, nothing.

Book I, l. 635-636
"quapropter qui materiem rerum esse putarunt
ignem atque ex igni summam consistere solo. . ."

Here is Lucretius' rebuttal of Heraclitus' belief that the whole sum of matter as we know it consists solely of the elements of fire. Lucretius says that this cannot be so and that those who believe in such are far from reason.

Book I, l. 705
"Quapropter qui materiem rerum esse putarunt. . ."

Almost verbatim from lines 635-636.

Book II
l. 274-275
"nam tua materiem totius corporis omnem
perspicuumst nobis invitis ire rapique. . ."

Lucretius talks here of the mass of one's entire body that is forced backwards or forwards by the potential mighty strike of another person. He says that the entire mass of our body

is thus moved back against our will, until our will is then regained and can then drive our body to wherever we so desire.

Book II, l. 512-514
"quae quoniam non sunt sed rebus reddita certa
finis utrimque tenet summam, fateare necessest
materiem quoque finitis differre figuris."

Lucretius notes here that there exists a certain limit set for all things. This is no exception for the "sum" of all things. He says that the sum of all things is "shut in" from all sides (utrimque), which conjures up the "Universe in a box" idea, and that nothing can be added or subtracted from this and because of the apparent finiteness of matter, there also exists a finiteness to the number of shapes that form this matter.

Book III
l. 847-848
"nec, si materiem nostram collegerit aetas
post obitum rursumque redegerit ut sita nunc est. . ."

This is another postulation of Lucretius, theorizing about the idea of what would happen if all our atoms (materiem nostrum) could somehow come back together again after death and be placed exactly as they are as we live. The idea he is reaching at is that, even if our atoms could come back together post mortem, our minds and souls would have no recollection of events that we did in the previous life. He encourages the reader to look at the past, measureless time, and recognize that at some point, surely the combination of atoms of which we now consist "occurred." And yet, we can not recollect any events from that lifetime, so how could it be any different when once again our atoms are dissolved and scattered into Nature after our deaths?

Materiemque

Book V
l. 1266-1268
". . .ut sibi tela daren't, silvasque ut caedere possent
materiemque dolare et levia radere tigna valerent
et terebrare etiam ac pertundere perque forare."

The "materiemque" here is again used as the preferred word for "timber," as we've seen once already. Lucretius is describing the discovery of metals by man and then the possible uses of these metals by men. In this instance here, the metal could be used to cut down forests and then literally "beat-up" the wood, to cut it into more practical pieces.

Materies

Book I
l. 171

"materies ubi inest cuiusque et corpora prima."

Lucretius is again mentioning that the very source of all living things comes "into the light of life" first as atoms, the material substance of which all things in existence are composed. Nothing originally came into existence as its fully-potential state, but first as its primary elements.

Book I, l. 203-204
". . .si non, materies quia rebus reddita certast
gignundis, e qua constat quid possit oriri?"

Lucretius talks here about the idea that men so large that they can "wade through the deep sea" cannot possibly be produced because the material from whence they come is "fixed." Because the original elements that are responsible for the make-up of humans was fixed and never allowed for such abnormalities to be thus created, the same material today will still not allow for such occurrences.

Book I, l. 238-240
"denique res omnis eadem vis causaque volgo
conficeret, nisi materies aeterna teneret
inter se nexus minus aut magis indupedita."

Lucretius is attempting here to disprove the idea that things can be reduced to absolute nothing. He says that if this is so, and all things are inevitable reduced to nothing, there would never be a source from whence the things in existence today could come. To reiterate another point, if things could be annihilated to nothing, the very same force or strength could potentially destroy all types of matter and material. Since this is not so, there must be differences in strengths in the bonds which hold all matter together.

Book I, l. 244-245
"at nunc, inter se quia nexus principiorum
dissimiles constant aeternaque materies est. . ."

Here Lucretius recognizes that the bonds of matter are different and that matter itself is everlasting, so different forces are necessary to break each type of bond and therefore affect the constitution of the material or body of mass.

Book I, l. 345
". . .undique materies quoniam stipata quiesset"

Lucretius now introduces the reader to the concept of Void, that along with matter, there must also be Void, areas not occupied by any type of matter at all. Here, he augments his argument, claiming that if there were no Void, things of mass could not move in the least, everything being thus compiled into one vast and stationary mass.

Book I, l. 471-472

"denique materies si rerum nulla fuisset
nec locus ac spatium, res in quo quaeque geruntur. . ."

"Materies" is here used as the primary material of things. Lucretius is arguing that nothing could ever be if there were no matter for everything in existence and space and places for these things to be in existence.

Book I, l. 518
"materies igitur, solido quae corpore constat. . ."

Lucretius recognizes that matter is in fact contained in a "solid body" and is thus everlasting, even when all else may dissolve.

Book I, l. 540
"praeterea nisi materies aeterna fuisset. . ."

Lucretius recognizes the impossibility that unless matter is eternal and contains no void, eventually things would have to be born from nothing, from Void, which is ludicrous.

Book I, l. 547
". . .materies ut suppeditet rebus reparandis."

Here, Lucretius familiarizes the importance of the role of matter in the "renewal" of all things in existence. All things are made up of mass, and so mass must be necessary in the very beginning for things to become as they are, as they will. It is the primal seed of matter from all things must originate and it is matter that keeps restoring life over and over again.

Book I, l. 632-634
". . .non possunt ea quae debet genitalis habere
materies, varios conexus pondera plagas
concursus motus, per quae res quaeque geruntur."

The "materies" is here modified by the "genitalis" and translated as "generative matter." Lucretius is again postulating (as he's wont to do) about the qualities certain forms of matter must have if they are to reproduce and keep their kind going. For matter to be reproductive, it must have established "all sorts of various connections, weights, blows, [attempts at] combinations, and motions." These are the characteristics necessary for "all things to come to pass."

Book I, l. 990-991
"quippe ubi materies omnis cumulata iaceret
ex infinito iam tempore subsidendo."

This is another of Lucretius' arguments against the finiteness of space and the Universe. He says that if all space was finite, surely all matter would now be lying in one giant heap

and that there would basically be no heaven or light from the sun because all matter would be crammed together by now from the whole expanse of past time and that the Universe would be "bursting at the sides."

Book I, l. 1039-1041
". . .sic omnia debent
dissolvei simul ac defecit suppeditare
materies aliqua ratione aversa viai."

This is another idea backing up the idea that matter is necessary for the replenishment of all things, of all life. Lucretius says here that all things would eventually be dissolved away if somehow matter as we know it was "turned off its course," somehow diverted from existence as we know it. Without the continual replenishment of matter, all things would eventually die out and never be restored.

Book II
l. 67-68
"nam certe non inter se stipata cohaeret
materies, quoniam minui rem quamque videmus. . ."

Lucretius argues that mass isn't one solid and "coherent" mass that is completely unchanging. He claims that things do lose mass through the stream of Time; things seem to ebb away as time ebbs away. Because the sum of all matter is of course unchanging and constant, when bodies of matter are subtracted from one thing, they are inevitably added to another thing.

Book II, l. 769-770
". . .materies ubi permixta est illius et ordo
principiis mutatus et addita demptaque quaedam. . ."

In this section, Lucretius is discussing the potentiality for objects to become different colors throughout the time of existence. The whole reason behind color change comes from different motions that occur in the primary elements of the thing. The example that Lucretius gives is the apparent change in color that the ocean takes on when stirred heavily by the wind—the apparent brilliant white that the waves become from the usually bluish hue of the deep. He says that this is because the wind has a way of stirring up the constituents, primary bodies of the waves and that the color change results.

Book II, l. 939-940
". . .nimirum quia materies disiecta tenetur
aere fluminibus terris terraque creatis. . ."

Lucretius is discussing our idea of nerves, saying that bodies cannot possibly have any sensation before they come into existence because their elements are dispersed in all types of different media, their atoms floating about in the "air, rivers, and lands." It is not until their atoms come together that the vital motions needed for feeling can exist.

Book II, l. 949
". . .donec materies, omnis concussa per artus,
vitalis animae nodos a corpore soluit
dispersamque foras per quaulas eiecit omnis."

Lucretius is sort of discussing the physics of death here, saying that a blow of certain strength and sent through all the limbs could then loosen all the vital motions of the atoms within and consequently cause the soul to escape through the pores of the body. Materies is used to describe the material of the whole body.

Book II, l. 1067-1069
"praeterea cum materies est multa parata,
cum locus est praesto, nec res nec causa moratur
ulla, geri debent nimirum et confieri res."

Lucretius theorizes here about the potential for the same conditions that made all life possible here on earth to exist elsewhere in the Universe, for new races of people to appear if the vital motions of the primary bodies, the space necessary, and matter is abundant enough to allow for these new races to appear.

Book III
l. 967
"materies opus est ut crescent postera saecla."

This is simply another addition to Lucretius' argument that initial matter—the primary bodies—are necessary if future generations, if future ages are to continue and increase in terms of abundance of life.

Book V
l. 269-271
"percolator enim virus, retroque remanat
materies umoris et ad caput amnibus omnis
convenit. . ."

Lucretius mentions "materies" here as the very substance of water, "umoris." Lucretius claims that there never seems to be a superabundance of water because, although the source of each and every stream and river is constantly replenishing the volume of the liquid, the sun and wind are also constantly scraping the elements of the stream off of the top. This is of course referring to evaporation.

Book VI
l. 636
"materies umoris et ad caput amnibus omnis. . ."

These verses are almost completely verbatim with lines 269-271 in Book V and the whole idea of evaporation is once again presented to the reader.

Book VI, l. 1061
". . .lignea materies in quo genere esse videtur."

"Materies" is used here to denote the "substance" attributed to wood. Lucretius is talking about those materials that are affected and not affected by the magnet and says that the "substance" is so filled with Void, that the magnetic current seems to just fly through the wood and thus, wood is unaffected by the magnet.

Book VI, l. 1069-1071
"glutine materies taurino iungitur una,
ut vitio venae tabularum saepius hiscant
quam laxare queant compages taurea vincla. . ."

Lucretius is talking here of the effective combinations and affinity of certain substances with other substances, or with certain masses for certain masses. Here again, "materies" is used to denote the substance of which wood is composed. The "materies" of wood has a certain affinity for bull's glue (according to Pliny, the best glue is made from the ears and genitals of bulls), which is best for holding grainy and "Void-y" wood together.

Marty Pickens

Bibliography of Lucretius

Bergson, Henri. The Philosophy of Poetry: The Genius of Lucretius. Edited, translated by Wade Baskin. Philosophical Library: New York, 1959.

Chapters to this work include Introduction, the Text of the De Rerum Natura, the Poetry of Lucretius, and the Physics of Lucretius. This study discusses all of these elements of the De Rerum Natura as a whole and draws textual parallels between the DRN and Virgil, Augustus, Cicero, Ovid, and even Horace.

Bignone, Ettore. Storia della Letteratura Latina: Volume Secondo. Editore G.C. Sansoni: Firenze, 1945.

Of all three editions, it was the second one (chapters Six and Seven) alone that dealt with Lucretius. Chapter Six deals with the political, spiritual, and religious crises of Lucretius' age and how the affected Lucretius. It goes into such topics as the roles of skepticism and superstition, astrology, magic, cults and Lucretius' "passionate rebellion" against such superstitions. This chapter also deals with the Lucretius' invocation of Venus in the DRN. Chapter Seven gives us a more thorough picture of the life of Lucretius and the influence of Epicureanism on his vast poem. It gives an "ideal" biography of Lucretius and what we know of to be the "real" biography. This chapter also talks about the role of Memmius in the DRN and compares Lucretius to other famous poets/thinkers such as various didactic poets of Alexandria, Empedocles, and Dante. Chapter Eight deals with the De Rerum Natura itself, its content, its usage, its imagery, and its meter.

Brophy, Brigid. Black Ship to Hell. Harcourt, Brace, & World, INC.: New York, 1962.

This book only briefly talks about Lucretius. He is used merely as a primary example of an atheist—he uses the idea of gods, but otherwise believes that a god has no place among humans or wastes any time in human intervention.

Carus, Titus Lucretius. De Rerum Natura: Libri Sex. Eds. William Ellery Leonard and Stanley Barney Smith. The University of Wisconsin Press: Madison, 1965.

This was the definitive text of the De Rerum Natura which I used extensively throughout my whole study of Book I of Lucretius' De Rerum Natura.

Carus, Titus Lucretius. The Loeb Classical Library: De Rerum Natura. Trans. W.H.D. Rouse, Litt.D. Harvard University Press: Cambridge, 1975.

When I was not quite sure about my own translations, this was the translation that I used to verify my own Latin/English translation.

Carver, Goerge Lafayette. The Gods of Lucretius: A Reexamination. Doctoral thesis completed at St. Louis University. University Microfilms, Inc.: Ann Arbor, Mi, 1965.

This is a simply a thorough investigation of the gods and their roles in the DRN. The first chapter is dedicated to Lucretius and Epicureanism, Chapter Two is concerned with Religion in the Epicurean School, Chapter Three is completed dedicated to the invocation of Venus, Chapter Four deals with the Divine in personification, apotheosis, and allegory, Chapter Five is an examination of the assault of the old gods by Lucretius, and Chapter Six is a study on the nature and form of the orthodox gods of Lucretius. The underlying argument of this book is that Lucretius actually paid very strict attention to the roles of the deities in life.

Catto, Bonnie Arden. The Concept of "Natura" in the De Rerum Natura of Lucretius and the "Georgics" of Vergil: Its Characteristics, Powers, Actions, and Effects Upon the Earth, Man, and Man's "Labor." Dissertation for the Doctor of Philosophy completed at the University of Pennsylvania. U.M.I. Dissertation Service, 1981.

This dissertation begins with a detailed study of the Greek word "physis," which is the "primary substance that of which the world is composed." The goal of the work is to investigate the supposed various meanings and uses of the word "natura" in the DRN. It also serves to examine the Georgics of Vergil and the influence of Lucretius on this work. Similarities in transitional phrases, simple modifiers, and descriptive passages arise in the Georgics. Parallels in the various themes in the title of the dissertation also come about in both works.

Cottrell, A.H. The Mechanical Properties of Matter. John Wiley and Sons, Inc.: New York, 1964.

This was a very advanced text that dealt with the mechanical properties of matter. It included chapters on perfect gases, condensed states of matter, the structure of crystals, elasticity, elastic stress distributions, waves and vibrations in solids, fluidity and viscosity, surfaces, plastic crystals, plasticity, fracture of solids, and fluid mechanics.

Cuda, Joseph Anthony. The Ultimate Pleasure: Death and Immortality in the De Rerum Natura. Dissertation for Doctor of Philosophy, Washington University: St. Louis, 1977.

This dissertation goes into great detail of the role of death and immortality in the De Rerum Natura. The author analyzes sections of the DRN and comes to psychological conclusions on the character of Lucretius. He theorizes that the whole of the DRN is composed as a simple rebellion of Lucretius against the crisis of mortality. Lucretius wrote this text not only as a consolation for the hoi polloi, but also for himself—as a way

to deal with inevitable death. Mortality is simply a sickness that can be dealt with and cured through quiet study of philosophy and the ultimate attainment of "tranquility."

Dalzell, Alexander. The Criticism of Didactic Poetry: Essays on Lucretius, Virgil, and Ovid. University of Toronto Press: Toronto, 1996.

This book discourses the idea of whether Lucretius was a philosopher or a poet or whether or not he could be both. Specific arguments are presented here as to the difficulties of expounding philosophy in poetry.

DeWitt, Norman Wentworth. Epicurus and His Philosophy. Greenwood Press: Connecticut, 1954.

As the author puts it, "the aim of this study is threefold." First, he aims to create a coherent biography of Lucretius from what little remnants of texts dealing with his life that we have, to develop a new interpretation of his doctrines based on "more virginal" texts of his writings, and thirdly, to illuminate the importance of Epicureanism as a "bridge" between the classical philosophies of Greece to Christianity. The author begins with a general outline of Epicureanism and discusses locations where the influence of Epicurean doctrine was strongest. The main focus of this text is Epicureanism, but there are sparse fragments discussing Lucretius throughout. For example, the book discusses in brief detail Lucretius' views on the process of learning, life, flight of the soul, civilization, diversity of character, conception, dreams, oracles, the forms of the gods, life of the gods, and the poverty of the Latin language. No more than two pages are dedicated to any of these facets that make up Lucretius' personal philosophy as purveyed in the De Rerum Natura.

Dudley, D.R., Farrington, B., Lowenstein, O.E., Maguinness, W.S., Spencer, T.J.B., Townend, G.B., Wormell, D.E.W. Lucretius. Ed. D.R. Dudley. Basic Books, Inc., Publishers: New York, 1965.

In this compilation of essays, several facets of Lucretius are discussed and analyzed. The Pre-Socratics, Lucretius himself, and Modern Science are discussed by O.E. Lowenstein, a Professor of Zoology. Following this are the form and purpose of the De Rerum Natura, the personal world of Lucretius, Lucretius' language, Lucretius' imagery, and the satiric element of Lucretius' poem.

Dunn, Howard Michael. Language and Rhetoric of the Law in De Rerum Natura. Doctoral thesis completed at Brown University, 1969.

This author here first creates a smaller, poly-author concordance of Latin words that deal with the idea of "law" in the same manner as Lucretius. There is then a thorough study of how the ideas of law and the particular rhetoric of the language of the law propitiate the De Rerum Natura.

Emerton, Norma E. The Scientific Reinterpretation of Form. Cornell University Press: Ithaca, 1984.

As the title suggests, this book looks at a rather wide variety of physical forms to be found in nature. The first chapter aims to study the forms of the Mineral Kingdom. Chapter Two discusses the development of the concept of form after Aristotle. The beginnings of a corpuscular approach to form are studied in Chapter Three. The smallest bodies, atoms, and a corpuscular reinterpretation of form are the topic of discussion at Chapter Four. Chapter Five compares atoms and crystals and uses a geometrical approach to their physical forms. The next chapter discusses the development of form in the Platonic tradition. The final chapters are dedicated to studying forms found in perceived nature.

Falsom, Elizabeth. The Attack on the Fear of Death in Lucretius. Thesis for the Master of the Arts degree, University of Minnesota, 1933.

This is a fairly short work, again dealing with only the basic ideas behind Lucretius. It gives us some general information on Lucretius' life and poem, but also delves a little more deeply into one of the most popular aspects of the DRN, the direct assault on the fear of death.

Farrington, Benjamin. The Faith of Epicurus. Weidenfeld and Nicolson: London, 1967.

This book gives a rather simple history of Greek political thught and the life of Epicurus and concentrates on the political aspect of Epicureanism. It also briefly discusses Epicurean physics and parallels Democritus' postulates with those of Lucretius.

Furley, David J. Two Studies in the Greek Atomists. Princeton University Press: Princeton, 1967.

There is a greater focus in this text on the ancient Greek sources of Epicureanism et al. The book is laid out into two studies. The first study is entitled "Indivisible Magnitudes" and basically uses Lucretius' ideas in the De Rerum Natura to support the Greek source. It also lays out the ideas of Pythagorean Atomism, the Eleatic concept of Indivisible Being, Aristotle's criticisms and Epicurus' answers to these criticisms, followed by a comparison of Epicurus to Diodorus Cronus and David Hume. The second study details both Aristotle and Epicurus on voluntary action, and goes on to discuss this in Lucretius' De Rerum Natura (2.251-2.293). It also talks about the psychology involved in Epicureanism.

Hadzsits, George Depue. Lucretius and His Influence. Cooper Square Publishers, Inc.: New York, 1963.

This work gives a brief account of the lives of Lucretius and Epicurus and the birth of Epicureanism. It then summarize, in particular, Lucretius' thoughts on the Atom, the Soul, Religion, and Ethics as well as his particular influence in the Roman Empire, the

Middle Ages, the Renaissance, and the seventeenth century, eighteenth century, and even the present.

Herford, C.H. Shakespeare's Treatment of Love and Marriage and Other Essays. T. Fisher Unwin LTD: London, 1921.

This is a short essay that deals with the basics of the life of Lucretius, his philosophy, ideas, times, beliefs, and contemporaries.

Houghton, Herbert Pierrepont. Lucretius and De Rerum Natura: Appreciation and Appraisal. University of Coimbra Press: Coimbra, 1950.

This is a rather basic book dealing with basic information on Lucretius and his great work. Chapter 1 is entitled "The Man" and gives a general biography of Lucretius, including the myths of the "love philter," his supposed madness, and his eventual suicide. The Second Chapter discusses "The Times" of Lucretius—contemporary events, movements, ideas, etc. The Third chapter is dedicated to basic facets of the DRN itself.

In Luminis Oras: Antologia Lucreziana. Ed. Carlo Piazziono. G.B. Paravia & c.: Firenze, 1948.

This is just another anthology of selections from the De Rerum Natura with some basic notes to accompany text.

Jones, G.O., Rotblat, J., Whitrow, G.J. Atoms and the Universe: An Account of Modern Views on the Structure of Matter and the Universe. Charles Scribner's Sons: New York, 1956.

This is an older text that may be a little outdated, but for the most part is pretty easy to read. It gives some of the fundamental concepts dealing with properties of single atoms. The first chapter discusses elementary particles that comprise the atom, including the electron, the proton, the neutron, the positron, the neutrino and mesons. The next several chapters discuss properties of the atom as a whole, including breaking the atom, smashing the atom, and the energy of the atom. The subject matter becomes a little broader when the book begins to talk about cosmic radiation, the properties of matter, and then the solar system, Milky Way, and size and age of the Universe. So we get a pretty broad spectrum of different contexts for the constituents of matter.

Jones, Howard. The Epicurean Tradition. Routledge: London, 1989.

This is a work that concentrates on the impact of Epicurean philosophy as a whole "upon the development of intellectual and scientific ideas." It seems to study the role of Epicurus' philosophy in different areas and cultures as well as in different eras.

Kenney, E.J. Lucretius. Greece & Rome: New Surveys in the Classics, No. 11. Clarendon Press: Oxford, 1977.

This is just a very simple book on the basics. The chapters include: I. The Poet and his Times, II. The Poem: Text, Sources, Scope, Structure, III. The Poetry, IV. The Message and the Mission.

Leclerc, Ivor. The Nature of Physical Existence. George Allen & Unwin LTD: New York, 1972.

This was actually a good, qualitatively-oriented text on physical concepts. The introductory chapter introduced some basic concepts of modern science, matter, space, time, motion, et cetera. Part I began with Chapter Two, with dealt with the problem of the infinite and Aristotelian analysis. This gave some alternative explanations for the concept of Infinity and Void. Chapter Three was on Aristotle's Doctrine of the Infinite, and it dealt with the differences in senses of being between potential and actual. Chapter Four is on the changed concept of the Infinite in Medieval thought, where the divine being is conceived as being completely transcendent. Et cetera. Part II deals with the concept of the physical, and examines the Greek, Aristotelian, Medieval, Renaissance, and early seventeenth-century conceptions of physical matter. Part III deals wholly with the modern concept of nature, including matter, motion, place, void, and space. It also discusses the current theory of atomism, the continuum, Descartes' theory of the physical, and the physical existent and mathematical existent of Sir Isaac Newton.

Logre, Benjamin Joseph. L'Anxiété e de Lucrece. J.B. Jarin: France, 1946.

This work aims to give us a thorough study of the history, myth, and textual analyses that may lead us to Lucretius' supposed "anxiety" or "madness." The first chapter goes into Saint Jerome's text, which first relates the story of the love philter, and Lucretius' madness to us in the first place. Chapter Two concerns Lucretius' support of Epicureanism and intonations in the DRN that may tell us of his state of being (e.g. vehemence, irony, sarcasm, digressions, hyperbole, and sincerity). Chapter Three is entirely devoted to the Venus invocation and Chapter Four describes the paradox of this invocation. Chapter Five talks about the elegy of Epicurus, Chapter Six discusses the causes of Lucretius' possible pessimism. Chapter Eight is an analysis of Lucretius' "anxiety," Chapter Nine is on the evils of religion; Chapter Ten is on the evils of the age and the evils (sickness) of Lucretius. Chapter Twelve concerns Lucretius' views on death deals with parallel opinions of Sigmund Freud and Henri Bergson. Chapter Thirteen is on Lucretius' view on love, Chapter Fourteen on Lucretius' pessimism

Lucretius on Matter and Man: Extracts from Books I, II, IV, and V of the De Rerum Natura. Ed. A.S. Cox. G. Bell and Sons LTD.: London, 1970.

This book begins by giving us some glossy plates—pictures that correlate with Lucretius and the De Rerum Natura, such as modern conceptions of the atom and ancient cave paintings depicting animals that were hunted by cavemen. This book also contains a basic introduction into Lucretius' life, character, his message, his science, his poetry, meter, language, and reactions to Lucretius. Otherwise, the book is laid out so that the

Latin selections from each of the books in the title are given, with introductions in English that aim to give the reader and idea of the purpose of each section. Each selection, of course, has the reoccurring theme of "Matter" and "Man." The appendices in the back give the reader modern explanations as compared with the ideas presented in the DRN, namely the modern concept of atoms and evolution.

McMullin, Ernan. The Concept of Matter. The University of Notre Dame Press: Notre Dame, 1963.

This book begins with a discussion of the role of matter in Greek and Medieval philosophy. It then discourses on the material substrate in Plato, matter in nature and the knowledge of nature in the Aristotelian tradition, matter and predication in Aristotle, matter as potency, and the Ockhamist Critique. Part II looks at the reflections on the Greek and Medieval problematic, specifically at matter as a principle, primary matter and unqualified change, the referent of "primary matter," matter and individuation, the four senses of potency. Part III discourses on the differences between matter and mass, and the role of matter in Seventeenth Century science. Part IV is concerned mostly with matter in modern philosophy and Part V discusses the "Dematerialization" of matter in modern science.

Minadeo, Richard. The Lyre of Science: Form and Meaning in Lucretius' De Rerum Natura. Wayne State University Press: Detroit, 1969.

This is a work dealing with literary criticism, with a special interest in Lucretius' "poetical abilities." Chapter 1("The Leit-Motif"): Structure and form of the poem provide clues to Lucretius' purpose. This chapter thoroughly examines the cycle of creation and destruction throughout the DRN. Chapter 2 ("The Great Design") aims to examine the beginning and ending of each book of the DRN. There is more examination of the creation/destruction motif, and discussion of the creation/destruction cycle as provider of the poem's formal design. All beginnings and endings of the books with the exception of two adhere to a creation/destruction motif/theme. Chapter 3 ("The Cycles") is concerned with working out of the cyclical movement of bodies in other books and chapter 4 ("Form and Meaning") has the theme that the MEANING of the poem serves as the FORM as well. This particular book is interesting in that it includes an appendix of most (if not all) of the words that relate to the idea of creation and destruction throughout the whole of the DRN.

Perelli, Luciano. Lucrezio: Poeta dell' Angoscia. La Nuova Italia Editrice: Firenze, 1969.

The first chapter deals with the life and the supposed "sickness" of Lucretius. The second chapter goes into his fear of death. The third chapter deals with Lucretius' fear of the gods. The fourth chapter deals with the "feeling" of Nature. Chapter five accounts for the world of humans, and the final chapter (6) is all about the poetry of Lucretius in general.

Epicurean philosophy that brings light to the matter. In short, this book attempts to look at physical imagery throughout books 1-6 of DRN and ascertain Lucretius' ethical values by analyzing the physics. Conclusion: DRN is a coherent, forceful poem if viewed as a statement of possibilities for harmony/disharmony in the world and an attempt to bring harmony to the reader.

Strodach, George K. The Philosophy of Epicurus: Letters, Doctrines, and Parallel Passages from Lucretius. Northwestern University Press: Evanston, 1963.

This book begins by moving through the history of the Pre-Socratics and throughout the development of the atomic theory. The main concepts that the first half of the book aims to cover are the first principles of Atomism, the motion of these atoms, sensation and perception, the theory of knowledge, religion and theology, and then ethics and the "good life." The book then examines several letters and the parallels of Lucretius that accompany them. Included here are excerpts from "The Life of Epicurus," by Diogenes Laertius, the "Letter to Herodotus," "Letter to Pythocles," and "Letter to Menoeceus."

The Stoic and Epicurean Philosophers: The Complete Extant Writings of Epicurus, Epictetus, Lucretius, and Marcus Aurelius. Ed. Whitney J. Oates. Random House: New York, 1940.

No real critical analyses are to be accounted for here, but this book has, as the title claims, the complete extant writings of both master and "student," Epicurus and Lucretius, and two famous stoics, Epictetus and Marcus Aurelius.

Thornton, Harry, Thornton, Agatha. Time and Style: A Psycho-Linguistic Essay in Classical Literature. Methuen & Co., LTD: London, 1962.

In general, this book draws a correlation between literary expression and psychology and attempts to establish the original author's mode of expression and direction in the time sequence. Concerning Lucretius, they determine that the appositional mode of expression is a characteristic feature. The amplification of thought for Lucretius comes through appositional movement—for example, the poet states a thought, amplifies it, then returns to the initial thought. From here, he amplifies it again, differentiating it further and obtaining a higher order of precision (e.g. Lucretius' appositional amplification in 5, 1143).

Traglia, Antonio. Sulla Formazione Spirituale di Lucrezio. Casa Editrice Gismondi: Roma, 1948.

Chapter 1 deduces modes of Roman lives as projected from the De Rerum Natura. Chapter 2 speaks of Lucretius' environment and poetical formation and describes the influence of Ennius, Empedocles, Sappho, Plato, Thucidides, and Catullus. Chapter 3 speaks of Lucretius' personal philosophical formation and the spread of Epicureanism throughout Rome, Lucretius' affiliation with Philodemus, and the philosophic culture of

Lucretius. Chapter 4 compares the De Rerum Natura to other great works of Latin literature. A whole chapter (V) is dedicated to Lucretius' usage of the goddess Venus, and chapter 6 is a simple study of Lucretius' linguistics.

Wallach, Barbara Price. Lucretius and the Diatribe against the Fear of Death. E.J. Brill, Leiden: Netherlands, 1976.

This work deals solely with Lucretius' diatribe against the fear of death in Book III, lines 830-1094. The purpose of the author is to thoroughly seek to explore the influence of rhetoric and the diatribe upon the end of the Third Book and draw conclusions concerning the entire diatribe in poetic form.

West, David. The Imagery and Poetry of Lucretius. Edinburgh University Press, 1969.

West first makes a case for the importance of imagery and talks about some of the general characteristics of imagery ("nicety of detail, dialectical function, plenitude"). He then dedicates the next several chapters to particular images in Lucretius' DRN and goes into detail about each one.

Winspear, Alban Dewes. Lucretius and Scientific Thought. Harvest House: Montreal, 1963.

Here is another standard text that gives a good, basic background into the world of Lucretius and the DRN. It covers the originality of Lucretius, the times and legend of Lucretius, his fight against Roman religion, his debt to Epicurus, his world outlook. It also gives some suggestions for further reading as well as short summaries on the lives of great thinkers mentioned throughout the text at the end.

Zeller, E. The Stoics, Epicureans, and Sceptics. Translated by Oswald J. Reichel. Russell & Russell Inc.: New York, 1962.

Part III, Chapter XV deals entirely with the Epicurean tradition. First, it gives a short biography of Epicurus and history of the scholars of Epicurus and Epicureans in the Roman period. Chapter XVI talks about the "character" of the Epicurean system and its power of self-preservation. This chapter also discusses basic elements of this philosophy, such as its ideas on sensation/perception, notions and opinions. Chapter XVII deals more with Epicurean views on Nature, including the idea of atoms, the swerve (clinamen) of atoms, origin of the world, structure of the universe, flora/fauna, and the origin of the human race. Chapter XVIII is dedicated to Epicurus' views on religion—his gods (and their nature), and his reasons for his beliefs. Chapter XIX: Pleasure as the highest good, freedom from pain, intelligence (intellectual happiness) and Virtue. Chapter XX: Epicurean ethics—the individual, civil society and family, friendship. Chapter XXI: Entire Epicurean system and its "position in history." This includes Epicurean teachings, and its relations to Stoicism, Aristippus, Democritus, Aristotle, and Plato.

Marty Pickens
Project Abstract
Original Draft

I intend to target specifically scientific words Lucretius employs in his *De Rerum Natura* which convey meaning perhaps obscure at the time. By this, I mean to study a small portion of Lucretius' scientific vocabulary and, by examining the multiple uses and multiple contexts of such words, my hope is to arrive at a larger definition of each word and to grasp the full contemporary meaning implied in each word. I intend to study those scientific words Lucretius utilizes in the *De Rerum Natura* whose concepts we continue to use in science today and to perhaps expand on Lucretius' definitions by comparing them to our own modern sense of each word/concept.

The main tool of my project will be a concordance of Lucretius, aptly entitled A Concordance of Lucretius.[1] My method will consist first of all with seeking the words Lucretius uses to describe what can only be deemed as scientific phenomena at the time, such as "materia" and "potestas." After choosing the most appropriate words, I shall use the concordance of Lucretius to uncover the number of times the word is used as well as the specific placement of each word throughout the whole *De Rerum Natura*. I shall then be able to discern how the word is employed in each context and draw a larger picture of the word's full definition in the times of Lucretius by examining each of these contexts. After I have studied the multiple contexts of each word, and perhaps have uncovered a fuller meaning of each scientific word, I hope to be able to then detect the deficits in the scientific ideas of Lucretius' times or at least seek to understand in modern English that which the poverty of the Latin language hindered.

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[1] Roberts, Louis. A Concordance of Lucretius. Garland Publishing, INC.: New York, 1977

Marty Pickens
Project Abstract
Second Draft

The general Latin word for "matter", or "woody substance", *materia*, occurs thirty-one times throughout Book I of Lucretius' *De Rerum Natura*. Throughout Book I, Lucretius uses *materia* mostly in contexts dealing with the *primordia* ("first-bodies"—atoms) of things. Lucretius goes to great lengths to logically deduce certain characteristics of *materia*, such as that it is an eternal substance (l.146-634), that Void (*inane*) does exist and that *materia* needs *inane* for its own existence (l.329-417), and that *primordia* hold certain properties, such that they are solid (*solido. . .corpore* l.486), indestructible (*nulla potest vis/stinguere* l.485-486), indivisible, and everlasting (l.483-634).

Lucretius uses his powers of logic and what he has successfully proven the properties of matter are to, in fact, refute the arguments of three other important Greek philosophers, namely Heraclitus (refutation at l.635-704), Empedocles (l.705-829), and Anaxagoras (l.830-920). Against Heraclitus, he claims to prove that fire cannot be the original substance of which all *materia* is created, for if that were so, everything would be fire, as the only thing fire can produce is fire. Lucretius then denies the views of Empedocles and others, which state that inane does not exist, there is no limit to the division of materia, their primordia are soft and, for the most part, mutually destructive. Anaxagoras takes a similar path as Empedocles, denying the existence of inane, not limiting division of materia, making the primordia soft in their nature. Anaxagoras also

goes on to claim that all things are hidden in all things. Lucretius attacks each one of these "false" opinions, using "pure reason" to shed light on the reader.

In many instances, Lucretius comes up with solid and not all-together false ideas of how matter works. Of course, Lucretius had no access to the technology that we have today, and yet his ideas on materia are not entirely inconsistent with the modern worldview of matter.

Marty Pickens
Description of Project

For my senior research project on Lucretius, I used a concordance of Lucretius to examine every instance of *materia* found in Book I of Lucretius' *De Rerum Natura*. For the most part, I found every instance of *materia*, the general Latin word for "matter" or "wood," in each of the six Books of the *De Rerum Natura*, and did a brief analysis of its context and meaning in each particular instance and then included this section as my Appendix. Next, I paid particularly close attention to all thirty-one occurrences of *materia* in Book I specifically. I analyzed each instance with much more detail, and tried to apply Lucretius' understanding of *materia* in a modern scientific context when necessary. By this method, I hoped to be able to develop a fuller definition of Lucretius' understanding of *materia*, alongside the broader, contemporary definition of matter. The goal of the project was to juxtapose the ancient with the modern, and to see if Lucretius conception of *materia* could be considered the least bit relevant to the scientific concept of matter today.

Marty Pickens
Project Evaluation

Over the course of the year, I have worked diligently, at least on a subjective level. I believe that one of the best things about my project is the doubtless possibility for improvement and expansion. This project could very well be turned into a Ph.D. thesis, and though I have only touched the surface of Lucretius' conception of *materia*, I believe that I have opened a great door for a project in my future studies.

I was disorganized during the greater course of this project, and so I feel like there are many facets of the project that are just so disorganized, and perhaps not as thoroughly examined as I would have liked to do. But, as I mentioned, I do realize that there is much room for improvement, and I look forward to revising my work in the future. I know that the idea behind the project is good, and that I might really be able to come up with something if I demonstrate the much-needed patience in the future.

If I could do this project over, and if I had knowledge of what I have done currently, I would focus on materia of Book I to begin with, and hopefully would have had a much more thoroughly investigative paper. I was just so disorganized at the beginning of the year, that I really did not find a real focal point of my research until about half-way through my second semester.

I have, undoubtedly, worked much harder on this project than I have for any other class. Though I by no means have a perfect paper here, I believe that I have at least an idea of how the research process for my studies in the future might proceed. For my effort (and believe me, there was a ton of it!), I think that I deserve an A. I have spent many a-sleepless night discoursing with the wise-words of Lucretius, and even now, it is

exactly 3:47 AM, and yet I toil, and toil, and toil. It has been a long and arduous task, but I have done what I can at this point (burn-out). I know that I have at least a *semen rerum* here, and look forward to working even harder in the future and reaching completion, if such a dream can be dreamt.