THE IMPACT OF DEMOCRITUS ON MODERN SCIENCE. pdf

1: Democritus: Father of Modern Science - Major Accomplishments

Ultimately, Democritus is credited as being one of the founders of the modern science because his methods and theories closely resemble those of modern astronomers and physicists.

There were two main chronologies current in antiquity for Democritus. According to the first, which was followed by Epicurus among others, Democritus was the teacher of the Sophist Protagoras of Abdera and was born soon after b. The other chronology puts his birth about b. Although there was also more than one ancient chronology for Anaxagoras, this statement probably supports the later dates for Democritus, and these have usually been accepted by modern scholars. The question is an important one for our understanding of the history of thought in the fifth century b. Most of the stories about Democritus are worthless later inventions, but it is probable that he was well-to-do, and stories of extensive travels may have a foundation in fact. His only certainly attested teacher was Leucippus. The titles of more than sixty writings are preserved from a catalog that probably represented the holdings of the library at Alexandria. Of these we have only some alleged quotations, many of which may not be genuine. Democritus left pupils who continued the tradition of his teachings and one of them, Nausiphanes, was the teacher of Epicurus. Epicureanism represents a further elaboration of the physical theories of Democritus, and surviving writings of Epicurus and others provide further interpretations and sometimes specific information about earlier atomist doctrines. According to Posidonius in the first century b. According to others, Democritus was a pupil of Persian magi and Chaldean astrologers, either as a boy in his native Abdera or later in Egypt. Both stories seem to have originated only in the third century b. Moreover, the date of the first appearance of the doctrine in India is probably subsequent to the founding of the Greek kingdom of Bactria, so that coincidences could be due to Greek influences on Indian thought. Consequently, Aristotle is probably right De generatione et corruptine, a23 ff. This need not exclude the possibility that the atomists were also influenced by what is sometimes called Pythagorean number-atomism, although whether this preceded or arose only after the time of Leucippus remains uncertain, and it is clear that Democritus did not invent atomism but received the essentials of the doctrine from Leucippus. By the middle of the fifth century b. Anaxagoras, at least in one view of his doctrine, made a heroic attempt to escape from the difficulty by supposing that all substances were always present in all other substances and that apparent change was simply the emergence of the required substanceâ€”which had been present unnoticed all the time. The atomism of Democritus was similar in its approach but went further in depriving the primary constituents of most, but not all, of the qualities apparent in objects derived from them. Moreover, Leucippus had boldly accepted empty space or voidâ€”the existence of which the Eleatics regarded as impossible because it would be that which is notâ€”as necessary to make movement possible. In general, the atoms were so small as to be invisible. They were all invisible for Epicurus, but later sources raise the possibility that for Democritus some exceptional atoms may have been large enough to be seen or even that an individual atom might be as big as the cosmos. The atoms are physically indivisibleâ€”this is the meaning of the name atomos, which, while not surviving in the fragments of Democritus, must certainly have been used by him. Whether the atoms were conceptually or mathematically indivisible as well as physically is a matter of dispute. They are homogeneous in substance, contain no void and no interstices, and are in perpetual motion in the infinitely extended void, probably moving equally in all directions. When a group of atoms becomes isolated, a whirl is produced which causes like atoms to tend toward like. Within a kind of membrane or garment, as it were, woven out of hook-shaped atoms, there develops a spherical structure which eventually contains earth, sky, and heavenly bodiesâ€”in other words a spherical cosmos. There is no limit to the number of atoms nor to the amount of void, and so not one cosmos but many are formed. Some dissolved again before the formation of our cosmos; others coexist with ours, some larger and some smaller, some without sun or moon, and some without living creatures, plants, or moisture. From time to time a cosmos is destroyed by collision with another. Our earth and everything in it, like everything, elsewhere, is compounded of atoms and void, and there are no other constituents of the universe of any kind. Apart from differences in shape, atoms differ in arrangement and position. We must add, although Aristotle does not say so here, that the spacings

between atoms may vary from the zero space of actual contact through increasing distances apart. Soft and yielding bodies and bodies light in weight contain more void than heavier or harder objects of equal extent. Iron is lighter than lead because it has more void, but it is harder because it is denser than lead at particular points, the void not being distributed evenly throughout, as is the case with lead. It is probable that for Democritus the atoms when entangled do not cease to be in motion their individual movement is naturally less extensive , but they participate in movements of the object of which they are a part. But physical objects possess weight, and according to Aristotle, atoms are heavier in proportion to their excess of bulk. Objects as a whole are heavier the greater the proportion of atoms to void. It may be that weight operates only in a developed world and is the result of a tendency of compound objects to move toward the center of a whirl. All events are determined, and if Cicero is right at all in saying Democritus attributed events to chance, this can have meant only that they could not be predicted, not that they were not determined. The perceived qualitative differences between objects depend upon the nature and arrangement of the relevant atoms and void. The importance and novelty of this doctrine were fully appreciated by Theophrastus, who discussed it at some length in his surviving De sensibus. But Theophrastus complains that Democritus is inconsistent on this point and that, while explaining sensations causally in terms of configurations, he insists that the perceived qualities depend upon the state of the percipientâ€”for example, his healthâ€”to such an extent that the qualities exist not in the object but only in the percipient at the time he is perceiving them. Democritus is said fr. The earth is flat and elongatedâ€”twice as long as it is broad. Although earlier it strayed about, it is now stationary at the center of the universe. The angle between zenith and celestial pole is explained by the tilting of the earth because the warmer air to the southâ€”under the earthâ€”offered less support than that in the north. Earthquakes are caused by heavy rain or drought changing the amount of water in the cavities of the earth. While some explanations of meteorological phenomena were offered in terms of the theory of atoms for example, the attraction of like atoms to like as an explanation of magnetism , in general Democritus seems to have followed traditional explanations drawn from earlier pre-Socratics, above all from Anaximander. The moon, like the earth, contained valleys and glens, and its light was derived from the sun. Two particularly quick-moving constituents of the universe, fire and soul, were for Democritus composed of spherical atoms. Spherical atoms are not themselves either fire or soul but become such by the suitable aggregation of a number of themselves. Such aggregation cannot be by entanglement, which is not possible with spherical atoms, but only by the principle of the attraction of like to like. Whereas air, water, and perhaps earth, and things containing them, were regarded as conglomerations of atoms of all shapes, only the one shape seems to have occurred in fire and soul. Aristotle more than once speaks as if soul and fire were identical, and he adds that the soul can be fed by breathing in suitable atoms from the air around us. In this way, losses of soul atoms from the body can be replaced. When we can no longer breathe, the pressure from the atmosphere outside continues to squeeze out the soul atoms from the body and death results. A slight excess of loss over replacement produces sleep only and not death. Even when death results, the loss of soul atoms takes time, so that some functions, such as growth of hair and nails, continue for a while in the tomb; a certain degree of sensation may also continue for a time, and in exceptional cases, even resuscitation may be possible. We do not know the contents of the work On Those in Hades, attributed to Democritus, except that it included reference to such resuscitations. Within the living body, soul atoms are distributed throughout the whole in such a way that single atoms of the soul and body alternate, and it has sometimes been said that this involves treating isolated atoms as soul atoms and so reintroducing qualities into individual atoms. But such an alternation could be achieved within a lattice pattern of one kind or another for the soul atoms, so that there is no actual inconsistency. These soul atoms are the immediate source of life, warmth, and motion in a living body. In addition to the soul atoms dispersed throughout the body, there is another part of the soul, the mind, located in one part of the body, namely the head. Sensation for Democritus was based upon touch and was due to images entering the sense organs from outside and producing alterations in the percipient. Sensation is thus the result of the interaction of image and organ. In the case of flavors, there is always a multitude of configurations of atoms present in what is tasted, but the preponderant configuration exerts the greatest influence and determines the flavor tasted, the result being influenced also by the state of the sense organs. In

the case of sight, images continually stream off the objects, which are somehow imprintedâ€”by stamping, as it wereâ€”on the intervening air. This imprinted air is then carried to the eyes, where its configuration produces the sensation of color. A similar analysis seems to have been offered for hearing and perhaps for smell. Taste, however, entails direct contact between organ and object: Thought, like sensation, is the result of a disturbance of the soul atoms by configurations of atoms from outside; it is what occurs when the soul achieves a fresh balance after the movement which is sensation. But there is no sure evidence to suggest that Democritus held the later theory of Epicurus that it is possible for certain externally originating images to bypass the senses and secure direct access to the mind in thought. For Democritus, thought follows after sensation, and we may believe that Democritus expressed his real view when he said fr. Nonetheless, in an important fragment fr. To the bastard belong the senses; genuine knowledge operates on objects too fine for any sense to grasp. This must surely refer to our knowledge of the atomic theory, including the imperceptible atoms and void of which things are composed, but we do not know what mechanical procedure, if any, Democritus envisaged for the acquisition of such knowledge. It follows from the above view of the soul and the way it leaves the body at death that there is no survival of the individual soul, although the soul atoms themselves survive because, like all atoms, they are indestructible. But he accepted that images of beings both beneficent and maleficent, destructible and yet able to foretell the future while being seen and heard, come to men apparently out of the air itself, without any more ultimate source. We do not know what doctrine lies behind this, but it is likely that there was no external source posited for these images other than the soul atoms at large in the air. Protagoras had argued that the tangent touches the circle not at one point but over a distance. It is inferred that he supposed that the sphere is really a polyhedron with imperceptibly small faces, presumably because a physical sphere involves atoms which cannot be further broken down. In such a case he would be in agreement with Protagoras as to the actual relation between tangent and circle while in disagreement as to the apparent relation. But with atoms in an infinite variety of shapes. In any case Democritus could probably distinguish a physical from a mathematical sphere well enough. If equal, it might seem that the cone is a cylinder, while if unequal, the cone becomes steplike and uneven fr. Some suppose that he argued for a stepped physical cone; others that he regarded the dilemma as genuine; and still others that he considered them equal, at least as far as mathematics was concerned. Archimedes records that Democritus was concerned with the ratios of size between cylinders, pyramids, and prisms of the same base and height. The indications that survive do not for the most part suggest that he made any very particular application of atomic theories to biology, and it is probable that his clearly extensive writings were essentially within the general framework of Ionian speculation. More we cannot say through lack of positive information. Later writersâ€”as well as some from the fifth and fourth centuries b. They have in common not only various particular points but also a basic conceptionâ€”namely, that civilization developed from lower levels to higher, which contrasted strongly with the dominant view that human history represented a continuous decline from an original golden age. The clearest version of this history of culture survives in the Bibliotheca historica of Diodorus bk. It is clear that Democritus held a similar view, and it is possible, although by no means certain, that he originated the whole tradition. Many of these are attributed in the manuscript tradition not to Democritus but to an otherwise unknown Democrates, so that their authority for the reconstruction of the views of Democritus is uncertain. Most of the fragments are extremely commonplace, and hardly any are related to atomic theory. It was based on a physical state, the actual constitution of the body at any one time, of which the external expression is pleasure or enjoyment when the state itself is satisfactory. Even this much is a matter of conjecture, and we do not know how it was all worked out by Democritus.

2: Scientific Contribution - Democritus

Democritus adopted the theory, developed it further, and provided a more detailed and systematic view of the physical world. According to Democritus' atomic theory, everything is made up of atoms, which are physically indivisible: atoms are indestructible, eternal and invisible, small and unable to be diminished.

Life and Works According to ancient reports, Democritus was born about BCE thus, he was a younger contemporary of Socrates and was a citizen of Abdera, although some reports mention Miletus. As well as his associate or teacher Leucippus, Democritus is said to have known Anaxagoras, and to have been forty years younger than the latter DK 68A1. A number of anecdotes concern his life, but their authenticity is uncertain. The work of Democritus has survived only in secondhand reports, sometimes unreliable or conflicting. Much of the best evidence is that reported by Aristotle, who regarded him as an important rival in natural philosophy. Aristotle wrote a monograph on Democritus, of which only a few passages quoted in other sources have survived. Democritus seems to have taken over and systematized the views of Leucippus, of whom little is known. Diogenes Laertius lists a large number of works by Democritus on many fields, including ethics, physics, mathematics, music and cosmology. Two works, the Great World System and the Little World System see the entry on doxography of ancient philosophy , are sometimes ascribed to Democritus, although Theophrastus reports that the former is by Leucippus DK 68A Atomist Doctrine Ancient sources describe atomism as one of a number of attempts by early Greek natural philosophers to respond to the challenge offered by Parmenides. Despite occasional challenges Osborne , this is how its motivation is generally interpreted by scholars today. Parmenides had argued that it is impossible for there to be change without something coming from nothing. Since the idea that something could come from nothing was generally agreed to be impossible, Parmenides argued that change is merely illusory. In response, Leucippus and Democritus, along with other Presocratic pluralists such as Empedocles and Anaxagoras, developed systems that made change possible by showing that it does not require that something should come to be from nothing. These responses to Parmenides suppose that there are multiple unchanging material principles, which persist and merely rearrange themselves to form the changing world of appearances. In the atomist version, these unchanging material principles are indivisible particles, the atoms: Reconstructions offered by Wardy and Sedley argue, instead, that atomism was developed as a response to Parmenidean arguments. The atomists held that there are two fundamentally different kinds of realities composing the natural world, atoms and void. They move about in an infinite void, repelling one another when they collide or combining into clusters by means of tiny hooks and barbs on their surfaces, which become entangled. Other than changing place, they are unchangeable, ungenerated and indestructible. All changes in the visible objects of the world of appearance are brought about by relocations of these atoms: Macroscopic objects in the world that we experience are really clusters of these atoms; changes in the objects we seeâ€”qualitative changes or growth, sayâ€”are caused by rearrangements or additions to the atoms composing them. While the atoms are eternal, the objects compounded out of them are not. Clusters of atoms moving in the infinite void come to form kosmoi or worlds as a result of a circular motion that gathers atoms up into a whirl, creating clusters within it DK 68B ; these kosmoi are impermanent. Our world and the species within it have arisen from the collision of atoms moving about in such a whirl, and will likewise disintegrate in time. Schofield argues that this particular phrase originated with Democritus and not his teacher Leucippus. By putting the full or solid and the void ontologically on a par, the atomists were apparently denying the impossibility of void. Void they considered to be a necessary condition for local motion: Melissus had argued from the impossibility of void to the impossibility of motion; the atomists apparently reasoned in reverse, arguing from the fact that motion exists to the necessity for void space to exist DK 67A7. Some controversy surrounds the properties of the atoms. They vary in size: They can take on an infinite variety of shapes: Many kinds of atoms can interlock with one another because of their irregular shapes and hooks at their surface, accounting for the cohesiveness of some compounds. It is not clear whether the early atomists regarded atoms as conceptually indivisible or merely physically indivisible Furley The idea that there is a smallest possible magnitude seems to suggest that

this is the lower limit of size for atoms, although notions like being in contact or having shape seem to entail that even the smallest atoms have parts in some sense, if only mathematically or conceptually. There are conflicting reports on whether atoms move in a particular direction as a result of their weight: Atoms may have an inherent tendency to a kind of vibratory motion, although the evidence for this is uncertain McDiarmid However, their primary movement seems to result from collision with other atoms, wherein their mutual resistance or antitupia causes them to move away from one another when struck. According to different reports, Democritus ascribed the causes of things to necessity, and also to chance. Democritus apparently recognized a need to account for the fact that the disorderly motion of individual distinct atoms could produce an orderly cosmos in which atoms are not just randomly scattered, but cluster to form masses of distinct types. He compares this to the winnowing of grains in a sieve, or the sorting of pebbles riffled by the tide: Although this claim has been interpreted differently e. No attractive forces or purposes need be introduced to explain the sorting by the tide or in the sieve: Democritus regards the properties of atoms in combination as sufficient to account for the multitude of differences among the objects in the world that appears to us. This passage omits differences of size, perhaps because it is focused on the analogy to letters of the alphabet: He famously denies that perceptible qualities other than shape and size and, perhaps, weight really exist in the atoms themselves: The contrast here is intended to be that between real and unreal properties Furley ; cf. If this report is genuinely Democritean, it would broaden the scope of the claim considerably: One report indeed attributes to Democritus a denial that two things could become one, or vice versa DK 68A42 , thus suggesting that combinations are regarded as conventional. However, Furley concedes that Plutarch at least understands the earliest atomists to be committed to the view that all combinations of atoms, as much as sensible qualities, should be understood as conventional rather than real Furley pp. This would suggest that everything at the macroscopic levelâ€”or, strictly, everything available to perceptionâ€”is regarded as unreal. The ontological status of arrangement or combination of atoms for Democritus is a vexed question, that affects our understanding of his metaphysics, his historical relationship to Melissus, and the similarity of his views to the modern primary-secondary quality distinction Wardy ; Curd ; Lee ; Mourelatos ; Pasnau Later atomists cite as evidence for this the gradual erosion of bodies over time. These films of atoms shrink and expand; only those that shrink sufficiently can enter the eye. It is the impact of these on our sense organs that enables us to perceive. Visible properties of macroscopic objects, like their size and shape, are conveyed to us by these films, which tend to be distorted as they pass through greater distances in the air, since they are subject to more collisions with air atoms. The properties perceived by other senses are also conveyed by contact of some kind. However, it may be that most explanations are directed towards the normal case of a typical observer, and that a different account is given as to the perceptions of a nontypical observer, such as someone who is ill. One is that a given substance like honey is not quite homogeneous, but contains atoms of different shapes. While it takes its normal character from the predominant type of atom present, there are other atom-types present within. The other is that our sense-organs need to be suitably harmonized to admit a given atom-type, and the disposition of our passageways can be affected by illness or other conditions. Other observed effects, however, require a theory whereby the same atoms can produce different effects without supposing that the observer has changed. The change must then occur in the object seen. The explanation of color seems to be of this variety: Aristotle gives this as the reason why color is not ascribed to the atoms themselves. This seems to assume that, while an appearance of a property P can be produced by something that is neither P nor not-P, nonetheless something P cannot appear not-P. Since atoms do not change their intrinsic properties, it seems that change in a relational property, such as the relative position of atoms, is most likely to be the cause of differing perceptions. In the shifting surface of the sea or the flutter of the pigeon with its irridescent neck, it is evident that the parts of the object are moving and shifting in their positional relations. By ascribing the causes of sensible qualities to relational properties of atoms, Democritus forfeits the prima facie plausibility of claiming that things seem P because they are P. Democritus is flying in the face of at least one strand of commonsense when he claims that textures produce the appearance of hot or cold, impacts cause colour sensations. The lists of examples offered, drawing on commonsense associations or anecdotal experience, are attempts to make such claims persuasive. Heat is said to be caused by spherical atoms, because these move

freely: The jagged atoms associated with bitter taste are also said to be heat-producing: It is not so much the specific intrinsic qualitiesâ€”smooth or jagged shapeâ€”as the motion of those shapes that provides the explanation. Aristotle sometimes criticizes Democritus for claiming that visible, audible, olfactory and gustatory sensations are all caused by touch DK 68A Quite how this affects the account of perception is not clear, as the sources tells us little about how touch is thought to work. Democritus does not, however, seem to distinguish between touch and contact, and may take it to be unproblematic that bodies communicate their size, shape and surface texture by physical impact. According to Aristotle, Democritus regarded the soul as composed of one kind of atom, in particular fire atoms. This seems to have been because of the association of life with heat, and because spherical fire atoms are readily mobile, and the soul is regarded as causing motion. Democritus seems to have considered thought to be caused by physical movements of atoms also. This is sometimes taken as evidence that Democritus denied the survival of a personal soul after death, although the reports are not univocal on this. One difficulty faced by materialist theories of living things is to account for the existence and regular reproduction of functionally adapted forms in the natural world. Although the atomists have considerable success in making it plausible that a simple ontology of atoms and void, with the minimal properties of the former, can account for a wide variety of differences in the objects in the perceptible world, and also that a number of apparently orderly effects can be produced as a byproduct of disorderly atomic collisions, the kind of functional organization found in organisms is much harder to explain. Democritus seems to have developed a view of reproduction according to which all parts of the body contribute to the seed from which the new animal grows, and that both parents contribute seed DK 68A; The theory seems to presuppose that the presence of some material from each organ in the seed accounts for the development of that organ in the new organism. Parental characteristics are inherited when the contribution of one or other parent predominates in supplying the appropriate part. The offspring is male or female according to which of the two seeds predominates in contributing material from the genitals. In an atomist cosmos, the existence of particular species is not considered to be eternal. Like some other early materialist accounts, Democritus held that human beings arose from the earth DK 68A , although the reports give little detail. Theory of Knowledge One report credits Democritus and Leucippus with the view that thought as well as sensation are caused by images impinging on the body from outside, and that thought as much as perception depends on images DK 67A Thought as well as perception are described as changes in the body. Democritus apparently recognized that his view gives rise to an epistemological problem: A famous fragment may be responding to such a skeptical line of thought by accusing the mind of overthrowing the senses, though those are its only access to the truth DK68B Other passages talk of a gap between what we can perceive and what really exists DK 68B6â€”10; But the fact that atoms are not perceptible means that our knowledge of their properties is always based on analogy from the things of the visible world. Thus the potential for doubt about our knowledge of the external world looms large. Arguments of this form were used for sceptical purposes, citing the conflicting evidence of the senses in order to raise concern about our knowledge of the world de Lacy Democritus does not seem to be pursuing a consistently skeptical program, although he does express concern about the basis for our knowledge. Some scholars take this to be a deflationary attack on traditional theology as based on mere images Barnes , pp.

3: Atomic Ideas / Early ideas of Democritus and Dalton

Drawbacks of Democritus Atomic Theory - Origins and Impacts to Modern Atomic Theories - Democritus' statement was based on his mere observation that was inspired by the sand particles that formed the beach.

Plasmas are only found in the coronae and cores of stars. The state of matter is determined by the strength of the bonds between the atoms that makes up matter. Thus, is proportional to the temperature or the amount of energy contained by the matter. For example, ice solid water converts melts into liquid water as energy is added. Continue adding energy and the water boils to steam gaseous water then, at several million degrees, breaks down into its component atoms. The key point to note about atomic theory is the relationship between the macroscopic world us and the microscopic world of atoms. For example, the macroscopic world deals with concepts such as temperature and pressure to describe matter. The microscopic world of atomic theory deals with the kinetic motion of atoms to explain macroscopic quantities. An ideal gas is a gas that conforms, in physical behavior, to a particular, idealized relation between pressure, volume, and temperature. Such a relation for a substance is called its equation of state and is sufficient to describe its gross behavior. Although no gas has these properties, the behavior of real gases is described quite closely by the ideal gas law at sufficiently high temperatures and low pressures, when relatively large distances between molecules and their high speeds overcome any interaction. A gas does not obey the equation when conditions are such that the gas, or any of the component gases in a mixture, is near its condensation point. This is done by using as the mass unit the gram-mole; i. This constant has been measured for various gases under nearly ideal conditions of high temperatures and low pressures, and it is found to have the same value for all gases: A gas does not obey the equation when conditions are such that the gas, or any of the component gases in a mixture, is near its triple point see below. While all the above conditions are not strictly true, where they breakdown interesting things happen - such as friction in general the behavior of matter is well described by this kinetic theory. A fast graphic way to display the various states is called a phase diagram. A phase diagram is a graph showing the limiting conditions for solid, liquid, and gaseous phases of a single substance or of a mixture of substances while undergoing changes in pressure and temperature or in some other combination of variables, such as solubility and temperature. The figure shown below displays a typical phase diagram for a one-component system i. At any point on the curves, the temperature and pressure allow two phases to exist in equilibrium: For example, the line drawn for the variation with temperature of gas pressure for the liquid is the boundary between liquid and gas; only gas can exist on the low-pressure, high-temperature side of the line, while the substance must be liquid on the high-pressure, low-temperature side; liquid and gas exist together at temperatures and pressures corresponding to points on the line; at the place where this line vanishes, called the critical point, the liquid and its gas become indistinguishable. Along the line between liquid and solid, the melting temperatures for different pressures can be found. The junction of the three curves, called the triple point, represents the unique conditions under which all three phases exist in equilibrium together. A substance triple point can have an enormous impact on the evolution of that substance. A central consideration of thermodynamics is that any physical system, whether or not it can exchange energy and material with its environment, will spontaneously approach a stable condition equilibrium that can be described by specifying its properties, such as pressure, temperature, or chemical composition. If the external constraints are changed for example, if the system is allowed to expand , then these properties will generally alter. The science of thermodynamics attempts to describe mathematically these changes and to predict the equilibrium conditions of the system. The first law of thermodynamics is often called the law of the conservation of energy actually mass-energy because it says, in effect, that, when a system undergoes a process, the sum of all the energy transferred across the system boundary--either as heat or as work--is equal to the net change in the energy of the system. Cars rust, dead trees decay, buildings collapse; all these things are examples of entropy in action, the spontaneous movement from order to disorder. There is one more influence of cosmological relationships upon macroscopic physics, which arises in connection with thermodynamics. The existence of irreversible processes in thermodynamics indicates a distinction between the positive and negative directions in time. As

Clausius recognized in the 19th century, this irreversiblity reflects a quantity, first defined by him, called entropy, which measures the degree of randomness evolving from all physical processes by which their energies tend to degrade into heat. Entropy can only increase in the positive direction of time. In fact, the increase in entropy during a process is a measure of the irreversiblity of that process. For example, you can pump heat out of a refrigerator to make ice cubes , but the heat is placed in the house and the entropy of the house increases, even though the local entropy of the ice cube tray decreases. In a closed system, entropy never decreases. In open systems, entropy can decrease in local regions e. In the growth of crystals, for example, the ordered arrangement of ions in a lattice produces heat which flows away to the nearby environment. The entropy of the whole Universe always increased with time. The approach to equilibrium is therefore an irreversible process. The tendency toward equilibrium is so fundamental to physics that the second law is probably the most universal regulator of natural activity known to science. The concept of temperature enters into thermodynamics as a precise mathematical quantity that relates heat to entropy. The interplay of these three quantities is further constrained by the third law of thermodynamics, which deals with the absolute zero of temperature and its theoretical unattainability. Absolute zero approximately C would correspond to a condition in which a system had achieved its lowest energy state. The third law states that, as this minimum temperature is approached, the further extraction of energy becomes more and more difficult. Why are our memories always of the past and never of the future? All the fundamental Newtonian laws are time reversible. Collisions look the same forwards or backwards. However, it is possible to show that the continual random molecular motions will cause the entire ensemble to visit and revisit every possible state of the box, much like the continual shuffling of a deck of cards will eventually reproduce any sequence. If a box of gas is in a low entropy state at one moment, it will very probably soon be in a less ordered state since given the large number of states for it to evolve to, most of those states are of higher entropy. So just by the laws of chance, the box has a higher probability of becoming a higher entropy state rather than a lower one since there are so many more possible high entropy states. Cracked eggs do not repair themselves. Defined by these events, time has an arrow, a preferred direction. Entropy and the arrow of time are strongly linked. Increasing entropy is in the direction of positive time. However, a study of the components to systems shows that the parts are describable in terms of time-symmetric laws. In other words, the microscopic world is ruled by time-symmetric laws, but the macroscopic world has a particular direction.

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4: Who is Democritus? Biography & Atomic Theory Discoveries of Democritus

1. Life and Works. According to ancient reports, Democritus was born about BCE (thus, he was a younger contemporary of Socrates) and was a citizen of Abdera, although some reports mention Miletus.

Z Democritus â€" B. Democritus was born at Abdera, about BCE, although according to some His father was from a noble family and of great wealth, and contributed largely towards the entertainment of the army of Xerxes on his return to Asia. As a reward for this service the Persian monarch gave and other Abderites presents and left among them several Magi. Democritus, according to Diogenes Laertius, was instructed by these Magi in astronomy and theology. After the death of his father he traveled in search of wisdom, and devoted his inheritance to this purpose, amounting to one hundred talents. He is said to have visited Egypt, Ethiopia, Persia, and India. Whether, in the course of his travels, he visited Athens or studied under Anaxagoras is uncertain. During some part of his life he was instructed in Pythagoreanism, and was a disciple of Leucippus. After several years of traveling, Democritus returned to Abdera, with no means of subsistence. His brother Damosis, however, took him in. According to the law of Abdera, whoever wasted his patrimony would be deprived of the rites of burial. Democritus, hoping to avoid this disgrace, gave public lectures. Petronius relates that he was acquainted with the virtues of herbs, plants, and stones, and that he spent his life in making experiments upon natural bodies. He acquired fame with his knowledge of natural phenomena, and predicted changes in the weather. He used this ability to make people believe that he could predict future events. They not only viewed him as something more than mortal, but even proposed to put him in control of their public affairs. He preferred a contemplative to an active life, and therefore declined these public honors and passed the remainder of his days in solitude. Democritus has been commonly known as "The Laughing Philosopher," and it is gravely related by Seneca that he never appeared in public with out expressing his contempt of human follies while laughing. Accordingly, we find that among his fellow-citizens he had the name of "the mocker". He died at more than a hundred years of age. It is said that from then on he spent his days and nights in caverns and sepulchers, and that, in order to master his intellectual faculties, he blinded himself with burning glass. This story, however, is discredited by the writers who mention it insofar as they say he wrote books and dissected animals, neither of which could be done well without eyes. Democritus expanded the atomic theory of Leucippus. From the difficulty of assigning a beginning of time, he argued the eternity of existing nature, of void space, and of motion. He supposed the atoms, which are originally similar, to be impenetrable and have a density proportionate to their volume. All motions are the result of active and passive affection. He drew a distinction between primary motion and its secondary effects, that is, impulse and reaction. This is the basis of the law of necessity, by which all things in nature are ruled. The worlds which we see -- with all their properties of immensity, resemblance, and dissimilitude -- result from the endless multiplicity of falling atoms. The human soul consists of globular atoms of fire, which impart movement to the body. Maintaining his atomic theory throughout, Democritus introduced the hypothesis of images or idols eidola , a kind of emanation from external objects, which make an impression on our senses, and from the influence of which he deduced sensation aesthesis and thought noesis. He distinguished between a rude, imperfect, and therefore false perception and a true one. In the same manner, consistent with this theory, he accounted for the popular notions of Deity; partly through our incapacity to understand fully the phenomena of which we are witnesses, and partly from the impressions communicated by certain beings eidola of enormous stature and resembling the human figure which inhabit the air. We know these from dreams and the causes of divination. He carried his theory into practical philosophy also, laying down that happiness consisted in an even temperament. From this he deduced his moral principles and prudential maxims. It was from Democritus that Epicurus borrowed the principal features of his philosophy. Author Information The author of this article is anonymous. The IEP is actively seeking an author who will write a replacement article. An encyclopedia of philosophy articles written by professional philosophers.

5: Drawbacks of Democritus Atomic Theory - Origins and Impacts - Az Chemistry

Democritus was an amazing philosopher who mainly studied the atomic theory. He was born somewhere around BC, and died around BC. Many of his findings and beliefs are what we still hold correctly today.

The originator of the atomic theory, Leucippus fifth century BCE , must be considered a speculative thinker of the first order, but to Democritus c. We have very little biographical data for Leucippus. Leucippus was probably born at Miletus; reports associating him with Elea or Abdera should be taken as reflecting views concerning his philosophical affiliations rather than as reliable evidence for his birthplace. He was presumably older than Democritus. His book On Mind may have been directed partly against Anaxagoras, and according to Theophrastus, Diogenes of Apollonia derived some of his theories from Leucippus. All this suggests that Leucippus was a slightly younger contemporary of Anaxagoras and that his main philosophical activity fell some time within the broad limits of â€" BCE. Democritus was born at Abdera. On this evidence the date given for his birth by Apollodorus in the 80th Olympiad, â€" BCE is generally preferred to that suggested by Thrasylus the third year of the 77th Olympiad, â€" BCE. He is variously reported to have lived between 90 and years. To judge from the number of his writings, his literary activity extended over a considerable period, but we have no means of assigning different works to different times in his life. There are the accounts of his saving the Abderites from a plague, of his dying by voluntarily abstaining from food, and of his reputation as the "Laughing Philosopher. All that has been preserved of the original writings of Leucippus and Democritus is a poor selection of isolated quotations, most of which derive from the ethical works of Democritus. For the atomic theory itself we rely on reports in Aristotle, Theophrastus, and later doxographers, who were often unsympathetic to the views of the atomists. In most of the principal texts referring to Leucippus, his doctrines are not clearly distinguished from those of Democritus, and the precise contribution of each philosopher is in question. Aristotle, however, undoubtedly treated Leucippus as the founder of atomism De Generatione et Corruptione a23ff. Democritus evidently elaborated the atomic theory and was responsible for the detailed account of sensible qualities, besides going far beyond Leucippus both in the range of his scientific inquiries and in his interest in moral philosophy. Democritus, on the other hand, wrote some sixty-odd works, the titles of which provide valuable evidence of the scope of his interests. The main works were cataloged by Thrasylus into thirteen tetralogies. These were followed by nine works not arranged in tetralogiesâ€"for example, Causes of Celestial Phenomena, Causes concerning Seeds, Plants and Fruits, and three books of Causes concerning Animals. Three tetralogies are classified as mathematics, two deal with music and literature, and two consist of technical works, including treatises on medicine, agriculture, painting, and warfare. Tthe Atomic Theory The basic postulate of Greek atomism in its original form was that atoms and the void alone are real. The differences between physical objects, including both qualitative differences and what we think of as differences in substance, were all explained in terms of modifications in the shape, arrangement, and position of the atoms. This theory was already interpreted by Aristotle as an answer to the Eleatic denial of change and movement. Other post-Parmenidean philosophers had countered this denial in different ways, but both Empedocles and Anaxagoras had assumed a variety of elemental substances, on the one hand, the four "roots," on the other, an original mixture containing every kind of natural substance. Yet whereas the Eleatics denied the existence of the void, or "what is not," Leucippus maintained that not only "what is" the atoms , but also "what is not" the void , must be considered real. Leucippus thereby reinstated both plurality and change; the void is that which separates the atoms and that through which they move. The atoms are infinite in number, dispersed through an infinite void. Their shapes are infinitely various, there being no reason that any atom should be of one shape rather than another. Democritus, at least, also allowed differences in the sizes of the atoms, but whether he thought any atom large enough to be visible seems doubtful. The atoms are in continuous motion. Aristotle, among others, objected that the atomists did not explain the origin of movement or say what kind of movement is natural to the atoms. However, they evidently assumed that the motion of the atoms is eternal, just as the atoms themselves are, and they perhaps drew no clear distinction between original and derived motion. Although Epicurus was later to suggest that atoms naturally fall vertically, the earlier

atomists probably did not consider movement in any particular direction prior to movement in any other. Weight for them, it seems, was not a primary property of the atoms nor a cause of their interactions, although in a developed cosmos the atoms have "weight" corresponding to their size and the weight of compound bodies varies according to the proportion of atoms and void they contain. The movements of the atoms give rise to constant collisions whose effects are twofold. Sometimes, the atoms rebound from one another; alternatively, when the colliding atoms are hooked or barbed or their shapes otherwise correspond, they cohere and thus form compound bodies. Change of all sorts is accordingly interpreted in terms of the combining and separating of atoms, which themselves remain unaltered in substance. The compound bodies thus formed possess various sensible qualitiesâ€”color, taste, temperature, and so onâ€”and Democritus undertook a detailed exposition relating these qualities to specific atomic configurations. The process begins when a large group of atoms becomes isolated in a great void. There they conglomerate and form a whirl or vortex in which atoms of similar shape and size come together. In this vortex the finer atoms are squeezed out into the outer void, but the remainder tend toward the center, where they form a spherical mass. More atoms are drawn into this mass on contact with the whirl, and some of these are ignited by the speed of the revolution, thus forming the heavenly bodies. Earth is formed by atoms that cohere in the center of the mass. The cosmogonical process is not unique. The atomists argued that since atoms and the void are infinite, there are innumerable worlds. These worlds are not all alike, however; Democritus held that some worlds have no sun or moon and that some lack moisture and all forms of life Hippolytus, Refutatio I, 13, 2f. Leucippus explicitly stated that "nothing happens at random, but everything for a reason and by necessity" Fr. Thus, they doubtless conceived the vortex to arise from certain mechanical interactions between the colliding atoms, although it is unlikely that they attempted to say precisely how this came about. Democritus illustrated his doctrine that like things tend to come together with examples drawn from both the inanimate and the animate sphere Fr. And like many of the pre-Socratics, the atomists constructed their cosmogony in part on an embryological model. He accepted the old Ionian picture of a flat earth, tilted toward the south, and he believed that the sun is the most distant of the heavenly bodies. This theory was a materialist one in line with the principles of atomism. Democritus conceived of the soul as consisting of spherical atoms, this being the shape best adapted to penetrate and move things. Fire, too, is composed of spherical atoms, and he evidently subscribed to the common Greek belief in the connection between life and heat, now interpreted in terms of the similarity in the shapes of soul atoms and fire atoms. The soul atoms tend to be extruded from the body by the pressure of the surrounding air, but this process is counteracted by other soul atoms that enter the body with the air we breathe; life depends on this continuous replenishment. Several of the fragments that he quotes appear to express an extreme skepticismâ€”for instance, "We know nothing truly about anything" Fr. However, Fragment 11 shows that Democritus was no outright skeptic. There he distinguished between two modes of cognition; the senses provide what is called a "bastard" knowledge but contrasted with this is a "legitimate" knowledge, which operates on objects too fine for the senses to perceive. Clearly, "legitimate" knowledge relates to atoms and the void, which alone are real; the objects of sensation, on the other hand, exist "by convention" Fr. Yet although we must rely on reasoning to attain knowledge, Democritus acknowledged that the mind derives its data from the senses Fr. Not a pure intellectualist like Parmenides, a crude sensationalist like Protagoras, nor a complete skeptic as Gorgias made himself out to be, Democritus advocated critical reflection on the evidence of the senses as our best means of approaching the truth; yet since thought itself, like sensation, involves physical interactions between atoms, it, too, is subject to distortion, and even "legitimate" knowledge is at best, it seems, only opinion Fr. According to Alexander In Librum de Sensu 24, 14ff. Democritus modified and complicated this doctrine by suggesting that images from both the object and the eye itself meet and imprint the air in front of the eye. Each of the other senses, too, is produced by contact between the organ and images deriving from the object, and thought was analogously explained as the contact between soul atoms and images coming from outside the body. But not content merely to assert in general terms that secondary qualities are due to differences in the shapes and sizes of the atoms, Democritus also proposed a detailed account relating specific tastes, colors, smells, and so on to specific shapes. Thus, an acid taste is composed of angular, small, thin atoms and a sweet taste of round, moderate-sized ones. We have,

however, little evidence on the part of his mathematical work that related directly to the atomic theory. The atoms are definitely conceived of as physically indivisible on the grounds that they are solid and contain no void , but it is not clear whether they are absolute minima in the sense of being mathematically indivisible. Epicurus later distinguished between atomic bodies which are physically indivisible but logically divisible and the "minima in the atom. Unless Aristotle has completely misrepresented the atomists, it would appear that Democritus was unaware of any inconsistency in holding both 1 that the atoms have different shapes and sizes and 2 that they are mathematically as well as physically indivisible. But it must be repeated that the evidence on which to convict or absolve Democritus of this gross confusion is scanty. There remain, however, wide disagreements on the nature and value of his moral teaching. And sayings such as Fragment 45 "The wrongdoer is more unfortunate than he who is wronged" express views more commonly associated with Socrates than with Democritus. The ethical ideal is termed "well-being" or "cheerfulness," which is to be gained through uprightness and a harmonious life. Although Democritus clearly implied that life without pleasure is not worth living and even said that pleasure is the mark of what is expedient Fr. Sensual pleasures are condemned as short-lived. He repeatedly stressed that we should moderate our desires and ambitions, become self-sufficient, and be content, in the main, with simple pleasures. Yet Democritus was no quietist. Rather, he recognized that worthwhile objects are to be achieved only through effort Frs. In part, he seems to have rationalized belief in the gods as a mistaken inference from terrifying natural phenomena Sextus, Adversus Mathematicos IX, 24 , and yet he did not dismiss notions of the gods entirely, for he appears to have related certain such ideas to images, some beneficent, some harmful, that visit humans Fr. Religious sanctions are, however, rigorously excluded from his ethics. He refuted those who concocted fictions concerning the afterlife Fr. Equally, he castigated those who invented chance as an excuse for their own thoughtlessness or who failed to recognize that their misfortunes stemmed from their own incontinence Frs. Throughout his ethics he may be said to have set high standards of personal integrity and social responsibility. In some respects, such as in the idea that excesses "cause great movements in the soul"â€”that is, presumably, in the soul atoms Fr. Whether we should expect other aspects of the atomic doctrine to be in evidence in the ethical fragments seems very doubtful. Democritus clearly did not feel nor need he have felt that the notion of necessity in his physics the belief that every event has a definite cause to be sought in the interactions of the atoms conflicted with his doctrine of moral responsibility in the sphere of human behavior. His denial of supernatural sanctions in his ethics parallels his rejection of teleology in his cosmology. And his ethics have in common with his epistemological theory that he argued against an unreflecting acceptance of the evidence of the senses concerning what is pleasant just as much as concerning the nature of reality as a whole. According to this, primitive peoples originally gathered in groups for the sake of mutual protection from wild animals, and subsequently language and the arts were also invented under the spur of human needs. Fragment may be taken to suggest that he believed that the earliest arts although not some of the later ones were products of necessity, and in Fragment he argued that humans learned many of their skills by copying the behavior of animals. The theory founded by Leucippus and developed by Democritus was the most coherent and economical physical system of its day, and the history of its influence can be traced from the fourth century BCE to modern times. Although Plato mentioned neither Leucippus nor Democritus, the Timaeus is markedly indebted to their thought. Even Aristotle, who rejected atomism outright, conceded that of all his predecessors Democritus was the most notable physicist. Later, the Epicureans championed atomism against the continuum theory of the Stoics. Harvard University Press, More recent collections of texts are S. Luria, Democritea Leningrad, ; original texts of fragments and testimonia with Russian translation and commentary and C. A Text and Translation with a Commentary Toronto:

6: Democritus - Wikipedia

Democritus was a remarkable Greek Philosopher best known for his contributions to modern science that exceed those of any other pre-Socratic philosopher. He is famously known as the "laughing philosopher" due to his habit of mocking people on their mistakes.

The order of the works is not chronological the chronology is now difficult to determine but was deliberately chosen by Theophrastus to constitute a well-structured system. Aristotle discusses the square of opposition or square of Apuleius in Chapter 7 and its appendix Chapter 8. Chapter 9 deals with the problem of future contingents. The Prior Analytics Greek: The Posterior Analytics Greek: Analytica Posteriora deals with demonstration , definition , and scientific knowledge. Topica treats of issues in constructing valid arguments, and of inference that is probable, rather than certain. It is in this treatise that Aristotle mentions the predicables , later discussed by Porphyry and by the scholastic logicians. The Sophistical Refutations Greek: Aristotle introduced what may be called a scientific method. He provided another of the ingredients of scientific tradition: For Aristotle, universal truths can be known from particular things via induction. To some extent then, Aristotle reconciles abstract thought with observation, although it would be a mistake to imply that Aristotelian science is empirical in form. Indeed, Aristotle did not accept that knowledge acquired by induction could rightly be counted as scientific knowledge. Nevertheless, induction was for him a necessary preliminary to the main business of scientific enquiry, providing the primary premises required for scientific demonstrations. Aristotle largely ignored inductive reasoning in his treatment of scientific enquiry. To make it clear why this is so, consider this statement in the Posterior Analytics: We suppose ourselves to possess unqualified scientific knowledge of a thing, as opposed to knowing it in the accidental way in which the sophist knows, when we think that we know the cause on which the fact depends, as the cause of that fact and of no other, and, further, that the fact could not be other than it is. It was therefore the work of the philosopher to demonstrate universal truths and to discover their causes. For this task Aristotle used the tool of deductive reasoning in the form of syllogisms. Using the syllogism, scientists could infer new universal truths from those already established. Aristotle developed a complete normative approach to scientific inquiry involving the syllogism, which he discusses at length in his Posterior Analytics. A difficulty with this scheme lay in showing that derived truths have solid primary premises. Aristotle would not allow that demonstrations could be circular supporting the conclusion by the premises, and the premises by the conclusion. Nor would he allow an infinite number of middle terms between the primary premises and the conclusion. This leads to the question of how the primary premises are found or developed, and as mentioned above, Aristotle allowed that induction would be required for this task. Towards the end of the Posterior Analytics, Aristotle discusses knowledge imparted by induction. Thus it is clear that we must get to know the primary premises by induction; for the method by which even sense-perception implants the universal is inductive. In particular, it seems that Aristotle considers sense-perception only as a vehicle for knowledge through intuition. He restricted his investigations in natural history to their natural settings, [18] such as at the Pyrrha lagoon, [19] now called Kalloni , at Lesbos. Aristotle and Theophrastus together formulated the new science of biology, [20] inductively, case by case, for two years before Aristotle was called to tutor Alexander. With that said, Aristotle brings us somewhat closer an empirical science than his predecessors. Some philosophers held that there are only atoms and void ; others that the atoms are divine fire , others only wind , others only water , others only earth. Emergence of inductive experimental method[edit] During the Middle Ages issues of what is now termed science began to be addressed. There was greater emphasis on combining theory with practice in the Islamic world than there had been in Classical times, and it was common for those studying the sciences to be artisans as well, something that had been "considered an aberration in the ancient world. Several scientific methods thus emerged from the medieval Muslim world by the early 11th century, all of which emphasized experimentation as well as quantification to varying degrees. Ibn al-Haytham[edit] "How does light travel through transparent bodies? Light travels through transparent bodies in straight lines only We have explained this exhaustively in our Book of Optics. He combined observations , experiments and rational

arguments to support his intromission theory of vision , in which rays of light are emitted from objects rather than from the eyes. He used similar arguments to show that the ancient emission theory of vision supported by Ptolemy and Euclid in which the eyes emit the rays of light used for seeing , and the ancient intromission theory supported by Aristotle where objects emit physical particles to the eyes , were both wrong. And those who are engaged upon the quest for anything for its own sake are not interested in other things. Finding the truth is difficult, and the road to it is rough. He stated, "[This] is clearly observed in the lights which enter into dark rooms through holes. He also explained the role of induction in syllogism , and criticized Aristotle for his lack of contribution to the method of induction, which Ibn al-Haytham regarded as superior to syllogism, and he considered induction to be the basic requirement for true scientific research. For example, after demonstrating that light is generated by luminous objects and emitted or reflected into the eyes, he states that therefore "the extramission of [visual] rays is superfluous and useless. He wrote that "we do not go beyond experience, and we cannot be content to use pure concepts in investigating natural phenomena", and that the understanding of these cannot be acquired without mathematics. After assuming that light is a material substance, he does not further discuss its nature but confines his investigations to the diffusion and propagation of light. The only properties of light he takes into account are those treatable by geometry and verifiable by experiment. For example, in his treatise on mineralogy , Kitab al-Jawahir Book of Precious Stones , al-Biruni is "the most exact of experimental scientists", while in the introduction to his study of India , he declares that "to execute our project, it has not been possible to follow the geometric method" and thus became one of the pioneers of comparative sociology in insisting on field experience and information. Biruni was concerned with how to conceptualize and prevent both systematic errors and observational biases, such as "errors caused by the use of small instruments and errors made by human observers. Avicenna discussed the issue of a proper procedure for scientific inquiry and the question of "How does one acquire the first principles of a science? Avicenna criticized Aristotelian induction, arguing that "it does not lead to the absolute, universal, and certain premises that it purports to provide. Concluding from particular observations into a universal law, and then back again, from universal laws to prediction of particulars. Grosseteste called this "resolution and composition". Further, Grosseteste said that both paths should be verified through experimentation to verify the principles. In his account of a method, Bacon described a repeating cycle of observation , hypothesis , experimentation , and the need for independent verification. About he joined the Franciscan Order and became subject to the Franciscan statute forbidding Friars from publishing books or pamphlets without specific approval. After the accession of Pope Clement IV in , the Pope granted Bacon a special commission to write to him on scientific matters. There are two methods of knowledge: Mere argument is never sufficient; it may decide a question, but gives no satisfaction or certainty to the mind, which can only be convinced by immediate inspection or intuition, which is what experience gives. Experimental science, which in the Opus Tertium p. It verifies their conclusions by direct experiment; It discovers truths which they could never reach; It investigates the secrets of nature, and opens to us a knowledge of past and future. Roger Bacon illustrated his method by an investigation into the nature and cause of the rainbow , as a specimen of inductive research. Within the sciences, medieval philosophers were not afraid of disagreeing with Aristotle on many specific issues, although their disagreements were stated within the language of Aristotelian philosophy. All medieval natural philosophers were Aristotelians, but "Aristotelianism" had become a somewhat broad and flexible concept. With the end of Middle Ages, the Renaissance rejection of medieval traditions coupled with an extreme reverence for classical sources led to a recovery of other ancient philosophical traditions, especially the teachings of Plato. Basle The discovery of the Americas at the close of the 15th century showed the scholars of Europe that new discoveries could be found outside of the authoritative works of Aristotle, Pliny, Galen, and other ancient writers. Galen of Pergamon â€” c. In his Methodus Medendi, Galen had synthesized the empirical and dogmatic schools of medicine into his own method, which was preserved by Arab scholars. Thomas Linacre , the teacher of Erasmus, thereupon translated Methodus Medendi from Greek into Latin for a larger audience in As a physician, Leoniceno was concerned about these botanical errors propagating to the materia medica on which medicines were based. Other Renaissance teaching gardens were established, notably by the physician Leonhart Fuchs , one of the

founders of botany. Skepticism either denies or strongly doubts depending on the school the possibility of certain knowledge. In this, he is echoed by Francis Bacon who was influenced by another prominent exponent of skepticism, Montaigne ; Sanches cites the humanist Juan Luis Vives who sought a better educational system, as well as a statement of human rights as a pathway for improvement of the lot of the poor. In the meantime, as I prepare to examine Things, I shall raise the question anything is known, and if so, how, in the introductory passages of another book, [58] a book in which I will expound, as far as human frailty allows, [59] the method of knowing. Baconian method "If a man will begin with certainties, he shall end in doubts; but if he will be content to begin with doubts, he shall end in certainties. He believed philosophy must be taught its true purpose, and for this purpose a new method must be devised. With this conception in his mind, Bacon left the university. As Bacon put it, [A]nother form of induction must be devised than has hitherto been employed, and it must be used for proving and discovering not first principles as they are called only, but also the lesser axioms, and the middle, and indeed all. For the induction which proceeds by simple enumeration is childish. In an example he gives on the examination of the nature of heat, Bacon creates two tables, the first of which he names "Table of Essence and Presence", enumerating the many various circumstances under which we find heat. In the other table, labelled "Table of Deviation, or of Absence in Proximity", he lists circumstances which bear resemblance to those of the first table except for the absence of heat. From an analysis of what he calls the natures light emitting, heavy, colored, etc. Those natures which are always present in the first table, but never in the second are deemed to be the cause of heat. The role experimentation played in this process was twofold. Such histories would document a mixture of common knowledge and experimental results. Secondly, experiments of light, or, as we might say, crucial experiments would be needed to resolve any remaining ambiguities over causes. Bacon showed an uncompromising commitment to experimentation. Despite this, he did not make any great scientific discoveries during his lifetime. This may be because he was not the most able experimenter. Bacon gave a substantial but secondary role to mathematics "which ought only to give definiteness to natural philosophy, not to generate or give it birth" Novum Organum XCVI. There are and can be only two ways of searching into and discovering truth. The one flies from the senses and particulars to the most general axioms, and from these principles, the truth of which it takes for settled and immoveable, proceeds to judgment and to the discovery of middle axioms. And this way is now in fashion. The other derives axioms from the senses and particulars, rising by a gradual and unbroken ascent, so that it arrives at the most general axioms last of all. This is the true way, but as yet untried. Lastly, we have three that raise the former discoveries by experiments into greater observations, axioms, and aphorisms. These we call interpreters of nature.

7: Democritus, 1st Atomic Theory - Timeline Index

According to Bertrand Russell, the point of view of Leucippus and Democritus "was remarkably like that of modern science, and avoided most of the faults to which Greek speculation was prone." [49].

And along the way, many names stand out as examples of people who achieved breakthroughs and helped lay the foundations of our modern understanding. There has also been significant controversy â€" particularly in Germany during the 19th century â€" over whether or not Democritus deserves credit for atomic theory. This argument is based on the relationship Democritus had with contemporary philosopher Leucippus, who is renowned for sharing his theory about atoms with him. However, their theories came down to a different basis, a distinction that allows Democritus to be given credit for a theory that would go on to become a staple of the modern scientific tradition. Democritus, by Hendrik ter Brugghen â€" Heraclitus, The precise date and location of Democritus birth is the subject the debate. However, other sources claim he was born in Miletus, a coastal city of ancient Anatolia and modern-day Turkey, and that he was born in BCE. It is further argued that as a reward for his service, the Persian monarch gave his father and other Abderites gifts, and left several Magi among them. Democritus was apparently instructed by these Magi in astronomy and theology. After his father had died, Democritus used his inheritance to finance a series of travels to distant countries. Desiring to feed his thirst for knowledge, Democritus traveled extensively across the known world, traveling to Asia, Egypt and according to some sources venturing as far as India and Ethiopia. His writings include descriptions of the the cities of Babylon and Meroe in modern-day Sudan. Upon returning to his native land, he occupied himself with the study of natural philosophy. His wealth allowed him to purchase their writings, and he wrote of them in his own works. In time, he would become one of the most famous of the pre-Socratic philosophers. The ruins of the ancient Greek city of Abdera, with the west gate shown. Democritus is also said to have known Anaxagoras, Hippocrates and even Socrates himself though this remains unproven. During his time in Egypt, he learned from Egyptian mathematicians, and is said to have become acquainted with the Chaldean magi in Assyria. In the tradition of the atomists, Democritus was a thoroughgoing materialists who viewed the world in terms of natural laws and causes. This differentiated him from other Greek philosophers like Plato and Aristotle, for whom philosophy was more teleological in nature â€" i. According to the many descriptions and anecdotes about Democritus, he was known for his modesty, simplicity, and commitment to his studies. One story claims he blinded himself on purpose in order to be less distracted by worldly affairs which is believed to be apocryphal. Democritus is renowned for being a pioneer of mathematics and geometry. He was among the first Greek philosophers to observe that a c one or pyramid has one-third the volume of a cylinder or prism with the same base and height. While none of his works on the subject survived the Middle Ages, his mathematical proofs are derived from other works with contain extensive citations to titles like On Numbers, On Geometrics, On Tangencies, On Mapping, and On Irrationals. Right circular and oblique circular cones. Dominique Toussaint Democritus is also known for having spent much of his life experimenting with and examining plants and minerals. Similar to his work in mathematics and geometry, citations from existing works are used to infer the existence of works on the subject. From his examination of nature, Democritus developed what could be considered some of the first anthropological theories. According to him, human beings lived short lives in archaic times, forced to forage like animals until fear of wild animals then drove them into communities. He theorized that such humans had no language, and only developed it through the need to articulate thoughts and ideas. Through a process of trial and error, human beings developed not only verbal language, but also symbols with which to communicate i. Each step in this process led to more discoveries, more complex behaviors, and the many things that came to characterize civilized society. In terms of astronomy and cosmology, Democritus was a proponent of the spherical Earth hypothesis. He believed that in the original chaos from which the universe sprang, the universe was composed of nothing but tiny atoms that came together to form larger units a theory which bears a striking resemblance to The Big Bang Theory and Nebular Theory. He also believed in the existence of many worlds, which were either in state of growth or decay. In a similar vein, Democritus advanced a theory of void which challenged the paradoxes raised by his

fellow Greek philosophers, Parmenides and Zeno â€" the founders of metaphysical logic. According to these men, movement cannot exist because such a thing requires there to be a void â€" which is nothing, and therefore cannot exist. And a void cannot be termed as such if it is in fact a definable, existing thing. To this, Democritus and other atomists argued that since movement is an observable phenomena, there must be a void. According to Democritus, truth is difficult, because it can only be perceived through senses-impressions which are subjective. The latter is concerned with perception through the senses, which is subjective by nature. This is due to the fact that our sense-perception are influence by the shape and nature of atoms as they flow out from the object in question and make an impression on our senses. This is consistent with the inductive reasoning method later elaborated by Renee Descartes, and is a prime example of why Democritus is considered to be an early scientific thinker. However, Democritus greatest contribution to modern science was arguably the atomic theory he elucidated. He was not alone in proposing atomic theory, as both his mentor Leucippus and Epicurus are believed to have proposed the earliest views on the shapes and connectivity of atoms. Like Democritus, they believed that the solidity of a material corresponded to the shape of the atoms involved â€" i. Using analogies from our sense experiences, Democritus gave a picture or an image of an atom that distinguished them from each other by their shape, size, and the arrangement of their parts. In essence, this model was one of an inert solid that excluded other bodies from its volume, and which interacted with other atoms mechanically. As such, his model included physical links i. While this bears little resemblance to modern atomic theory where atoms are not inert and interact electromagnetically , it is more closely aligned with that of modern science than any other theory of antiquity. While there is no clear explanation as to how scholars of classical antiquity came to theorize the existence of atoms, the concept proved to be influential, being picked up by Roman philosopher Lucretius in the 1st century CE and again during the Scientific Revolution. In addition to being indispensable to modern molecular and atomic theory, it also provided an explanation as to why the concept of a void was necessary in nature. If all matter was composed of tiny, indivisible atoms, then there must also be a great deal of open space between them. Early atomic theory stated that different materials had differently shaped atoms. That the worlds were infinite, created, and perishable. But that nothing was created out of nothing, and that nothing was destroyed so as to become nothing. That the atoms were infinite both in magnitude and number, and were borne about through the universe in endless revolutions. And that thus they produced all the combinations that exist; fire, water, air, and earth; for that all these things are only combinations of certain atoms; which combinations are incapable of being affected by external circumstances, and are unchangeable by reason of their solidity. Democritus died at the age of ninety, which would place his death at around BCE; though some writers disagree, with some claiming he lived to or even Since Socrates died at the hands of the Athenian government who condemned him, it is possible that Aurelius attributed Democritus death to human folly or politics. While Democritus was highly esteemed amongst his contemporaries, there were also those who resented him. This included Plato who, according to some accounts, disliked him so much that he wished that all his books would be burned. Pubic Domain Ultimately, Democritus is credited as being one of the founders of the modern science because his methods and theories closely resemble those of modern astronomers and physicists. And while his version of the atomic model differs greatly from our modern conceptions, his work was of undoubted value, and was a step in an ongoing process that included such scientists as John Dalton, Neils Bohr and even Albert Einstein. As always, science is an process of continuing discovery, where new breakthroughs are built upon the foundations of the old and every generations attempts to see a little farther by standing on the shoulders of those who came before.

8: Leucippus and Democritus | www.enganchecubano.com

Democritus, the "father of modern science," changed the face of science forever with his theories. He was believed to have excelled in all branches of knowledge, most notably philosophy and science. His name is most widely associated with the foundlings of the atomic theory of matter, according to which all matter is composed of single.

Democritus Save Democritus ; Greek: His exact contributions are difficult to disentangle from those of his mentor Leucippus , as they are often mentioned together in texts. Their speculation on atoms, taken from Leucippus, bears a passing and partial resemblance to the 19th-century understanding of atomic structure that has led some to regard Democritus as more of a scientist than other Greek philosophers; however, their ideas rested on very different bases. Many consider Democritus to be the "father of modern science". Democritus spent the inheritance which his father left him on travels into distant countries, to satisfy his thirst for knowledge. He traveled to Asia, and was even said to have reached India and Ethiopia. He particularly mentions the Egyptian mathematicians , whose knowledge he praises. Theophrastus , too, spoke of him as a man who had seen many countries. He traveled throughout Greece to acquire a better knowledge of its cultures. He mentions many Greek philosophers in his writings, and his wealth enabled him to purchase their writings. Leucippus , the founder of atomism , was the greatest influence upon him. He also praises Anaxagoras. One story has him deliberately blinding himself in order to be less disturbed in his pursuits;[23] it may well be true that he lost his sight in old age. He was cheerful, and was always ready to see the comical side of life, which later writers took to mean that he always laughed at the foolishness of people. Most sources say that Democritus followed in the tradition of Leucippus and that they carried on the scientific rationalist philosophy associated with Miletus. Both were thoroughly materialist , believing everything to be the result of natural laws. Unlike Aristotle or Plato, the atomists attempted to explain the world without reasoning as to purpose, prime mover , or final cause. For the atomists questions of physics should be answered with a mechanistic explanation "What earlier circumstances caused this event? Aesthetics Later Greek historians consider Democritus to have established aesthetics as a subject of investigation and study,[29] as he wrote theoretically on poetry and fine art long before authors such as Aristotle. Atomic hypothesis The theory of Democritus held that everything is composed of "atoms", which are physically, but not geometrically, indivisible; that between atoms, there lies empty space; that atoms are indestructible, and have always been and always will be in motion; that there is an infinite number of atoms and of kinds of atoms, which differ in shape and size. Of the mass of atoms, Democritus said, "The more any indivisible exceeds, the heavier it is". But his exact position on atomic weight is disputed. They reasoned that the solidness of the material corresponded to the shape of the atoms involved. Thus, iron atoms are solid and strong with hooks that lock them into a solid; water atoms are smooth and slippery; salt atoms, because of their taste, are sharp and pointed; and air atoms are light and whirling, pervading all other materials. Moreover, connections were explained by material links in which single atoms were supplied with attachments: In contrast, modern, quantum-mechanical atoms interact via electric and magnetic force fields and are far from inert. The theory of the atomists appears to be more nearly aligned with that of modern science than any other theory of antiquity. However, the similarity with modern concepts of science can be confusing when trying to understand where the hypothesis came from. Classical atomists could not have had an empirical basis for modern concepts of atoms and molecules. However, Lucretius , describing atomism in his De rerum natura , gives very clear and compelling empirical arguments for the original atomist theory. He observes that any material is subject to irreversible decay. Through time, even hard rocks are slowly worn down by drops of water. Things have the tendency to get mixed up: Mix water with soil and mud will result, seldom disintegrating by itself. However, there are mechanisms in nature and technology to recreate "pure" materials like water, air, and metals. The seed of an oak will grow out into an oak tree, made of similar wood as historical oak trees, the wood of which has already decayed. The conclusion is that many properties of materials must derive from something inside, that will itself never decay, something that stores for eternity the same inherent, indivisible properties. The basic question is: Why has everything in the world not yet decayed, and how can exactly some of the same

materials, plants, and animals be recreated again and again? One obvious solution to explain how indivisible properties can be conveyed in a way not easily visible to human senses, is to hypothesize the existence of "atoms". The other central point of classical atomism is that there must be considerable open space between these "atoms": Lucretius gives reasonable arguments that the void is absolutely necessary to explain how gasses and liquids can flow and change shape, while metals can be molded without their basic material properties changing. Void hypothesis painting of Democritus by Dosso Dossi. They held that any movement would require a voidâ€”which is nothingâ€—but a nothing cannot exist. The Parmenidean position was "You say there is a void; therefore the void is not nothing; therefore there is not the void". The atomists agreed that motion required a void, but simply ignored the argument of Parmenides on the grounds that motion was an observable fact. Therefore, they asserted, there must be a void. The knowledge of truth, according to Democritus, is difficult, since the perception through the senses is subjective. As from the same senses derive different impressions for each individual, then through the sensual impressions we cannot judge the truth. And again, many of the other animals receive impressions contrary to ours; and even to the senses of each individual, things do not always seem the same. Which then, of these impressions are true and which are false is not obvious; for the one set is no more true than the other, but both are alike. And this is why Democritus, at any rate, says that either there is no truth or to us at least it is not evident. Furthermore, they find Xenophanes, Zeno of Elea, and Democritus to be sceptics: The "bastard" knowledge is concerned with the perception through the senses; therefore it is insufficient and subjective. The reason is that the sensual perception is due to the effluences of the atoms from the objects to the senses. When these different shapes of atoms come to us, they stimulate our senses according to their shape, and our sensual impressions arise from those stimulations. In this way one can get away from the false perception of the "bastard" knowledge and grasp the truth through the inductive reasoning. This is the procedure of thought from the parts to the whole or else from the apparent to nonapparent inductive reasoning. This is one example of why Democritus is considered to be an early scientific thinker. The process is reminiscent of that by which science gathers its conclusions: But in the Canons Democritus says there are two kinds of knowing, one through the senses and the other through the intellect. To quote his actual words: Of knowledge there are two forms, one legitimate, one bastard. To the bastard belong all this group: The other is legitimate and separate from that. Then, preferring the legitimate to the bastard, he continues: When the bastard can no longer see any smaller, or hear, or smell, or taste, or perceive by touch, but finer matters have to be examined, then comes the legitimate, since it has a finer organ of perception. But we in actuality grasp nothing for certain, but what shifts in accordance with the condition of the body and of the things atoms which enter it and press upon it. The ethics and politics of Democritus come to us mostly in the form of maxims. As such, the Stanford Encyclopedia of Philosophy has gone as far as to say that: Poverty in a democracy is better than prosperity under tyrants, for the same reason one is to prefer liberty over slavery. While making money is not useless, he says, doing so as a result of wrongdoing is the "worst of all things". He is on the whole ambivalent towards wealth, and values it much less than self-sufficiency. He disliked violence but was not a pacifist: He believed that one should distance oneself from the wicked, stating that such association increases disposition to vice. Anger, while difficult to control, must be mastered in order for one to be rational. Those who take pleasure from the disasters of their neighbors fail to understand that their fortunes are tied to the society in which they live, and they rob themselves of any joy of their own. Democritus believed that happiness was a property of the soul. He advocated a life of contentment with as little grief as possible, which he said could not be achieved through either idleness or preoccupation with worldly pleasures. Democritus approved of extravagance on occasion, as he held that feasts and celebrations were necessary for joy and relaxation. He considers education to be the noblest of pursuits, but cautioned that learning without sense leads to error. Democritus was among the first to observe that a cone and pyramid with the same base and height has one-third the volume of a cylinder or prism respectively. They were driven together into societies for fear of wild animals, he said. He believed that these early people had no language, but that they gradually began to articulate their expressions, establishing symbols for every sort of object, and in this manner came to understand each other. He says that the earliest men lived laboriously, having none of the utilities of life; clothing, houses, fire, domestication, and farming

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2) Democritus also stuided physics, astronomy, zoology, botany and medicine. 3) He was the first to say that the Milky Way Galaxy was a conglomeration of stars. He also proposed that space was limitless.

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