Cosmic Education, Lesson 1: God Without Hands

Deeply religious, Dr. Maria Montessori's "Big Bang" story reflects her belief that an appreciation for God and Man should frame the essential narratives of education. The first rendition of the story included here, dated 1962-63, is attributed to her son Mario Montessori, who considered it part of her "unfinished work. Señora Honneger's re-telling of the story (1973) tries to retain the mystery of the origins of the universe without references to God, relying on metaphoric language and experiments to dramatize the events.

Each teacher must bring his or her own imagination to the re-telling of this story. It is helpful to remember that the purpose of the story is to inspire wonder and appreciation rather than conveying facts. We do have more and more scientific facts as cosmologists continually apply technology in new ways. We now have microwave images of deep space and even stress patterns there that may be evidence of the original "jerk" or "warp" occurring in an incomprehensible fraction of time—a billionth of a billionth of a second. However, the more we see and know, the more mysterious the origins of the universe becomes, making each teacher's version or the story both unique and valid, a combination of understanding and imagination.

Introductory notes about the story lesson suggest students should do some experiments before they hear the story, that they should have prior experience observing states of matter, combinations, gravity, and phenomena referenced in the story. In my experience, inviting students to work with those experiments first made a big difference in their interest and sustained attention when I told the story. A quick demonstration of a few experiments may still enhance the story, and the expanded versions of the experiments are good follow-up activities.

PLEASE NOTE THAT SEVERAL EXPERIMENTS CALL FOR CHEMICALS NOW CONSIDERED HIGHLY DANGEROUS IN THE CLASSROOM. DON'T USE MERCURY, SULPHURIC ACID OR SULPHUR, POTASSIUM DICHROMATE, AMMONIA DICHROMATE, HYDROCHLORIC ACID or LEAD NITRATE. The experiments using these materials should be avoided. They are included here only as an historical footnote. **Baking soda, vinegar and food coloring work fine for demonstrating a volcanic explosion.**

The picture charts are usually introduced at appropriate times during the story. Unfortunately, I do not have graphics files of those charts, only descriptions of them.

The Honneger story ends with the introduction to the Clock of Eras and the first "strip of time."

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8) Subject: Mixture.
Materials: Some iron-filings, some sand, a plate, a magnet, a handkerchief. (Be sure to always have a piece of metal attached to your magnet so it does not loose its attractive force.
Command: Take the iron-filings and the sand, mix them on a plate. Then wrap a magnet in the handkerchief and bring it near the plate.

What happens? - If you like, write down your observations.

Statement: There are certain substances we mix but do not combine and therefore can be separated: these are called: mixtures.

9) Subject: Chemical combination of gas.
Materials: Ammonia, hydrochloric acid, a glass, a plate.
Command: Moisten the bottom of a glass with a drop of ammonia; turn over the glass on a plate wet with hydrochloric acid.

What happens? If you like, write down your observations.

Statement: A new gas has formed called ammonium chloride, due to the combination of ammonia and hydrochloric acid.

10) Subject: Crystallization.
Materials: A little bit of copper sulphate water in a little jug, a test tube, a spirit lamp or a gas-burner, a silk or a nylon thread, some matches.
Command: In the test tube put some little bits of copper sulphate and some water. Light the fire. Put the test tube on the fire moving it until it forms a saturated solution. While it is still boiling, put in a tiny piece of copper sulphate tied to a thread. Let the solution get cold; take out what you have put in. (a solution is saturated when the substance added no longer dissolves - here add until that point.)
What has happened? If you like, write down your observations.

Statement: Some matter in passing from the fluid to the solid state has the property of crystallizing itself.
Note: test tube must be dry or it breaks; must be heated gradually & evenly.

11) Subject: Chemical reaction.
Materials: Sugar, sulphuric acid, a glass.
Command: Put some sugar in a glass until it is 3/4 full. Pour enough sulphuric acid so that it reaches about half the height of the sugar. Stir with a glass-rod. The mixture must become black. Be very careful with the sulphuric acid, it burns everything, even the skin!
Be careful also in holding the glass.

What do you observe? If you like, write down your observations.
Statement: A chemical reaction has taken place: a new substance

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12) Subject: Precipitation.
Materials: Potassium bichromate, lead nitrate, water in a little jug, a test tube, a little spoon.
Command: Take the test tube, pour in it a pinch of potassium bichromate and a little water. Stir it until it dissolves; then add some drops of lead nitrate.

What do you observe? If you like, write down your observations.

Statement: There are certain liquid substances which combine with others to form a new substance and they are called: precipitation. (a precipitated substance)

13) Subject: Properties of solids, liquid and gas.
Materials: A little piece of glass , a little piece of wood, some receptacles of glass in different shapes, a small bottle of ammonia, some water in a small jug. (interesting test tubes of different shapes used here)

Command: a) Take the piece of glass and the piece of wood and observe its form.
b) Take the receptacles of different shapes, pour some water in them. Go on pouring some water in one of them until it overflows.
c) Open the bottle of ammonia and leave it open for a moment.

What do you observe? If you want, you can write down your remarks.

Statement: The solids have a shape of their own; the liquids take the shape of the vessel that contains them, and when overflowing they go in all directions except upwards.
The gases have no shape, they have the tendency to occupy the maximum space, and they expand in all directions even upwards.

14) Subject: Elastic - plastic - rigid.
Materials: A piece of marble, or stone, or brick, a rubber ball, some plasticene.
Command: Take the piece of marble, the rubber ball and the plasticene. Using the hand apply some pressure on each of them successively.
Apply the terms:
plastic - rigid - elastic.

What have you observed? If you want, you can write down your observations.

Statement: Matter which when put under normal pressure does not change the form, is called "rigid".
Matter which when put under normal pressure changes form, but once the pressure is taken away, takes back its original form, is called "elastic".
Matter which when put under normal pressure changes its form and once the pressure is taken away, does not take

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15) Subject: The matters change their state at different temperatures.

Materials: A little piece of wax candle, a piece of tin, a bit of lead, a piece of iron, a tin plate, a glass, a piece of ice, some matches, a spirit lamp or a gas burner.

Command: Take a match and light the spirit lamp or the gas burner. Put the piece of wax, the piece of tin, the piece of lead, the piece of iron on the tin plate and put the plate on fire.
Put the piece of ice in the glass and leave it on the table.

What happens? If you want you can write your observations.

Statement: All matter changes it state; but each at its own temperature and therefore the difference in temperature.
(this is an important balance in the universe)

16 a) Subject: Law of gravity.

Materials: a test tube, a stopper, some mercury, some water, some oil.

Command: Take the test tube; pour in some mercury, some water, some oil, until the test tube is nearly full. Close the mouth of the tube with the stopper, turn it upside down; see what happens. (all always take the same arrangement)

Write down your observations.

16 b) Subject: Law of gravity.

Materials: A receptacle, some cork or celluloid object, some iron or lead objects, dry sand, a towel.

Command: Put the cork and celluloid objects in the receptacle, cover them with the sand and than put on the surface the iron and lead objects. Cover now the receptacle with the towel and shake it rather hard. Now take the towel away and see what happens.

Write down your observations.

Statement: The Earth attracts matter like a big magnet. Heavy bodies tend toward the bottom while lighter bodies tend to remain on top, that is to say that the lighter bodies remain more distant from the centre of the Earth.

17) Subject: the rapidity of cooling depends on the mass of the bodies.

Materials: a burner, a small pan bowl, a small bowl water.

Command: Put about half a litre of water into the pan and put it on the burner. When the water boils, pour a little bit of it into the small bowl and the rest of it into the other bowl. Let the bowls remain for a while; then dip the fingers of both hands into then at the same time.

Which of the two has cooled more quickly?

18) Subject: Volcano
Materials: Some clay, ammonia bichromate crystals, some sulphur, some matches.
Command: Make a model of a volcano with moist clay. Pour some ammonia bichromate crystals and some sulphur into the crater. Put a lighted match on the crystals until some of them catch fire.

What do you observe? If you like, write down your observations.

Statement: Inside the earth there are some substances which tend to come out and if they do not find their way, create it, thus forming, among other things, the volcanoes.

19) Subject : Matter expands when heated.
Materials: An iron box with an opening, a small iron circle with an opening, a flask with a stopper, some water in a little jug, a net, some matches, a spirit lamp or a gas-burner.
Command: Take the small iron circle and pass it through the opening of the box. Then heat the circle a good deal and try to pass it again through the same opening.
Fill half the flask with water (dry the outside of the flask very well), close it lightly with the stopper and place it on fire (with the net placed on the burner) .

What happens? You can write down your observations.

Statement: All matter - and therefore also gaseous matters - expand when heated.

20) Subject: Quick evaporation.
Materials: Some water in a small jug, an iron plate, some matches, a spirit lamp or a gas-burner.
Command: Take a match, light the spirit lamp or the gas-burner, put the plate on the fire and let it become red-hot; than pour a few drops of water on it.

What happens? If you want you can write down your observations.

Statement: All matter when heated pass-es from solid to liquid, from liquid to gaseous. The stronger the heat is, the more rapidly the change takes place.

THE HISTORY CHARTS: a series of sixty charts which accompany the presentation of history.

1a. The Fiery Sun: shown with long flames among which is found the tiny speck of the earth. A portrayal to show the earth's relationship to the flames of the sun. It does not, of course, represent a real relationship of size; in that case, we would not be able to see the earth speck.

2a. The Planets and Their Orbits: a chart constructed so that we may see the relationship of the orbits and the planets to each other. In order to construct such a chart---we must disregard the size of the sun in its position at the center.

3a. The Dance of the Elements: Above the earth's surface, still in the viscuous state of liquid fire at the commencement of its formation, we see yellow angels representing the escaping gaseous elements, made lighter as they are heated; and blue angels who represent those same elements cooled into precipitation and descending once again into the fire. The ascension and descent is a continual motion that goes on for millions of years as the burning off process goes on.

4a. The Cooling of the Earth's Surface and Volcanic Activity: Here we see the earth's surface considerably cooled down with much volcanic activity, indicating the liquid fire that still seethes below the surface. A grey cloud hangs above the earth as a result of the volcanic ash and smoke. (We recall the candle's flame which gives off, along with the burning of the gas, a smoke.) Water not present.

5a. The Four Elements in Balance: The earth's surface now has cooled enough to retain water in the low places. So the volcanoes are shown surrounded with water. And we see here all four elements present: land, air, sun and water---balanced and ready for life.
NOTE: This is at the end of the 4th hour. Perhaps the surface of earth is truly ready for life: perhaps not. If there was life before the 7th hour, we have no evidence of it or we have not yet discovered it or that life left no trace. Our first knowledge of life, in any case, happens three hours after this point of balance with the plankton skeletons in rock discovered. As a layer of rock.

6a. The Cross-Section of a Star: showing the earth's cross-section composition as it is today, still with a center of molten fire, but compressed into addense mass with well-defined layers shown.

7a. The Sun's Light: Here shown again the tiny speck earth receiving only a very small part of the sun's rays; the rest of that energy and light is lost into space.

GOD WHO HAS NO HANDS

From the very beginning people have been aware of God. They could feel Him though they could not see Him, and they were always asking in their different languages who He was and where He was to be found. "Who is God?" they asked their wise men. "He is the most perfect of beings" was the answer. "But what does He look like? Has He a body like us?" "No, He has not got a body. He has no eyes to see with, no hands to work with and no feet to walk with; but He sees everything and knows everything, even our most secret thoughts". "And where is He?" "He is in Heaven and on this earth. He is everywhere". "What can He do?" "Whatever He wishes". "But what has God actually done,"

"What He has done is all that has ever happened. He is the Creator and Master Who has made everything; and all the things He has made obey His will. He cares and provides for them all, and keeps the whole of His creation in the most wonderful harmony and order.

In the beginning there was only God. Since He was completely perfect and completely happy, there was nothing He needed. Yet out of His goodness He chose to create and all that He willed came into being: the heavens and the earth, all that is visible; and all that is invisible. One after another He made the light, the stars, the sky, and the earth with its plants and animals. Last of all He made man. Man like the animals was made out of particles of the earth; but God made him different from the animals and like Himself, for into his body which would die He breathed a soul which would never die".

Many people thought this was just a tale. How could someone with no hands and no eyes make things? If God is a spirit who cannot be seen or touched or heard, how could He have made the stars that sparkle overheard, the sea which is always astir, the sun, the mountains and the winds? How could a spirit make the birds and fishes and trees, the flowers and the scent they shed around them? Perhaps He could make invisible things, but how could He make the visible world? It is all very well, they thought, to say that God is everywhere, but who has ever set eyes on Him? How can we be sure He is anywhere? They tell us He is the Master whom everybody and everything obeys, but why on earth should we believe that?

And really it does seem impossible. We who have hands could not do these things, so how could someone who has no hands do them? And can we imagine animals and plants and rocks obeying God? The animals do not understand when we talk to them, so could they be obedient? Or the winds and the sea and the mountains? You can shout and scream and wave your arms at them, but they cannot hear you for they are not even alive, and they certainly won't obey you.

Yes, that is how it seems to us. But, as you shall see, everything that exists, whether it has life or not, in all that it does and by the very fact of being there, actually obeys the will of God.

Gods creatures do not know that they are obeying. Those that are inanimate just go on existing, those that have life move and go on living. Yet every time a cool wind brushes your cheek, its voice, if we could hear it, is saying: "Lord, I obey". When the sun rises in the morning and colours the glittering sea, the sun and the sunbeams and the water are also whispering, "My Lord, I obey". And when you can see birds on the wing, or fruit falling from a tree, or a butterfly hovering over a flower, the birds and their flight, the tree and the fruit and its fall to the ground, the butterfly and the flower and its fragrance are all repeating the same words: "I hear, my Lord, and I obey".

At first there was chaos, and darkness was on the face of the deep. God said: Let there be light", and there was light. Before that there was only the deep: and immensity of space with no beginning and no end, indescribably dark and cold. Who can imagine that immensity, that darkness and coldness?

When we think of the dark, we think of night: but our night would be like brilliant sunshine in comparison with that darkness. When we think of cold, we think of ice. But ice is positively hot if you compare it with the coldness of space, the space that separates the stars: as hot, you might say, as a blazing furnace from which no heat can escape. In this measureless void of cold and darkness light was created. There appeared something like a vast fiery cloud* which included all the stars that are in the sky: the whole universe was in that cloud, and among the tiniest of stars was our own world. But they were not stars then: as yet there was nothing except light and heat. So intense was the heat that all the substances we know - iron, gold, earth, rocks, water - were gases, as insubstantial as the air. All these substances, all the materials of which the earth and the stars are composed, were fused together in one vast, flaming intensity of light and heat - a heat which would make our sun today feel like a piece of ice. This raging fiery cloud of nothingness, too huge to imagine, moved in the immensity of freezing space, which was also nothingness but infinitely vaster. The fiery mass was no bigger than a drop of water in the ocean of space : but that drop contained the earth and all the stars, which are really blazing suns millions of times bigger than the earth.

Exp. #1

* tiny invisible particles which collide, exploding in a chemical reaction which produces heat and very strong light. ... Collision of some particles create ashes, earth...

As this cloud of light and heat moved through empty space little drops fell from it. If you swing the water out of a glass, some of it holds together as it falls and the rest breaks up into separate drops. The countless hosts of stars are like these drops. Only instead of falling they are moving round in space, in such a way that they can never collide or meet again. They are millions of miles from each other.

Some stars are so far away from us that it takes millions of years for their light to reach us, even though light travels 186,000 miles in one second. God gave them special laws which they have always obeyed. They seem free, whirling dizzily through space with nothing to stop them, but they are all tied to their courses by an invisible string which is the will of God.

Two of these drops were our world and our sun, which move on their own courses through space. The earth moves round the sun, but it travels like a spinning ball, ceaselessly revolving round itself and always revolving at the same speed.

When God's will called the stars* into being, there was no detail He had not planned. Every scrap of the universe, every speck which we might think too tiny to matter, was bound to behave according to the rules He had made. For the drop of the blazing cloud which became our world He decided that there should no longer be chaos. Instead of a burning confusion of gases there was to be air and water and rocks*

* Whereas earth was formed it was a star; star is a gaseous fire - planet is, cold & distant give light.

God's arrangement was wonderfully simple. The blazing mass of the earth was made up of infinitesimal particles and it was they themselves that would be transformed into rocks and water and air. The shape they took depended upon how hot or cold they were. These particles, inconceivably small and all merged together, were whirling at a fantastic speed. As they cooled, they moved more and more slowly, clinging closer and closer to each other and occupying less and less space. It is this law of God's which has given us what we call the three physical states of matter: everything we know is either a gas or a liquid or a solid, and which of the three it is at a given moment depends on how hot or cold it is. Why then, we may ask, are there such millions and millions of different types of particles, each with its special instructions : each was given a special love for certain particles and a special dislike for others. Exp. #1 Just like human beings, they are attracted to some individuals, and refuse to have anything to do with others. So they form themselves into different groups.

In the solid state, God has made the particles* cling so tightly together that they are almost impossible to separate. They form a body which will not alter its shape unless great force is applied to it. If a piece is broken off - if for instance you start chipping a flint - the particles still cling together: the flint and the chips remain solid pieces of stone.

* some particles formed

When it came to liquids, God said to the particles: You shall hold together while

And, since you do not cling so tightly to each other, you take up more room than the particles of a solid. And to the gases God said: Your particles shall not cling together at all. They can move freely in all directions.

This was the simple plan God devised for the particles, and so it is that they form themselves into solids and liquids and gases. But He added certain conditions. Unless, He said, the temperature is very, very hot, hotter than the heat of the sun, or very very cold, like the cold of outer space, you shall not be gases, or liquids, or solids all at the same time. But at a certain degree of heat some of you shall be solid, some liquid and some gaseous. And if the heat increases, solids will become liquid, and the liquids will turn into gases which will mix with the other gases; but not all the solids will become liquid at the same degree of heat.

#6 And He gave another law: All of you shall have weight, but you will not all have the same weight. And those that are heavier will attract those that are light.

These were the laws God gave. And in obedience to these laws the little drop of nothingness which was made our world went on turning and turning and moving round and round the sun. The earth and the sun and the stars were balls of gas - gas which contained in itself all the elements of which our world, the earth, is made up - and they moved on their courses through space, which is so cold that ice is hot by comparison. If you put your hand into ice-cold water it becomes cold. For the same reason the stars and the sun and the earth gradually grew colder as time went on, and the smaller balls cooled more quickly than the larger. The earth, which is tiny compared with the sun, has become quite cold outside, while the sun is still blazing in the heavens.

As the gases of which the earth was formed cooled down, they obeyed the laws God had given them. One after another, at the appointed temperature, they became first liquid and then solid; and as they became liquid or solid their particles would join the other particles to which they were attracted and form new compound substances; Exp. #9 and the heavier substances attracted those which were lighter. When you throw a stone into a pond it sinks to the bottom. Similarly the heavier liquids sank towards the center of the earth's ball, and those that were lighter floated above them like oil floating on water. Thus they arranged themselves in layers according to their weight; Exp. #16 but all of them were attracted to the heaviest at the center, and to this day each layer is still pushing on the layer below it. While this was going on and each group of elements that had joined together was obeying the special laws God had given it, the whole earth which they formed was also obeying His laws and continuing to spin on its course round the sun.

As the surrounding gases cooled slightly the boiling liquid also began to cool and thicken into a paste. The liquid at the center remained intensely hot, but it was pushed on all sides by the enormous weight that lay over it, one compound on top of another. It was nothing like cool enough to turn into a solid, but all the same it began to solidify because of the sheer pressure from above. Some of the upper layers were semi - solid pastes, others remained liquid, all pushing against one another with all their might. Sometimes a mass that was pushed on two sides found itself squeezed on top of its neighbours; and in this bending process hollows might be formed, which Exp. 18 were immediately filled with liquid. And above them all stretched a sea of flaming gases.

Can you imagine this dance of the elements?

By the law God had given them, as they cooled their bulk grew smaller and their weight increased. So when they soared up to meet the utter coldness of enveloping space, they shrank in size and back they fell into the raging fire they had left.

Here they grow hot and light again, light enough to rise up once more, carrying Exp. 19 with them part of the heat from below, which was taken off into space; and when they

and bringing cold. How marvellous it is, and how simple is the law God has made! If you become hot you expand, and as you expand you become lighter and soar upwards, like a bubble of air in water. But if you become cold you shrink and fall downwards, as a grain of sand sinks to the bottom of a tank. Because of this law the earth gradually changed from a ball of fire to the earth we know. This was the law that the tiny radiant particles obeyed as they danced their exultant dance; particles too minute to be seen or even imagined, yet numerous enough to have produced the world.

For hundreds, thousands, millions of years the dance went on. More and more gases became liquid, more and more liquids solidified, and with the continuous assault of cold from outer space the earth shrank in size and became wrinkled like an apple that has been left in a cupboard. The wrinkles are the mountains and the hollows between them are the oceans; and above them is the air we breathe. Exp.#6

Rocks, water, air - solids, liquids, gases: each is what it is because of its degree of temperature. Today, as it was yesterday and a million years ago, God's laws are obeyed in the self-same way. The world spins round and round itself and round and round the sun. And today, as it was a million years ago, the earth and all the elements and compounds of which it is composed, as they fulfil their task, whisper with one voice:

LORD, THY WILL BE DONE, WE OBEY.

Mario M. Montessori

Mrs. Honnegger retells the fable: The Story of Creation

What do we see around us? What do we see in the day? in the night? Have these things around us always existed?

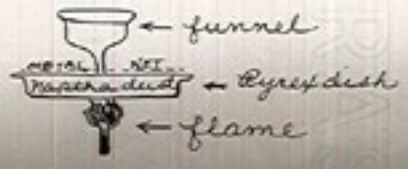
Many many many millions of years ago, nothing existed. It is said that in that time there was a great emptiness, and a deep darkness and cold. This is the darkness and cold that is beyond our atmosphere. But, in the midst of that darkness and cold, something existed. So many tiny invisible particles. And then---we do not know how---those particles were attracted one to the other, they collided and there originated a big explosion. An explosion produces light, like fireworks. And in this way the light was formed. The incandescent particles spread all over infinite space, running very quickly. (Show pictures of galaxies.)

The galaxies are white: we see the Milky Way's whiteness in our own sky, our own galaxy. (A GOOD EXPERIMENT: show a color disc with red, blue, yellow, etc., spinning, so that when it goes very fast it looks white. An electric drill can be used for the motion.) Our sun and earth were enclosed in that ball of fire: EVERYTHING THAT EXISTS was in that ball that exploded.

Gradually the particles (substances) united more closely again. When they united, they formed a sphere. Nor a triangle nor a square. And in these particles existed everything that we know: silver, iron, water, etc. But all the substances were still in the form of an incandescent gas. (A SIMPLE EXPERIMENT: we turn on the gas, then ignite it, and we have light.) Smaller stars started to travel around larger ones.

The universe is governed by certain laws which all must obey, even the sun and the stars. One law is that, when substances are incandescent, they are gasses: when they cool, they turn into solids. Everything we know is a gas, a liquid, or a solid. (Experiments 3,4,5,6,) Not all particles are alike: in these incandescent masses we have some that attract each other and some that repel each other. Therefore, different substances are formed. (Experiments 9, 9, 10.) Particles also obey other laws: when particles are in a solid state, they are so united that they cannot be separated. When liquid or viscous, they take the shape of the container and, if they come out, they spread out, going down, never up. When in this state, the particles are not so tightly together; therefore, the particles in a liquid occupy more space. When particles are in a gaseous state, they move in all directions, and tend upwards. And they occupy much more space. (Experiments 13, 14.)

There are still more laws: all matter (bodies) have three states. And each changes states: each at a particular temperature. All matter has a certain temperature at which it changes states. (Experiment 15) Not all matter has the same weight. The matter arranges according to its weight: the heaviest at the center of the earth, the lightest ones rising. Gas, as it cools, usually becomes liquid, then solid. Some gasses pass directly to a solid.
An INTERESTING EXPERIMENT: Using the dust of naptha, from moth balls, we see a substance pass from a solid (in the container) to a gas (invisible) to another solid without passing through a liquid state. In the funnel we discover a crystallized form.



Cooling also depends on the quantity of the substance. (Experiment 17) Our earth, when it was formed, was a ball of incandescent substance. Is our earth smaller or larger than the sun? Much smaller. (Chart #1: How Small is our Planet Earth!) Which takes longer to cool? The sun.

HERE WE TAKE THE CLOCK OF ERAS. On the clock of eras we begin when this ball of incandescent mass begins to form towards an earth. Here we have the history of our planet from the time it was a huge mass of fire to the planet on which we live today.

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1) Subject: Cold - Freezing.

Materials: Some ice, 1 lb. of salt, two receptacles with the capacity of 1 pt., two thermometers.

Command: In a receptacle put some small bits of ice and then put in a thermometer. Do the same in another receptacle adding a large amount of salt; put in another thermometer. After a while compare the temperature of the two thermometers.

What do you observe? - If you like, write down your observations.

Statement: The cold of the ice is not the coldest; there are temperatures much, much colder, that it is much lower.

Note: humidity condenses & freezes on leaves - frost; when temperature milder, fog... when colder, frost.

2) Subject: The formation of the star.

Materials: oil, alcohol (better pure alcohol) water in a little jug, a glass. (Colored oil; red is nice)

Command: pour some water in the glass until it is 3/4 full. Add a few drops of olive-oil (or another more dense type of oil) then add slowly, pouring near the rim of the glass, a bit of alcohol. (alcohol is lighter; equilibrium between water & oil so the oil does not spread out.

What happens? - If you like, write down your observations.

Statement: The innumerable groups of star are something like those drops, and are spinning in the space.

Note: when matter unites, it forms spheres; all celestial forms are spherical

3) Subject: Solid - liquid - gas.

Materials: A little piece of painted glass, some water in a small jug, three test tubes, a glass tube holder, three slips of paper.

Command: Put the three test tubes in the holder. Put the little piece of painted glass in one of them, some water in the second, leave the third as it is.
Apply the names: solid - liquid - gas. (the air around us is a gas - what happens when this empty tube is submerged... note bubbles)

Statement: Matter can assume three states: solid, liquid, gaseous.

Notice with the child the forms that things take: a pencil, candle flame, etc.

4) Subject: Liquid - viscous.

Materials: Sugar, some water in a little jug, two glasses, a little spoon.

Command: Take the two glasses and pour some water in them; then addone sugar to are of the glasses until the water thickens into a semiliquid. (Children should prepare this)
Apply the two terms: liquid, viscous.

What have you observed? - If you want, write down your observations.

Statement: A substance is liquid when it is fluid. A substance is

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5) Subject: Passing from solid to liquid and to gas.
Materials: a piece of wax candle, a spoon, a spirit lamp or a gas-burner, some matchs.
Command: Take the match and light the spirit lamp or the gas-burner. Put the piece of wax-candle on the spoon and hold it over the flame. Keep the spoon on the flame, till there isn't anything.

What did you observe? - If you want you can write down your remarks.

Statement: Matter, when heated, passes from solid to liquid and then to gaseous.
All things can be changed to gas, some without passing first to liquid.

6) Subject: Passing from gasous to liquid and to solid.
Materials: a piece of ice, a pan and a lid, a spoon, some wax, a fire and some matchs.
Command: a) Put the piece of ice in the pan, and put it on the fire; as soon as the water boils put the lid on it. Observe what happens. You can collect some drops and put them into the freezer.
b) Melt some wax in a spoon, them drop it in a receptacle containing some cold water.

Observe what happens and if you want, you can write down your remarks.

Statement: Matter when cooled passes from the gaseous or vaporous state to the liquid state and from liquid to the solid state.

7) Subject: Particles which love each other and particles which do not love each other.
Materials: Some water in a little jug, sugar, some chalk powder, two glasses.
Command: Put some water in a glass, pour in some sugar, stir it with a teaspoon.
Take a glass, pour some water and some chalk powder in it; stir it energetically with the teaspoon.

What do you observe immediately?
What do you observe a little later? If you like write down your observations.

Statement: There are some particles which love each other and they stay joined; there are others which do not love each other very much and when joined may be separated.
The sugar substance dissolves; the chalk mixes, but does not dissolve and will eventually settle into layers.