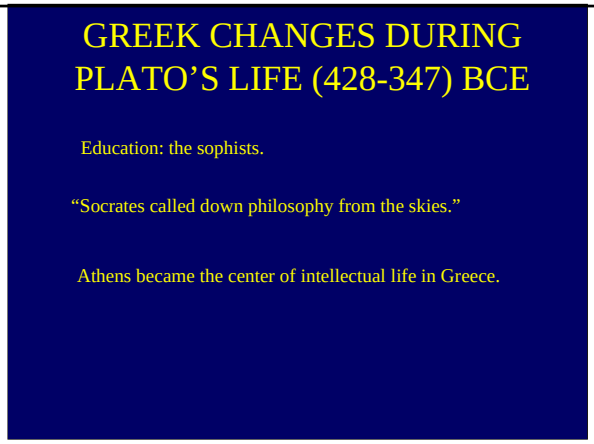
THE COSMOLOGY OF PLATO'S TIMAEUS PRESENTED AS A SERIES OF POSTULATES

Plato's Timaeus is written as a dialogue between three people, as Plato often did in his writings. Included in it is a cosmology, that is, his description of what he thought of the physical world around him. This is not the kind of thing Plato did very much. He spent more energy on human behavior than on the stars and the world.

Plato is the earliest philosopher for whom we likely have all of his works, amounting to about as many pages as are in the Bible. More important, each of his works is whole and complete, written by him for publication. This is quite a change from the fragments we have from Thales, Pythagoras, and the others who went before.

Plato's writing is not easy to read. He seems to have been deliberately vague, perhaps he knew he did not have a final understanding.

What I have done here is to recast part of Timaeus as a series of postulates, in an attempt to simplify the work and bring out essential points.



During Plato's long (81 years!) life, a number of significant changes were taking place. Traditional Greek education was limited to grammar, music, and poetry. The sophists were specialists who would lecture on any topic for a fee.So more people were educated enough to think about the nature of the world.

Second, Socrates, Plato's mentor, broadened the range of topics discussed by including ethics and government in his work. Earlier thinkers such as Thales, thought mainly about the physical world.

Third, Athens became the intellectual center of Greece. Before Athens' rise, earlier thinkers worked where they were born or lived (Miletus, Samos,…). Now Athens attracted people from around Greece to study there. Plato and Aristotle formed schools with students and libraries.

Plato's influence on science comes from his general attitude towards it, his philosophy of science, more than any particular theory he described. For example he says of the study of geometry (in the Republic, Book VII, pg 529ef): "Anyone experienced in geometry who saw such diagrams would grant that they are most beautifully constructed, but think it absurd to examine them seriously as if one could find in them the truth concerning equals or doubles or any other ratio."

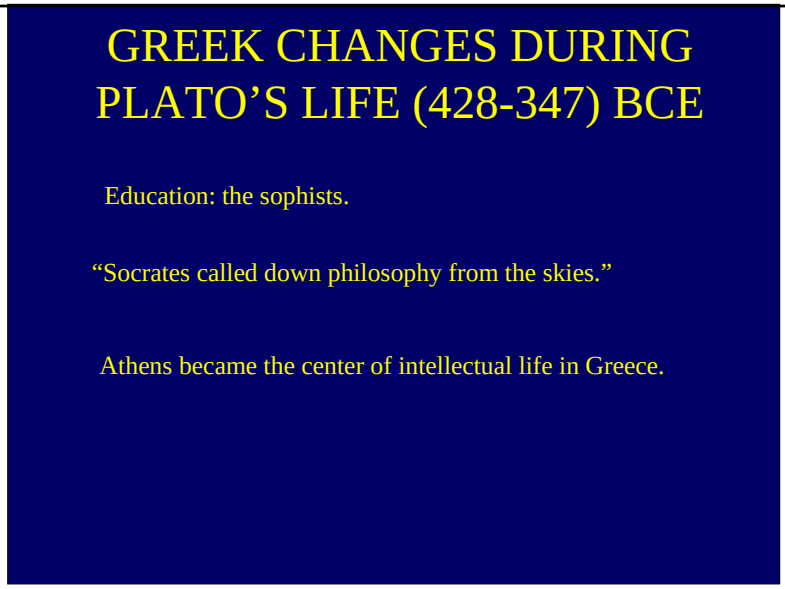
So Plato is saying that the triangle that you draw on a piece of paper may be beautiful, but you do not learn geometry by studying your drawing. When you learn to prove theorems, or to use theorems to prove two angles equal, two triangles congruent, etc, you are dealing with deeper truths than are contained in a physical drawing on paper.

The goal in studying geometry or astronomy is to learn the underlying rules or laws that govern the subject, which he regarded as being eternal. The only true knowledge was of these eternal laws, and this knowledge should be irrefutable, as far as possible. Plato had little interest in specific examples and transient events.

But in the Timaeus he deals with the transient world of the senses, and he recognizes that his descriptions therefore are not irrefutable. He says (Timaeus 29c):

"If in our discussion of many matters, we are not able to give perfectly exact and self-consistent accounts, do not be surprised: rather we should be content if we provide accounts that are second to none in probability."

That is, he will provide the best account possible. He believed on principle, that no account of the transient world of the senses can be certain.



Throughout his account, Plato describes the existence of an intelligent, purposive agency in the Universe. In other words a designer. Such an approach is called teleological, and is regarded as one of the un-scientific features of Plato's physics. This approach worked better in the early studies of anatomy – body organs do have a purpose, and their design and location is related to that purpose.

Plato was right to say that the goal of scientists is to study the abstract laws that lie behind empirical data, and to insist that these laws, being eternal, must be expressed mathematically. In this he was right on the mark.

TIMAEUS 29c

Plato is describing the sensible world which he knows cannot be done perfectly, so he writes:

If in our discussion of many matters, we are not able to give perfectly exact and self-consistent accounts, do not be surprised; rather we should be content if we provide accounts that are second to none in probability.

In Timaeus Plato is describing the transient world of the senses, something he prefers not to do. So near the beginning he apologizes for the gaps and errors that are likely to follow. He will provide the best account possible, but believed on principle that no account of the sensible world can be certain.

He also wrote that if anyone else can come up with a better account, let them do so, and then their account will replace this one.

Timaeus 27d-28a:

We must, then, in my judgment, first make this distinction:
What is that which is always real and had no becoming, and
what is that which is always becoming and is never real?
That which is apprehensible by thought with a rational account
is the thing that is always unchangeably real; whereas that
which is the object of belief together with unreasoning sensation
is the thing that becomes and passes away, but never has
real being.

POSTULATE 1

Reality exists on two levels. The everyday world of the senses which is transient (constantly changing), and an underlying set of concepts (ideas, rules, laws) that are eternal.

The everyday world of the senses is constantly changing, in the sense that the sun shines today, and it may rain tomorrow; flowers bloom in the spring and die off in the fall. In addition, we know there will be a future, and there has been a past that we remember, but we live in the present. But as soon as I say the word “present” it has already become part of the past. So the present seems to have no existence at all. Knowledge of the sensible world Plato described as “opinion” and regarded it as an inferior kind of knowledge since it can only be approximate.

Only knowledge of the underlying concepts can in any sense be regarded as “true” since they never change. But he saw no way for us limited human beings living in our transient world to obtain such knowledge.

So the problem of learning about the world around us can be stated this way: How can we understand the sensible world when the only true knowledge is of the underlying ideas which however remains inaccessible to us?

It is easy to develop the idea that Plato had a very low opinion of the world of the senses. In Timaeus he wrote (33cd): “The cosmos is continually eating and excreting itself.” This attitude made it very difficult for him to imagine how we would ever learn about the eternal underlying concepts that govern the universe. How do we learn about them? Use our senses and make observations? But this is unreliable since this level of reality is constantly changing.

Only in mathematics did there seem to be a way to attain eternal knowledge. In Republic, vi, 510 he wrote: “You know that the geometers make use of visible figures and argue about them, but in doing so they are not thinking of these figures but of the things which they represent; thus it is the absolute square and the absolute diameter which is the object of their argument, not the diameter which they draw.”

In geometry the theorems that are proven refer to lines with zero width, and points with no dimension at all, rather than the fuzzy figures we draw on paper.

Timaeus 28a:

Everything which becomes must of necessity become owing to some cause; for without a cause it is impossible for anything to attain becoming.

POSTULATE 2

In the world of the senses, all that changes does so as a result of a cause.

Causality finds no application in the underlying world of ideas because they never change. In the sensible world, where change is paramount, causality is needed to make observed changes comprehensible. Any changes we observe are due to changes in the relationships between elementary constituents of the sensible world, each of which is a copy or reflection of one of the underlying ideas. Any change of relationship will therefore be the result of another change of relationship occurring earlier.

Causality is an important principle of physics today. Plato was right on the mark.

Timaeus 29a:

Now if so be that this cosmos is beautiful, and its Craftsman good, it is plain that he fixed his gaze on the eternal; but if otherwise, his gaze was on that which comes into existence. But it is clear to everyone that his was on the eternal; for the cosmos is the fairest of all that has come into existence, and he the best of all causes.

POSTULATE 3

The sensible world is the result of the ordering of a benevolent Craftsman.

For Plato, the idea of good is closely tied to beauty, harmony, order, simplicity. So a good cause would confer these qualities on the elements around him. This Craftsman is a peculiar god – he does not create the Universe, but partially orders it out of a primordial chaotic beginning. After doing so he retires from the Universe (Timaeus 42e), leaving mankind alone in a material, changing, partially ordered world.

Timaeus 48a:

For in truth this Cosmos in its origin was generated as a compound, from the combination of Necessity and Reason. And inasmuch as Reason was controlling Necessity by persuading her to conduct to the best end the most part of the things coming into existence, thus and thereby it came about, through Necessity yielding to intelligent persuasion, that this Universe of ours was being in this wise constructed in the beginning. Wherefore if one is to declare how it actually came into being on this wise, he must include also the form of the Errant Cause in the way that it really acts.

POSTULATE 4

An Errant Cause perpetually resists the order which the Craftsman has introduced into the Universe.

Given the amount of disorder in the world around us, Plato found it necessary to describe an agent of disorder, sometimes calling it Necessity, sometimes the Errant Cause. Otherwise, if only the Craftsman had ordered our world, would it not be a simpler, more ordered place?

Timaeus 37d

When the Craftsman ordered the heaven, he made, of eternity that abides in unity, an everlasting likeness moving according to number, that to which we have given the name “time”.

POSTULATE 5

Absolute time exists, moving uniformly forward eternally according to the numbered rotations of the celestial bodies.

Plato accounts for time, saying it is absolute, and is measured by the regular motions of the celestial objects. This view of time continued until Einstein showed, in 1905, that it was too simple.

This definition of time is suspect from the start. According to this understanding, we measure time only by the motions, say of the sun. But suppose the sun were to move irregularly, speeding up and slowing down. How would we know that this happened, since its motion is our definition of time. We clearly need a better understanding of time.

Timaeus 32c

The making of the Universe took up the whole bulk of the four elements. The Craftsman fashioned it of all the fire, air, water, and earth that existed, leaving over no single particle or potency of any one of these elements.

POSTULATE 6

All objects in the sensible world, including celestial bodies, are made of four elements: fire, air, water, and earth.

Here Plato makes use of Greek tradition built up over the generations before him. This view of the constituents of matter remained universally accepted until the birth of modern chemistry in the 18th century.

Plato went further than his predecessors however by building into his description a mathematical basis. First, why are there four and only four elements? He argued that fire and earth are both clearly necessary because of the existence of the Earth and the Sun. Because these elements are eternal, being among the ideas that underlie the sensible world, they can only be represented by mathematical objects, mathematics being the only eternal knowledge we have. Because our world has three dimensions, these elements must be represented by three dimensional geometrical shapes.

PROPORTIONS OF THE ELEMENTS

Why four elements?

Need Fire and Earth, because of the Sun and the Earth.

The elements must be three-dimensional. Let a^3 represent the volume of Fire, and b^3 the volume of Earth.

Then we can interpose two, and only two, other elements between them while keeping balanced proportions, a^2b and ab^2:

$$a^3/a^2b = a^2b/ab^2 = ab^2/b^3 = a/b$$

a^2b represents the volume of air, and ab^2 the volume of water.

Here is the argument for there being four elements, and their proportions. If a^3 is the volume of fire (think of a as the length of the side of a cube. Then its volume is a^3). And if b^3 is the volume of earth, then a simple algebraic argument shows that we can form four different dimensionless ratios from these quantities. Each of them equals a/b. He then says that a^2b is the volume of air, and $ab^2$the volume of water.

This argument is clever, but it has the same quality of overreaching that most of the Pythagorean arguments had.

It is like telling a story that circles around on itself, only this is done algebraically.

THE PLATONIC SOLIDS

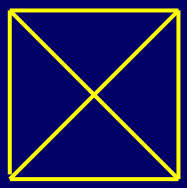
The elements are eternal and three-dimensional, so must be represented by mathematical objects: three-dimensional geometric shapes.

Fire: tetrahedron
Air: octahedron
Water: icosahedron
Earth: cube

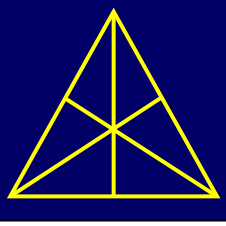
In Plato's time, five regular polyhedra were known. He associated four of them with these four elements. The fifth, the dodecahedron, with its 12 faces, was associated with the zodiac, with its 12 constellations.

CONSTRUCTION OF THE POLYHEDRA

Cube has square faces formed of four isosceles right triangles:



Faces of the other polyhedra are equilateral triangles, each formed from six scalene right triangles:



Plato described in detail how to construct these solids. Since they have faces of equal shape and size, all that is needed is to describe how to construct a face for each. Earth is associated with the cube. It has six sides, each a square. He showed how the square sides result from the combination of four isosceles right angled triangles: “This body is formed of four isosceles; the sides of their right angles join again in a center and form a quadrangular equilateral figure” (Timaeus 55b)

The faces of the other polyhedra, the tetrahedron (fire), octahedron (air), and icosahedron (water) are equilateral triangles. He showed how the equilateral triangles results from the combination of six right angled scalene triangles. He does not explain why six six right angled triangles are needed when two would have sufficed.

REPRESENTATION OF THE ELEMENTS

Element	regular solid	number of faces	number of triangles
fire	tetrahedron	4 equilateral triangles	24 scalenes
air	octahedron	8 equilateral triangles	48 scalenes
water	icosahedron	20 equilateral triangles	120 scalenes
earth	cube	6 squares	24 isosceles

Here is a table summarizing the construction of the four elements, and showing how many triangles are needed for each.

MATHEMATICAL LIMITATIONS ON ALCHEMICAL REACTIONS

Number and symmetry of right triangles forming the faces of the polyhedra cannot change.

Allowed:

2[fire] = 8 equilaterals → 1[air]

1[fire] + 2[air] = 20 equilaterals → 1[water]

Not allowed:

1[fire] + 1[air] → [water]

[earth] → any other elements

As these elements are transmuted into one another by natural processes in the sensible world, the alchemy that can occur follows this simple rule: The number of elementary right angled triangles can neither be created or destroyed. Consequently, in any transmutation (or chemical reaction) the number of triangles of each of the two shapes is conserved. Only elements formed from the same shaped triangles can be transmuted into one another. So water, air, and fire can be transmuted into one another, but these elements cannot react with earth.

EXAMPLES OF THE FOUR ELEMENTS IN TIMAEUS

Fire

flame, light , glow

Air

darkness, mist

Water

water, juices, wine, oil, honey
ice, snow
gold, copper

Earth

stone, diamond
pottery, lava
salt, soda

Plato asserted that these four regular solids representing the elements are too small to be seen. Only by lumping many together do we form enough matter to construct the visible objects we see in the world. Plato gives examples in the Timaeus of varieties of each of the four elements shown above.

In a general sense, air represents any gas, water any liquid, earth any solid, accounting for the three phases of matter. Fire was seen as a body equal to the other three rather than as a process.

Plato did not think of submitting any aspect of his description of the universe to an experimental test. The modern idea of experimental tests involves changing a very limited number of parameters, while supposing that the rest of the universe will not influence the outcome. This often requires building complex equipment to isolate the objects being tested from the rest of the universe except in a controlled way. This concept of experimental testing simply had not been developed in Plato's time. For him, an experimental verification requires an exact reproduction of nature, which is not possible. Here is how he put it:

But any attempt to put these matters to a practical test would argue ignorance of the difference between human nature and divine, namely that divinity has knowledge and power sufficient to do so, but no man is now, or ever will be, equal to the task. (Timaeus, 68d-e).

The above discussion of the Timaeus is modeled after that in Bresson and Myerstein's book "Inventing the Universe" SUNY Press, 1995. This book is recommended to students seeking further insight into this important work.

THEOLOGICAL ASTRONOMY

Celestial deities move uniformly in perfect circles about earth.

But the planets exhibit retrograde motion.

Plato's question to his students:
"What are the uniform and ordered movements by the assumption of which the apparent movements of the planets can be accounted for."

This became the question astronomers tried to answer for more than 2000 years.

Socrates, Plato's mentor, had been put to death in Athens when Plato was a young man for teaching young people to think for themselves ("corrupting the morals of the youth"). There were many people in Athens who did not like the idea of these philosophers thinking so much about the irregular planets, while the stars, sun, and moon, move incorruptibly in uniform circles about earth.

So Plato decided to take refuge in religion. He posed a question to his students, shown above, which when answered, would reassure all that the planets were indeed deities, and were worthy of attention and careful thought. In taking this step Plato was reversing the separation of science from the religions of the day started by
Thales. He did this in hopes it would make safer the work of his students and those that followed them.

This question far outlived Plato's imaginings. It became so ingrained in the subsequent development of astronomy that it was still the question astronomers were trying to answer during the arrival of the Renaissance.