V11

A

PATH OF

DISCOVERY

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A Program of a Waldorf
Grade School Teacher

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Volume Seven - Grade Seven

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Including lesson indications, verses, poems, etc.,

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INTRODUCTION

"A second phase in human life is puberty which in the male gender appears especially through the voice change and in the female gender in physical changes that are distributed over the whole body, in both cases around the age of thirteen or fourteen. What is really happening there? What is it that changes after puberty? It is the whole of the human life of will. The entire life of will changes, otherwise the feeling of love could not enter the life of will.....When we research spiritually-scientifically what is happening there, we find the following: We grow together with the outer world more and more, especially in the time between the change of teeth and puberty; we grasp more and more of this outer world, and our will becomes more and more focused. We learn to bring our will into conformity with the objects and events of the outer world. If one truly studies the whole of this complex, then one finds that at that time the human being makes the will element his own through his interaction with the outer world, not from within. It was a profound intuition when a poet said:

'A talent grows in stillness;
the character grows in the current of the world.'

Rudolf Steiner. **"Balance in Teaching"** (9/1920)

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Students in Grade Seven display an avid interest for worldly matters and phenomena and begin to develop a more abstract form of thinking. At the same time they develop a greater inner awareness and are able to reflect on their experiences.

Physical development is well underway with both girls and boys. Whereas the girls tend to adopt skimpier forms of attire, boys on the other hand opt for clothes which appear to be several sizes too large for them, thus successfully detracting attention away from their long gangling arms and legs. Adults are viewed with mixture of suspicion and sympathy! Communication skills especially amongst the boys, may deteriorate to monosyllabic grunts, accompanied by a sullen expression.

Alternatively, they can take delight in the use of words and begin to sense their 'power' of thought, becoming increasingly self-opinionated which in turn can lead to argumentative confrontations with the adults in their lives. It is the responsibility of the adult to ensure that such situations do not get out-of-hand. It is far too easy for us to become drawn into an argument, than to stand firm on one's point of view without inviting any discussion

Although their manner may indicate an attitude of disinterest and a lack of enthusiasm for school work, I have found that in actual fact, they love all manner of challenges, especially those which call upon them to take responsibility for their overall participation. The majority will delight in the challenge of a 'project', often going to extreme lengths to produce impressive results. Of course, this does not apply to every student, for there are always those who will shy away from anything which may remotely indicate the need for them to exert any effort in bringing a task to completion. In instances where this happens, I believe that it imperative for the teacher to insist on completion, rather than allowing the task to slip into unchallenged oblivion. Several of my students were most astonished when I insisted that they came to school for two extra main lessons after the school year had come to a conclusion, so that they could finish a 'history project'!! Their parents were most supportive!

The entire Grade Seven syllabus opens-up a new world to the students, often connecting with subject matter which they have met in earlier classes, such as Greece. Thales and Pythagoras are central to the mathematics program, whilst Archimedes leads students into the realm of physics. Our history program covers an enormous area, from the Dark Ages, thru the Middle Ages to the Renaissance and beyond. Throughout these lessons, students meet outstanding individuals from the legendary stories of King Arthur to the stories of Charlemagne *(Song of Roland)*, Richard the Lionheart and the Crusades, Saladin, Joan of Ark, etc.

We take the students out into the exploration of the world by following the incredible journeys of discovery made by individuals such as Marco Polo, Vasco da Gama, Ferdinand Magellan, Christopher Columbus, Pizzaro, etc.,.

Voyages of discovery into the unknown parts of the world were complemented by exploration in the realms of science and mathematics by men such as Aristotle, Archimedes, Pythagoras, Leonardo da Vinci. Copernicus, Tycho Brahe, Galileo and many others.

Art lessons will introduce students to 'perspective drawing' and further work with light/dark and shadow. A Morning Lesson block will introduce students to the artistic wonders of the Renaissance world from Giotto thru to the spreading of Renaissance art into all regions of Europe. I believe that it is important that students be introduced to the Great Masters: Leonardo, Michelangelo and Raphael. This lesson gives many students a fresh impulse with respect to their art work.

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GEOMETRY

THE SECRET BROTHERHOOD OF PYTHAGORAS

"Mathematics, rightly viewed, possesses.....supreme beauty, a beauty like that of sculpture; sublime, pure and yet capable of a stern perfection such as only the greatest art can show. The true spirit of delight, the exaltation, the sense of being more than man, which is the touchstone of the highest excellence, is to be found in mathematics as surely as in poetry."

Lord Bertrand Russell

THE GEOMETRY OF ANCIENT EGYPT

It is generally accepted that Geometry had its beginnings in ancient Egypt, which the Greek historian Herodotus places as early as Ramses II circa 1300 BC, although this is disputed by other accounts which place its beginnings even earlier.

It has been said that during the reign of Ramses II it was custom for the land bordering the the River Nile to be divided equally among the Egyptians. Each man was allocated a rectangular piece of land upon which the pharaoh levied an annual tax. However, each year the Nile flooded its banks and subsequently robbed many landholders of all or of part of their piece of land. They in turn would appeal to the pharaoh for a reduction in taxes as compensation for their loss.

To ascertain whether or not the farmer's claims were genuine or not, the pharaoh would send out surveyors to measure the land, so as to determine the amount of tax due on each holding. It was from this practise that the word **geometry** was formulated from a combination of the words **ge** (earth) and the word **metrein** (to measure). According to Plato, Socrates is supposed to have said that the ancient Egyptians gained the skills required to practise the art of geometry from the Egyptian God Thoth who was the first to discover arithmetic, geometry and astronomy.

A considerable knowledge of geometry was required for the construction of the enormous temples and pyramids of Egypt. From tomb paintings it is apparent that the Egyptians used ropes and pegs for the marking of the foundations of a temple. These skilled geometers, or rope-stretchers as they were most commonly referred to, used a continuous loop of rope which contained twelve knots spaced at equal distances around the loop. This knotted rope concealed a special secret!

By accident or intent, the knotted rope contained a perfect right-angle! The rope-stretcher would place the rope on the ground at a given point and hammer a split wooden peg into the ground over the rope thus securing the first knot. Counting along the knotted rope to the third knot, a second split-peg would be hammer over the rope. Taking a third peg, the rope-stretcher would count off a further four knots. Pulling the rope so that it became taught, the third peg would then be hammered into the soil. The result would be a perfect right-angle.

The Egyptian populace had great respect for the rope-stretchers and they were elevated to positions of great importance in society. Despite the development of geometry for practical purposes, it would appear that the Egyptians never really questioned the whys and wherefores of this new science, it always remained at a very practical level. The pyramids of Egypt are a worthy and lasting memorial to these early pioneers of the art of geometry.

The ancient Egyptians not only discovered the right-angle, but they also had knowledge of areas, such as the rectangle, triangle, trapezium, circle, and the value of pi. This information was gleaned by archaeologists from ancient papyri, such as the Papyrus Rhind written about 1700 BC and the Ahmes Papyrus (1550 BC) which reveals the area of an isosceles triangle as $1/2\ bh$, b being the base and h being the height.

It was left to the Greeks to develop a pure geometry so that it would become a real science in which theorems and problems were proven and solved. The Greeks furthered the knowledge of geometry to the extent that it influenced the development of western civilisation.

The Greeks had a love of knowledge for its own sake. This interest permeated not only the field of geometry and philosophy as evidenced by the studies of Thales, but also in the philosophy of great individuals such as Plato and Aristotle, or in the plays of Sophocles.

Thales of Miletus was one of the Seven Wise Men of ancient Greece. Besides being a mathematician, he was also a philosopher, statesman, businessman, astronomer and engineer. It is said that philosophy begun with Thales. It was he who first posed the question "what is the world made of?" He reasoned that as water was essential to life, it must be the source of life itself.

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THE GEOMETRY OF THALES

Thales lived in the sixth century BC (circa 640 - 546 BC) in the wealthy, cosmopolitan city of Miletus, which was the center of trade and culture in Asia Minor.

His first claim to fame can be coupled with his accurate prediction of a total eclipse of the sun in 585 BC. He is also credited with having given sound advice to townsfolk on political matters and later advised the Ionian-states to form a federation for mutual protection against the Persians.

There were of course those who scoffed at and ridiculed this unusual man with his strange ideas which contradicted much of what was accepted in those early times. However, their scorn would often be turned to dismay when Thales proved a valuable point. One year, predicting a bumper crop of olives, Thales quietly bought up all the olive presses in the region much to the hilarity of the olive growers. Imagine their dismay when Thales' prediction of a bumper crop was realised and the growers found themselves without their precious presses! There was such a demand, that Thales rented out all the presses he had so wisely bought earlier in the year, and thus made a very handsome profit for doing nothing!!

However, even the wisest man can sometimes fall foul of his own absent-mindedness! It is said that Thales was once so preoccupied with watching the heavens in his pursuit of knowledge of astronomy, that he forgot to watch the ground upon which he was walking and subsequently fell down his well, much to the amusement of his servant-girl who remarked: "How can you expect to know all about the heavens Thales, when you cannot even see what is before your very feet?"

Thales travelled widely and in the course of those travels he naturally visited Egypt in search of knowledge, and brought back with him the art of geometry. Whilst in Egypt he discovered a method of measuring the height of the pyramids by measuring the length of their shadows at the times of day when our shadows are equal to our height. Other important geometrical discoveries attributed to Thales are:

1. That a circle is bisected by its diameter.
2. That the two angles at the base of an isosceles triangle are equal.
3. When two straight lines intersect, they will form two pairs of equal triangles.
4. That two angles are congruent (equal in all respects) when two angles and a side of one are equal, respectively, to two angles and the side of the other.

PYTHAGORAS OF SAMOS

This was the Golden Age of Greece into which Pythagoras of Samos was born between the 50th and 52nd Olympiads (circa 582 BC). His father Mnesarchus had visited the Delphic Oracle before his birth and the High Priestess, whose name was Pythia, told Mnesarchus that he would have a son who would be a great teacher. So when the child was born, he was named after the High Priestess.

Pythagoras was a young man when he left Samos his island home, to travel in search of worthy teachers. It is said that Pythagoras studied under Thales and Anaximandros in Miletus, and under Pherekydes on the island of Lesbos. Not much is known about the life of Pythagoras. It is said that his father was a simple carpenter, whilst others maintain that his father was none other than Apollo himself. The mystique surrounding Pythagoras was so strong that it is perhaps not surprising that much of what is known about him is entwined with myth and legend, partly because his philosophical teachings were kept so secretive.

Pythagoras was prompted to leave Samos partly because he could not abide the tyrant Polycrates. However, it was from Polycrates that he obtained a letter of introduction which enabled him to be received at the court of Pharaoh Amasis. Pythagoras spent some 22 years in Egypt, and during this period of time, he moved in the higher circles of the priesthood of Memphis, speaking and discoursing with the wise priests and learning the mysteries of Egyptian civilisation. Undoubtedly during this period Pythagoras would also have met and spoken in depth with the great prophets of Israel, learning much about their religion and culture.

When the Persians invaded Egypt and overthrew the dynasty of the Pharaohs, Pythagoras was taken as a prisoner to Babylon, together with other Egyptian sages. In all, he spent 12 years as a captive in Babylon, but was permitted to pursue his studies amongst the wise men of Persia and the wizards of the Chaldees.

On his release from captivity at the age of 56, it is said that Pythagoras travelled as far as India in order to learn from the mystics of that country. In all probability this is true, for there was a goodly trade in operation during this period of time between the east and west. On his return, he wandered throughout Greece, visiting places such as Delos, Crete and the Delphic Oracle where he stayed one whole year.

Finally, he made his way back to his island home of Samos full of enthusiasm at the thought of at last being able to share his philosophy with other like minded individuals. However, this was not to be! In fact, people were so uninterested in this aging man that Pythagoras is said to have been forced to pay a street urchin to listen to him!!

This was not such a bad deal for the boy, for Pythagoras was a good teacher and the boy was making easy money sitting quietly listening in the shade of the olive tree. Being a student was far easier than working in the fields in the heat of the blazing sun! It is said that the lessons were so good and that the boy became so enthused, that he begged Pythagoras to teach him more and more!

Eventually, Pythagoras left Samos and made his way to the island of Croton off the tip of Italy, which was at that time part of the Greece. There it was that he set-up his school of philosophy which quickly acquired a worthy reputation throughout the civilised world.

Pythagoras drew together elements of all the great religions and philosophies known to the western world at that time; gathered about him a group of students and established his Secret Brotherhood (although both male and female students were admitted). This brotherhood was like other religious cults of that day and age, having initiation rites and ceremonies.

The followers of Pythagoras were known as "Pythagoreans". As a student, one had the responsibility to prove that you were worthy of being a member of the Secret Brotherhood by undergoing and successfully completing various tests. You might be given a problem to solve during the course of one day, at the end of which you had to have worked out an acceptable solution.

Using knowledge gleaned from the East, Pythagoras taught the philosophy of reincarnation. He believed that at death the soul of the deceased would go on and enter the body of another living creature. For this reason, the Pythagoreans were strictly vegetarian, refusing to eat flesh of either birds, beast or fish in case the creature contained the soul of a former loved one or friend. Neither would his followers wear clothing made from wool or leather; there was also a ban on eating certain other foodstuffs, such as beans. They would not kill any living creature, except as a sacrifice to the gods. Furthermore, they were bound by a strict oath never to divulge any of the knowledge or secrets which they acquired during the course of their studies. One student discovered the secret of the twelve-sided solid and divulged it to someone outside of the brotherhood. He was murdered for his indiscretion!

It was Pythagoras's belief that to avoid temptation, one had to be meaningfully occupied at all times. To be idle would be to invite temptation. The task of the student was to seek for the truth in everything and to develop a love of wisdom. To a Pythagorean, religion and science did not conflict, they were inseparable factors in a single life. It was through science that humanity was shown the orderliness of the universe and this orderliness was in turn the model for a pure life.

The human body and the universe were in total harmony with one another and this was expressed in music. Music, as a Greek mathematical science, showed that there was harmony everywhere. The Pythagorean school excelled in medicine and music, as well as with mathematics. The physical body was healed with medicine. The soul was healed with music. To be healthy meant that there was harmony between the body and soul.

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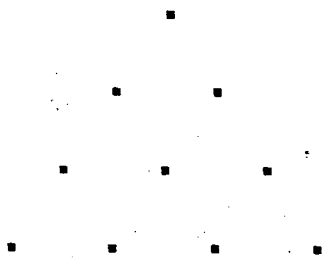
SECRETS OF THE BROTHERHOOD

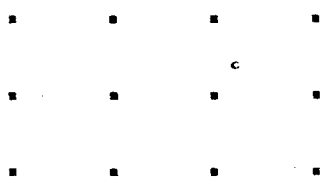
Harmony and order was to be found in numbers and thus the universe had to be expressed in number and proportion. Numbers did not merely represent quantities, but more importantly, numbers represented abstract, spiritual qualities.

One	Unity - the creative source of all numbers - *reason*
Two	Duality - Female - good/evil - light/darkness - *opinion*
Three	Trinity - Male - magical number - beginning/middle/end of life
Four	Justice - first product of two equal sides (2 x 2 = 4) - *the secret of fire*
Five	Marriage - (union of male and female numbers) - *the secret of color*
Six	Life and luck - the perfect number - *the secret of the earth*
Seven	Harmony - (7 colors in the rainbow; 7 notes in an octave)
Ten	The perfect number (the sum of 1, 2, 3, and 4)
Twelve	12 signs of the zodiac - *the secret of the universe*

Geometrical figures could also be represented by numbers in the form of dots, e.g. the numbers 1, 2, 3, and 4 form a triangle:



The even numbers, 2, 4, 6 etc., form a rectangle and were called oblong numbers; e.g.:



One of the secrets of the Brotherhood were the Square Numbers. Square Numbers are the relatives of the odd numbers 1, 3, 5, 7, 9, 11, etc.,. Taking any number of these odd numbers in sequential order and adding them up, the sum total is always a Square Number:

1 = 1 = **1 squared**
1 + 3 = 4 = **2 squared**
1 + 3 + 5 = 9 = **3 squared**
1 + 3 + 5 + 7 = 16 = **4 squared**
1 + 3 + 5 + 7 + 9 = 25 = **5 squared**
1 + 3 + 5 + 7 + 9 + 11 = 36 = **6 squared**
1 + 3 + 5 + 7 + 9 + 11 + 13 = 49 = **7 squared**

Another of the sworn secrets of the Brotherhood was the pattern of Triangular numbers. We are able to create a pyramid of triangular numbers by having 1 "triangle" at the apex, two on the next level down, then three, etc.,. The number of small triangles in the longest line is equal to the number of lines in the big triangle. Each triangle number is the sum of all the whole numbers from 1 up to the number of lines in the triangle. The first six triangular numbers are:

1 = **1**
1 + 2 = **3**
1 + 2 + 3 = **6**
1 + 2 + 3 + 4 = **10**
1 + 2 + 3 + 4 + 5 = **15**
1 + 2 + 3 + 4 + 5 + 6 = **21**

Pythagoreans also discovered that the "triangular numbers" are relatives of the "square numbers". If one adds the sum of any "triangular number" to the sum of the next higher "triangular number", the result is always a "square number", e.g:

Triangle 1 = **1**
Triangle 1 + 2 = **3**

Therefore **1 +3** = 4 = 2 squared

or

Triangle 1 + 2 + 3 + 4 = **10**
Triangle 1 + 2 + 3 + 4 + 5 = **15**

Therefore **10 + 15** = 25 = 5 squared

The "triangular numbers" are also related to the "square numbers" in another way. If one takes a "triangular number", multiply it by 8 and add 1, the result is always a "square number", e.g:

Triangle	1 x 8 + 1 =	9 =	3 squared
Triangle	3 x 8 + 1 =	25 =	5 squared
Triangle	6 x 8 + 1 =	49 =	7 squared
Triangle	10 x 8 + 1 =	81 =	9 squared
Triangle	15 x 8 + 1 =	121 =	11 squared

And once again we observe how the "odd numbers" 3, 5, 7, 9, 11 reoccur!!

Square roots:

4 = 2

9 = 3

16 = 4

25 = 5

36 = 6

49 = 7

64 = 8

81 = 9

100 = 10

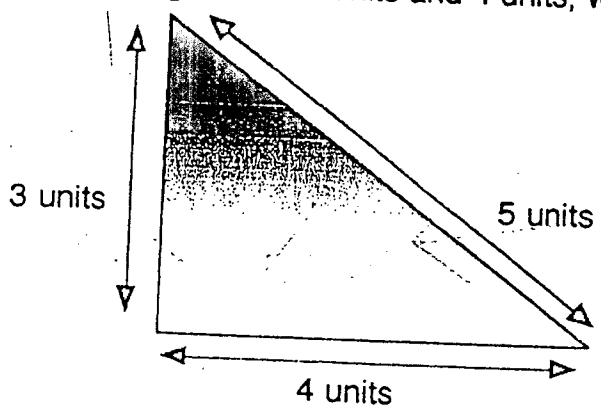
THE MEASURE OF GOLD

The study of geometry was transformed into a liberal education by Pythagoras and our term "mathematics" arose directly out of his lectures on *mathemata*, which in the language of the time was the word used to signify a course of study. The very term "mathematician" implied that person bearing the title had been accepted into the "inner mysteries" of the Brotherhood, as distinct from a novice student.

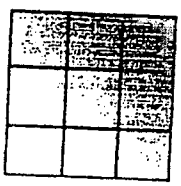
The bearer of the title "mathematica" (also known as 'acousticoi') had to submit to a stern regime of meditation, exercise and study each day over a period of several years, before they were even permitted to hear Pythagoras speak from behind a screen!! It was only on completion of this rigorous training that they were fully initiated into the Brotherhood and permitted to attend lectures actually given by the "Master" himself. Entry into this inner sanctum of the Secret Brotherhood had its rewards, for it was here that great discoveries were made and revealed, for Pythagoras was the first to examine the principles of the science, to discover new theorems, and to give proofs for those already discovered.

Perhaps the most famous of such discoveries was that known as the "Pythagorean Theorem", also known as the "measure of gold"

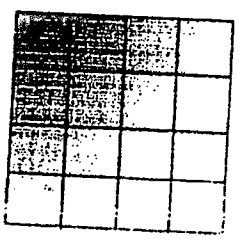
The "Master" may have drawn a a triangle in the sand covering a special tutorial floor area of his school (chalkboards were not available in those days!). The triangle would have been similar to that made by the ancient Egyptians where the sides of the right angle were 3 units and 4 units, with an hypotenuse of 5 units.



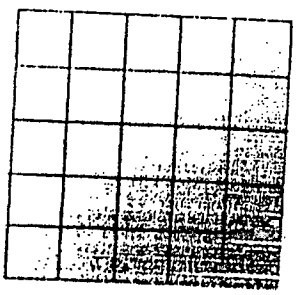
Pythagoras may have then drawn three separate squares with sides 3 units, 4 units and 5 units respectively:



$3 \times 3 = 3_2 = \mathbf{9}$



$4 \times 4 = 4_{2=} \mathbf{16}$



$5 \times 5 = 5_{2=} \mathbf{25}$

Other combinations of squares could be:

5^2 12^2 13^2 or 8^2 15^2 17^2 or 12^2 16^2 20^2

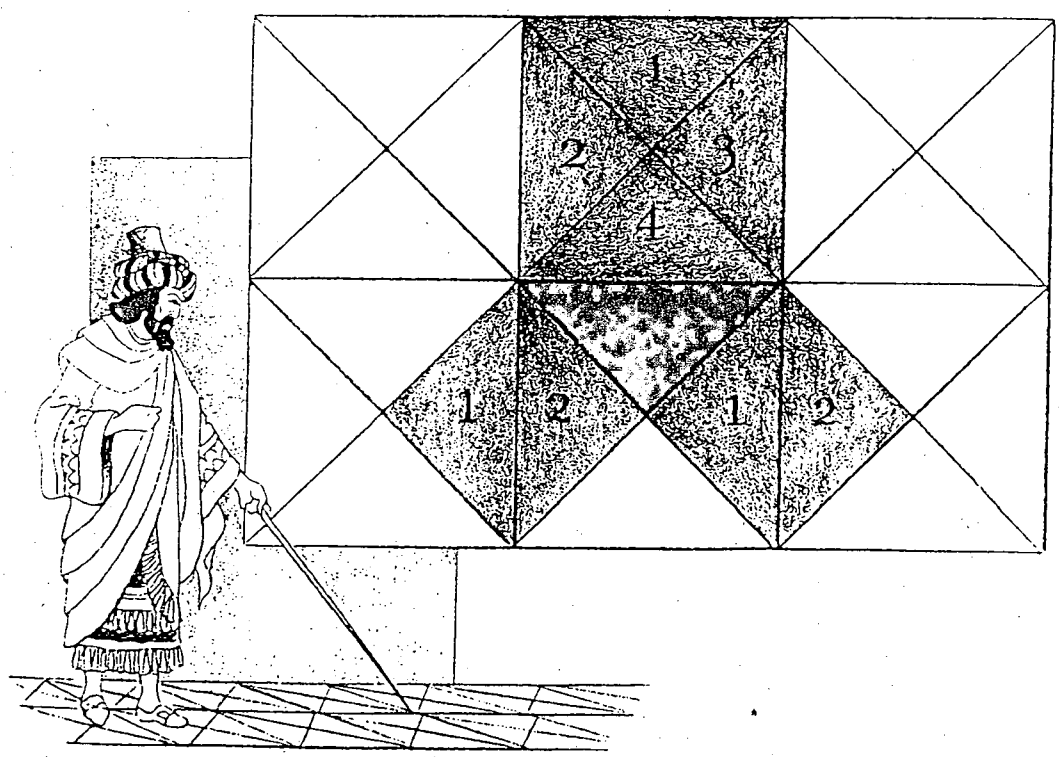
15^2 20^2 25^2 or 12^2 35^2 37^2

No doubt Pythagoras would have asked his students to meditate on what he had divulged to them, with the instruction that they were to solve the "problem" of the right-angled triangle.

One can well imagine the tension next morning when the students met together prior to their lesson with Pythagoras. What secrets had they discovered about the the right-angled triangle, or would it be up to Pythagoras to to divulge the secret? Trembling before the great "Master", each student related what he or she had discovered, whilst Pythagoras listened intently. Finally he took his long cane and once more drew a right-angled triangle in the soft sand of the sand-tray. With all eyes watching intently, he added first one, then a second and finally a third square to the three sides of the triangle. A tense silence followed his actions as the students waited to hear what their revered "master" had to say. A last the silence was broken as Pythagoras shared with his eager students the following theorem:

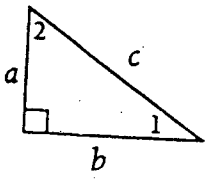
"In any right-angled triangle, the sum of the area of the two squares on the two sides of a right-angled triangle is equal to the area of the square on the hypotenuse."

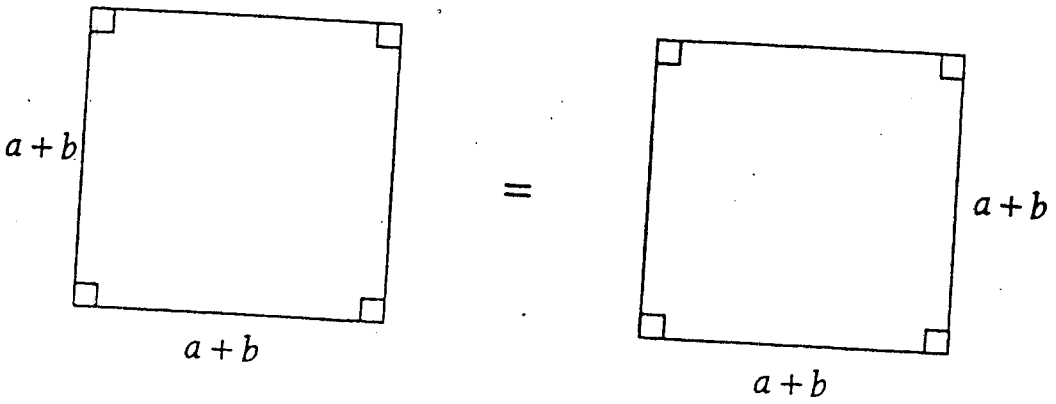
This was such a major advance in mathematical thought, that it was, henceforth, to play a central role in all aspects of geometry. Many years later, after the death of Pythagoras, philosophers were to call his theorem: *"The Measure of Gold"*

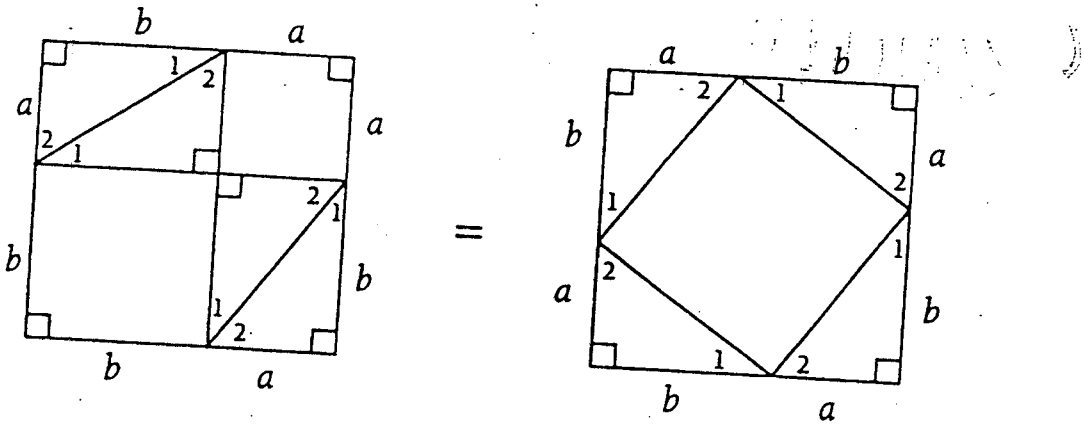


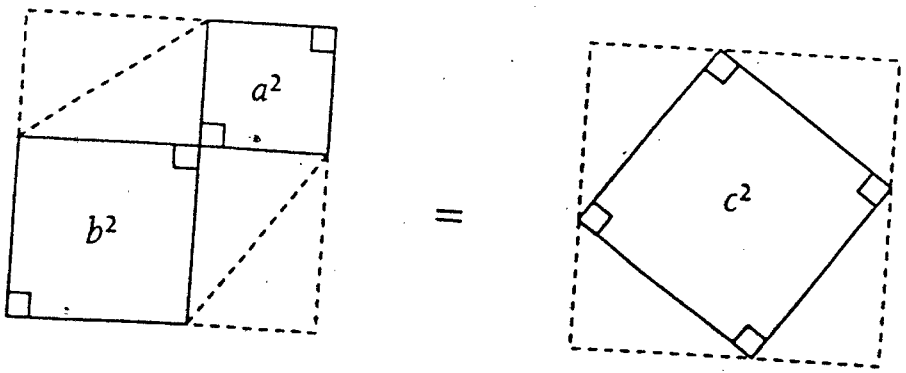
However, Pythagoras was not content with a mere theory, after all, it might not hold good with every right-angled triangle!! His students must have another task. They must set-out to "prove" his theorem, perhaps working with the tiles on covering the floors of the buildings.

Proof of Pythagoras's Theorem known as the 'Tile Proof"



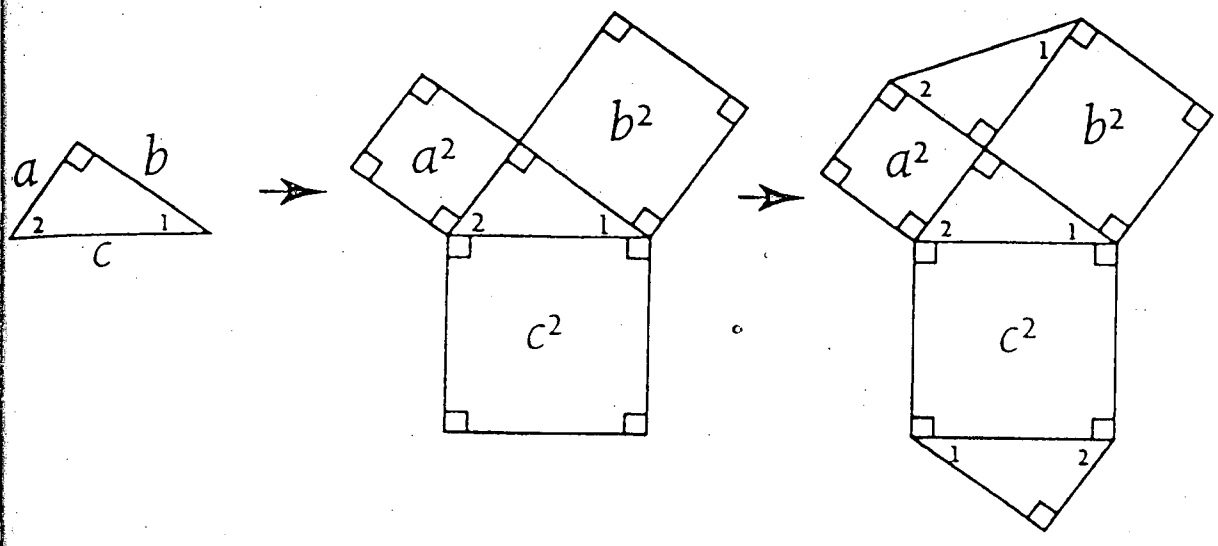




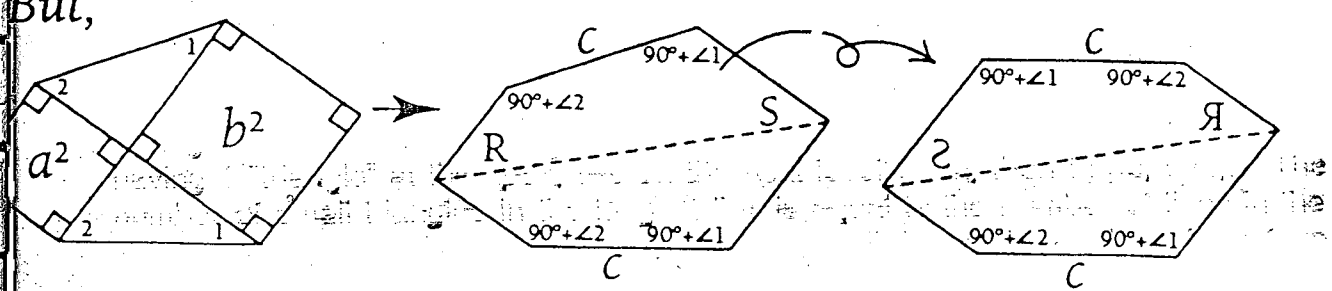


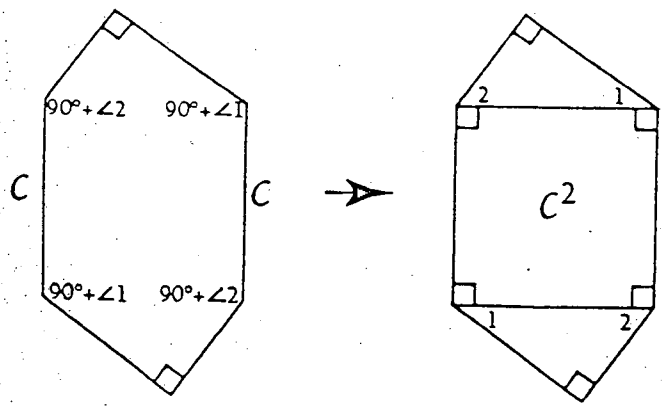
Therefore, $a^2 + b^2 = c^2$

Leonardo da Vinci's 'proof':

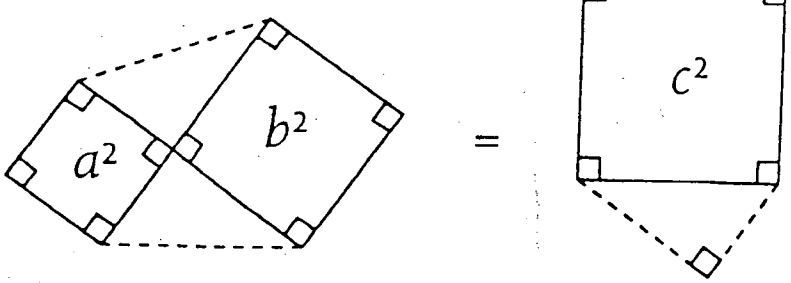


But,

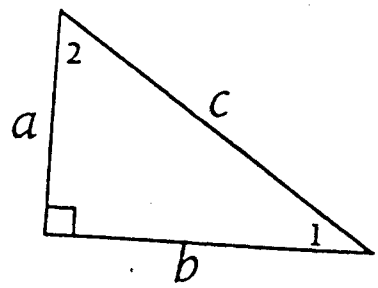


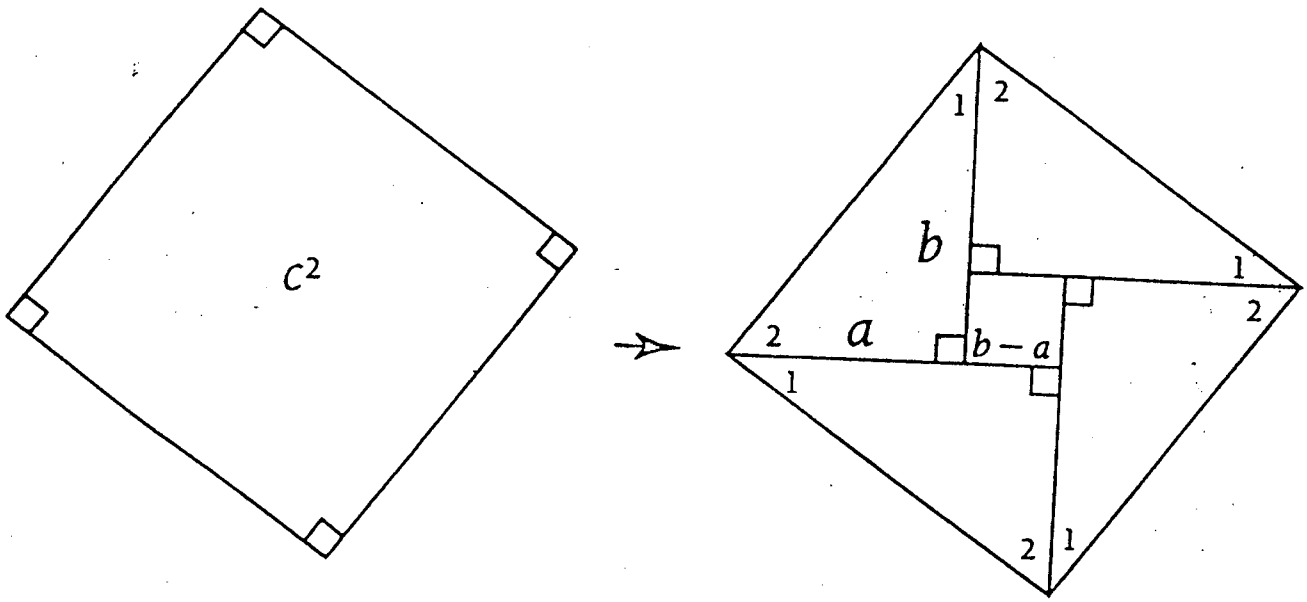


Therefore,



From China comes the following "proof":



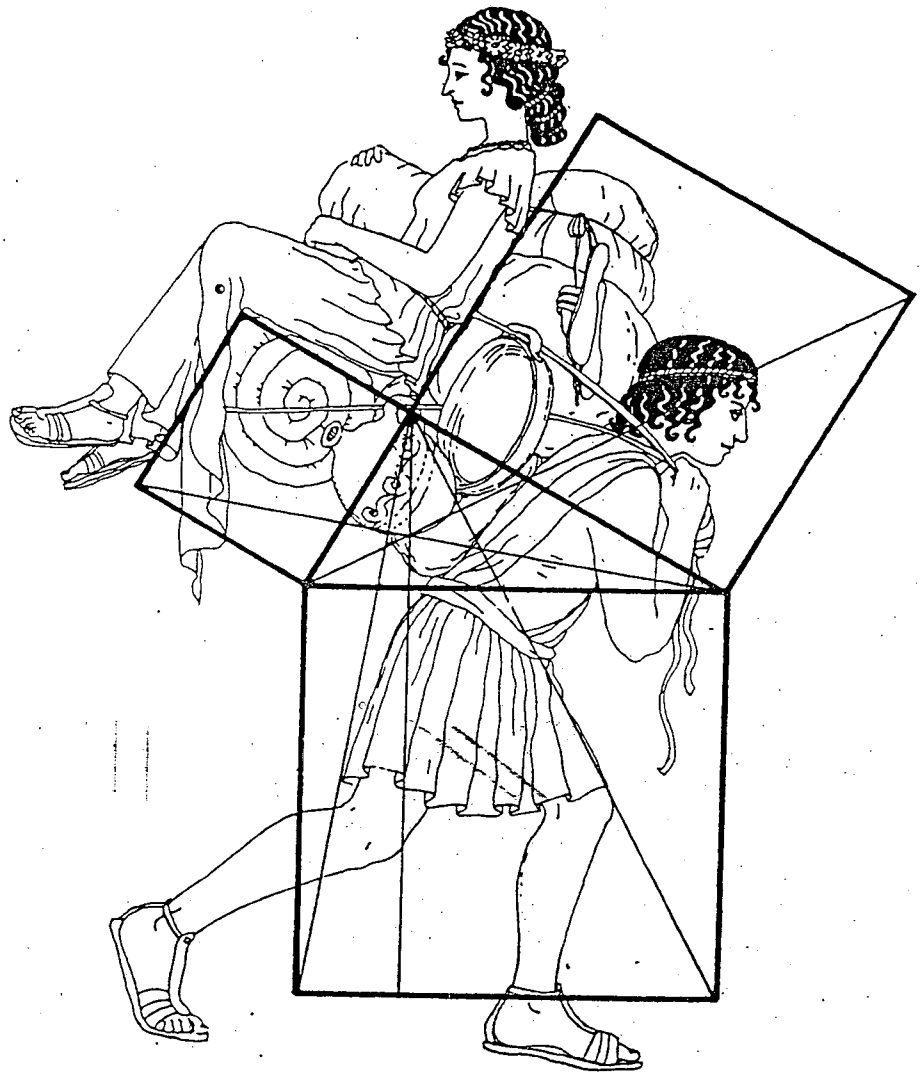


$$c^2 = 4(\tfrac{1}{2}ab) + (b-a)^2$$

$$= 2ab + b^2 - 2ab + a^2$$

Therefore, $c^2 = a^2 + b^2$

The Bride's Chair:
(acknowledgements to Sidney J. Kolpas)



Thinking is power;
Loving means creating;
Existing means radiating truth and beauty.

Pythagoras

CHEMISTRY

"...You must develop in yourselves capacities that allow you, the moment you enter upon a subject with the children, to become absorbed by the subject as the child is by the lesson, regardless of what the subject is you are treating. .....You must have the ability to transform yourself in such a way that the children literally wake up through your lessons and that you yourself become a child with the children, but not in a childish way. .....we must transform what is more mature into something childlike. To be capable of doing this in the right way, we have to look more deeply into the nature of the human being. We have to take seriously the fact that just with regard to his/her most important spiritual characteristic, the human being becomes productive by retaining the childlike element throughout life...."

Rudolf Steiner: **"Practical Course for Teachers"**(1919) Lecture 8.

THE ELEMENTS

In clarity of clear crystal;
In depths of dark rock;
In weight of world's matter;
In moulding silent stone;
In bones of the bare globe's darkness
Is built Earth's form.

The leaping, lashing oceans swell;
The lapping, lulling ripples wash;
The glistening swirling rapids flow;
The tumbling, twinkling falling drops
And the still lakes sunlit silence,
Weave the Water's world.

Rolling in air-borne currents;
Whirling in hurricanes wrath;
Whistling in the winter's wind;
Rustling through the raging storm
Breathes Air's freedom.

Fury of enfolding flames;
Flight of their dancing forms;
Heat of heaven's sun;
Fire of its celestial sphere
And the seeds shoot, spring
towards the spreading sky
Flame with Fire's force.

Mark Scrivener.

ALCHEMY TO CHEMISTRY

THE DEVELOPMENT OF THE SCIENCE OF CHEMISTRY

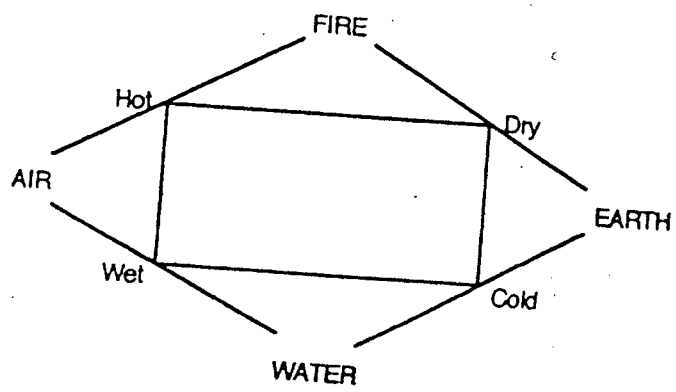
'The most lively imagination is not capable of devising a thought which could have acted more powerfully and constantly on the minds and faculties of men, than that very idea of the Philosopher's Stone. Without this idea, chemistry would not now stand in its present perfection..... In order to know that the Philosopher's Stone did not really exist, it was indispensable that every substance accessible.....should be observed and examined..... But it is precisely in this that we perceive the almost miraculous influence of the idea. The strength of opinion could not be broken till science had reached a certain stage of development.'

Professor. Dr. von Liebig (1803 - 73)

Humanity has been occupied with chemistry since earliest times, when fire was first discovered and brought under control. The role of 'fire' was central in many of the worlds ancient cultures and beliefs, along with the three other elements: earth, air and water. It is possibly from ancient Egypt that the west first learnt of 'el khemye', the name given to this science by the Arabs. When alchemy first came into being, there was no separation between science, religion and magic. What we might nowadays regard as superstition, was in those times quite acceptable science and it is from that that we have been able to develop our sciences of modern times.

Many cultures regarded gold as the most valuable and prized metal. Kingdoms rose and fell on its possession. It was also full of symbolism and stood for light, perfection and wisdom amongst other things. The early alchemists sought for ways in which gold could be created by changing the state of other ordinary metals. Alchemists also had a higher ideal, which was to seek proof of the interrelationship and essential unity of all things. It was further believed that there existed a potent transmuting agent, known as the Philosopher's Stone. This, it was believed, would have the power to 'heal the ills of ordinary metals' and by so doing 'ennobling them to perfect metals, silver and gold'. It followed that if such an agent could be found, it would also be effective in healing the illnesses and infirmities of humanity, and by so doing, prolong human life. In other words **'The Elixir of Life'** or **'Water of Life'** *(Elixir Vitae).*

Central to alchemy was Aristotle's theory of the existence of four elementary properties: hot/cold, wet/dry. When combined in pairs, they would give rise to the elements of earth, air, fire and water. A fifth non-material element existed which Aristotle called the element of the stars, the 'ether'. This was later known by medieval philosophers as the *quinta essencia*, sometimes confused in alchemy as the Philosopher's Stone.



The theory of Aristotle dominated scientific thought up until the dawn of the 17th century, which heralded the birth of modern science. Central to this new science was that of 'astronomy' and the discoveries and ideas of Galileo (1564-1642) concerning mass and enertia. Interestingly, in the same year that Galileo died, another great scientist was born who would eventually take up the research of his predecessor. This was Isaac Newton (1642-1727), who in his publication *Principia* (1687) presented his research into the correlation of motion on the earth and of that in the skies, ideas which were central to the 17th century scientific revolution. However, this break through in scientific thought had no impact on the science of chemistry, which continued to lag behind advances in other fields right through the century.

Perhaps this delay was not surprising, if we take into consideration the fact that alchemy had been practised for well over one thousand years! Several obstacles of alchemy had to be overcome and resolved, before advancements could be made. At the forefront was the process of combustion and the flame. It was a process which combined all the 'four elements' of Aristotelian thought. It was also the most obvious of the chemical processes and had been central to alchemy. The 18th century saw the rise of the theory of *'phlogiston'*, but this was a retrograde step. A marked change came about during the second half of the 18th century with the emergence of five prominent scientists. One of these was Englishman, Joseph Black (1728-99). He undertook research into *'fixed air'* (carbon dioxide). He showed that a piece of magnesium carbonate *'effervesced with acids, and changed by ignition into a white powder devoid of this property, thereby losing seven-twelfths of its weight. He showed that the loss of weight was due to a gas quitting the calcined material; this gas he characterised and called 'fixed air'.* In a similar way, Black showed that chalk (or marble) underwent such a change when heated. He also showed that 'fixed air' was formed in the burning of carbon. Black went onto show how this 'fixed air' could be 'poured' into a vessel containing a flame and was able to extinguish it.

Although not a chemist, Michael Faraday (1791-1867) showed great interest in the the flame and gave his famous lecture series to young audiences. These six lectures given in 1860, were entitled: **'The Chemical History of A Candle'** and are well worth reading prior to presenting this main lesson to a Grade Seven. Avail. on the Internet at: *www.fordham.edu/halsall/mod/1860Faraday-candle.html*

SUBJECT AREAS

Combustion: **2 days**

How organic substances burn
Controlled combustion (candle)
Products of combustion

Phosphorus, Sulphur and Carbon: **2 days**

Combustion of phosphorus,
sulphur, carbon
The presence of phosphorus, sulphur
and carbon in nature and humans

Acids and Bases (Alkali): **3 days**

Properties of acids and bases
The presence/function of acids/bases in humans
The production of acids

Limestone and the Lime Cycle: **3 days**

The presence of lime in nature
The Lime Cycle (burning/slaking/hardening)
Lime kiln process and its industrial significance

Salt: **3 days**

Indicators
Relationship of acids, bases and salts
Acid and Base of Salt: Sodium Chloride (NaCl)

Water: **1 day**

Its "connecting" role
Ossicilation between solid/liquid state
Evaporation/condensation
Expansion/contraction
Circulation - ocean currents
in human body
Effect of warmth on water

Earth, Air, Fire and Water: **1 day**

Separation by FIRE of organic substance into
ACID and BASE and combining effect of WATER

Days 1 and 2 Combustion

The Sun Fire

".....There was a time when the only light in the world came from the moon and the stars.....When there was no moon, the world was in darkness. One such moonless night Emu and Brolga (an Australian bird) were fighting, There was no real purpose to their quarrel. Brolga ran over to Emu's nest, picked up the largest egg and with a quick jerk of his beak, tossed it into the air.

.....The egg went up and up until it reached the sky, where it smashed into a pile of firewood which the spirits had built. The egg broke, the yellow yolk flowed over the wood and burst into flame. The sky glowed in the light of the flames and, for the first time since the world was created, it glowed with color. Warmth crept into the cold valleys, the lakes steamed gently, and all the animals basked in the unaccustomed heat.

.....Every day, the fire of the sun is rekindled by the spirits of the sky, and as the wood catches fire, the flames grow higher. By midday the blaze is at its fiercest, but during the afternoon it dies down, and when evening comes, only the embers remain. They glow hotly, and their red gleam is often seen after sunset. A few of the embers are saved by the sky spirits, who wrap them in fleecy layers of cloud and keep them alive ready to light the fire the following morning."

Abridged from the Aboriginal story "The Jackass and the Sun Fire"
retold by A.W.Reed in his book "Aboriginal Fables and Legendary Tales"
Reed Books. 1965

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Fire throughout history

Throughout the course of history, fire has always played a prominent role in the evolution of humanity. The foregoing Aboriginal fable is just one of many such tales from cultures throughout the world. We may care to recall the Greek legend of Prometheus as told in Grade Five; tell a tale from the traditions of the North American indigenous peoples, or have the students learn the following beautiful song:

FLAME SONG

Burn, wood, burn,
Wood that was once a tree and knew
Blossom and leaf and the spring's return,
Nest and singing and rain and dew,
Burn, wood, burn.

FLAME SONG - continued

Shine, flame, shine,
Woven of sunlight through and through,
Light of the centuries golden, fine,
Clear and exquisite, warm and true.
Shine, flame, shine.

Bless, fire, bless,
Play on lintel and wall and beam,
Touch our lives with your loveliness,
Fill our hearts with your singing dream.
Bless, fire, bless.

Combustion:

Experiment #1

- Our first experiment should be of a magnitude which impresses our students!

Students and teacher will have assembled a goodly assortment of 'crumble dry' organic material, including blossom, stem, leaf and root. In a darkened space, make separate piles of different organic materials on a fire-proof surface. Students should then carefully observe the process of combustion of individual piles in total silence, ensuring that all aspects of the combustion process is experienced, including the smoke. *However, care should be taken to protect any students who may be suffering from breathing ailments.*

No discussion will take place after the experiment is completed. This will be left until the following morning.

It would be an opportune moment to draw the attention of the students to the importance of "fire" in our daily lives, beginning perhaps with its presence in nature in the form of lightning, in volcanoes, in stone (flints) eventually leading to self-combustion and acids.

It would be good to include as much of the following as possible:

Fire in Religion:

Purification
Sacrifice
Trial by Fire
Cremation

Candles -
- Churches or synagogue
- Birthdays, Hanukkah, Christmas, etc

Fire, Family, Home:

The "social center"
Campfires (as with early humans)
First European settlers
The "place" of fire in the home:
- in the center of the abode
- to the side of the abode
- enclosing of the fire (stoves)
- gas fires
- electric fires
- removal of 'fire' to cellar (central heating)
- elimination of 'fire' in favor of solar power

Fire in Industry:

smiths (work with iron)
potter (kiln)
baker (oven)
iron and steel industry (furnace)
nuclear fission

Fire and Emotions:

We frequently use terms connected with fire, heat and warmth to describe our feelings and emotions, these may include:

To act in the HEAT of the moment
In relation to intelligence as in: a bright SPARK
In relationships: an old FLAME!
In connection with emotions/actions:
- COLD hearted
- WARM hearted
- COOL headed
- HOT headed
- FIERY nature
- etc.,.

Recapitulation and discussion of Experiment #1:

Students to be asked to describe in detail the process of combustion. These descriptions should include everything observed by the different bodily senses *(sight, sound and smell in particular).*

The teacher may wish to make a *comparison* between the growth of the 'fire' and the growth of a 'plant'. Rudolf Steiner suggests that the process of combustion can also be related to the human being in that the 'growth' activity of the flame and flower has similarities to the process of digestion in the human being. Through combustion, the weightless light and warmth which the plant has obtained from the sun and imprisoned within itself, is once again released.

The 'dying' process as observed in the creation of ash of the fire or in the dry roots of the plant, both of which have measurable weight and are substances of the earth, could be seen to have a correlation with the seat of the nerve/sense system in the human head.

It is important to follow a definite sequential process of lesson presentation in the teaching of science, which will ideally be: 'observation' on day one, followed on day two by recall, discussion and finally conclusion. Students would then be required to make their own accurate record of what they have observed and learnt.

In the report of a series of lectures which Dr. Manfred von Mackensen gave in 1978, he is reported as having said that the following two experiments should not be presented to the students. Mackenson argues that fire does not, in fact, use up 'air' *(oxygen? - my italics)*, but produces it.

On the other hand, the late Frits H. Julius in his work "The World of Matter and the Education of Man" strongly suggests that we do conduct these experiments with the students to show them the importance of ventilation in relation to combustion.

I leave readers to draw their own conclusions as to which is the 'right' path to follow. On my part, ! have chosen to follow the conventionally accepted scientific model.

Experiment #2

Conduct an experiment with equal size lighted candles placed under inverted jars of different sizes.

Have the students observe the burning candles. Why do some flames die-out before others? Discuss.

Experiment #3

Obtain a 'floating' candle and place it in a shallow container of water. Light the candle wick and then carefully place an inverted glass jar over the burning candle so that the lip of the jar rests on the bottom of the container.

Have the students observe how the flame gradually dies out and the resulting rise in the water level within the jar. Why is this? What has disappeared from the jar to make space for the water?

Both of the above experiments give the opportunity to bring to the students attention the fact that 'fire' needs 'air' (oxygen) to burn successfully. Discuss.

Experiment #4

If time permits, it would be good to prepare some oxygen by placing a heaped teaspoon of POTASSIUM PERMANGANATE crystals into a heat-proof flask. Gently heat the crystals over a bunsen burner or other heat source so that the crystals begin to break down.

Have to hand a long wooden spill, the end of which has been ignited so that a glowing tip remains. Insert the tip into the neck of the flask and observe the results. By heating the Potassium Permanganate, we have been able to produce oxygen (O_2). By giving off its own oxygen, it enables another substance to burn. Therefore when a substance does this, it is known as an OXIDISING agent

It is interesting that when fire burns, it in actual fact draws more air into its immediate area. Therefore the necessity to cut-off the supply of air to an undesirable fire.

Toxic, fine particles of manganese oxides are produced simultaneously when heat Pot. Perm to produce oxygen. It forms explosive mixtures with combustible materials (such as sulphur, phosphorus, ammonium salts or metal powders) or with organic compounds. The solid is also spontaneously flammable on contact with glycerine and other organic compounds. It will form highly explosive manganese heptoxide on mixing with concentrated sulphuric acid. Dispose of down the drain (to sewer).

Time could be usefully spent in introducing the students to fire prevention and fire management in the context of home and school. The school 'fire officer' could be brought into this discussion. A visit from a local fire officer would be even better!

Experiment #5

In preparation for the next part of the course, it would be helpful for students to spend a little time carefully observing a candle flame. Which part is whitest and brightest? Where does the flame have a blue color? Where does the source of the flame glow red? What is given off by the flame? Discuss

Days 3 and 4 Triology of Phosphorus, Sulphur and Carbon

Phosphorus:

Phosphorus can be found on earth as calcium phosphate and also in plants and creatures. In homeopathic medicine, it is used for disorders of the Nerve/Sense System and interestingly, a small amount of phosphorus is to be found in the brain and in the bones of the skull.

When burnt, white phosphorus gives off a blindingly brilliant, white light. Its name actually means "light carrier". Translated into Latin, the name becomes "Lucifer', which is the name of the fallen angel in the Garden of Eden. Lucifer was also at one time in common usage as the name for matches.

Phosphorus must be handled with great care at all times. White phosphorus is especially combustible and has to be kept immersed in water to avoid almcst instantaneous combustion. It is now illegal for white phosphorus to be used in school laboratories. With care, red phosphorus can be used in its place.

Red Phosphorus (also known as brown phosphorus) is relatively harmless, compared to white (also known as yellow) phosphorus. It is not poisonous (when pure), but it is of concern for two reasons:

Firstly, the heating of red phosphorus in a test tube produces phosphorus vapor which condenses to form white phosphorus. White phosphorus is extremely toxic, spontaneously flammable in air and is prohibited in schools. Do not heat red phosphorus in this way.

Secondly, red phosphorus is highly combustible and it forms dangerously explosive mixtures with oxidising agents.. Therefore, do not mix red phosphorus with:

a. potassium nitrate
b. sodium nitrate
c. potassium permanganate
or other oxidising agent.

Red phosphorus should only be lit in a fume cupboard or outside, down-wind from the students.

Sulphur:

Whereas phosphorus is called the "light carrier", sulphur is known as 'sun bearing'. We can find sulphur almost anywhere where there is volcanic activity, where the heat comes from the very 'bowels' of the earth.. When heated, it gives off a strong, pungent smell something like 'rotten eggs'!

Unlike the fire of phosphorus, the blue-lilac flame of burning sulphur is not very impressive to observe, although there is beauty in its small flame which emits intense heat and toxic fumes.

Sulphur is a prime component in the manufacture of fireworks (gunpowder) and is definitely associated with everything which is 'warm'. In the plant world, we find traces of sulphur in mustard, radish and camomile flowers.

Just as we are able to relate sulphur to the inner activity of the earth, so too are we able to associate it with the inner activity of our Metabolic System. Sulphur, in homeopathic form, is frequently prescribed for disorders of the digestive system. Sulphur soap is even useful for teenage skin problems!

Sulphur is non-toxic, but can be dangerous due to its flammability and hazardous due to the formation of sulphur dioxide gas as a product of combustion. This gas is highly irritant to the lungs and should not be inhaled. It can act as an asthmatic trigger. Carry out experiments in a fume cupboard or outside, down-wind from students.

Do not mix with oxidising agents, since such mixtures are explosive

Carbon:

Carbon is central to life on earth. We can find it within the earth in the form of coal or diamond. When oil is burnt, it gives off a soot which when purified, can be used for Indian ink. Soot can also be used as a low grade fertiliser.

Wood when burnt, is transformed into charcoal. Charcoal has a myriad uses, from a substance to produce works of art with; for a fuel for BBQs; as a filter for water or air purifiers.

It is therefore perhaps not surprising that carbon in homeopathic form (Carbo) can be helpful in treating disorders of the Rhythmic System, such as instances of asthma.

When charcoal is burnt, it is noticeable that there is very little flame if any at all. The charcoal becomes a glowing ember and retains the fire and warmth within itself.

Carbon holds a balance between the activities of phosphorus and sulphur in the human organism.

Carbon (charcoal blocks/pieces) are hazardous in one way only: they smoulder and burn for a long time after ignition and may cause fires if put away before they have been properly extinguished. They are known to have caused a number of fires in schools. The best method of ensuring that they are extinguished is to leave them immersed in water for a period of time. They can be dried out again for further use.

Days 5 to 7 Acids and Bases (Alkali)

Experiment #6

Darkening the room and making use of the 'fume cupboard', burn separately, small amounts of phosphorus and sulphur.

Repeat the experiment with potassium permanganate to produce oxygen and then using a deflagrating spoon; insert alternately a piece of phosphorus, sulphur and carbon into the flask and observe the results on each occasion.

In all three instances, the pot. perm. has acted as an oxidising agent. Each substance has released its own particular gas with the respective names:

Phosphorus	Phosphorus pent oxide
Sulphur	Sulphur dioxide
Carbon	Carbon dioxide

If we were to now pass these gases through water, some of the gas would dissolve to be absorbed by the water, thus forming important substances which are known as ACIDs.

We would theoretically obtain:

Phosphorus pentoxide	Phosphoric acid
Sulphur dioxide	Sulphurous acid
Carbon dioxide	Carbonic acid

In the scientific language of chemistry, the process would be expressed as follows with regards to SULPHUROUS ACID.

S	**+**	**O_2**	**=**	**SO_2**
Sulphur	+	Oxygen	=	Sulphur dioxide
SO_2	**+**	**H_2O**	**=**	**H_2SO_3**
Sulphur dioxide	+	Water	=	Sulphurous acid

If **H_2SO_3** is exposed to air, then it attracts more oxygen to itself and becomes the much stronger SULPHURIC ACID (**H_2SO_4**).

H_2SO_3	+	O(from the air)	=	H_2SO_4
Sulphurous acid	+	Oxygen	=	Sulphuric acid

Sulphuric acid reacts violently with water. Pure sulphuric acid is known as 'concentrated' acid. The concept of 'dilution with water' is inappropriate for the concentrated acid: a vigorous chemical reaction occurs, releasing much heat..

***Never** add water to concentrated acid.*
***Always** dilute sulphuric acid by adding the acid slowly to water with continuous stirring.*
***Always** wear eye protection when handling concentrated sulphuric acid.*

Sulphuric acid is highly corrosive to the skin and eyes, being even worse when hot. ***Wash sulphuric acid off the skin immediately with LARGE quantities of cold water.***

Sulphuric acid forms spontaneously explosive mixtures with potassium permanganate and chlorate salts. Do not mix these chemicals together!

Dilute sulphuric acid solutions are far less dangerous than the concentrated acid. They do not evolve significant heat when further diluted.

Experiment #7

It would be good to take the students through the process of producing CARBONIC ACID. It heightens their enjoyment of the experiment if they are <u>not</u> made aware of its use as a drink (carbonated water) and if the teacher treats the evolving acid with all the required caution used in handling acids!

Taking every precaution, carefully pour a small quantity of hydrochloric acid on marble chips (Calcium Carbonate [$CaCO_3$]), thus releasing CO_2 (carbon dioxide). Pass this gas through water and theoretically, you will have produced weak carbonic acid (H_2CO_3) *(by adding an indicator to the water prior to the production of carbon dioxide, students can observe the change taking place).* Show the students what has taken place:

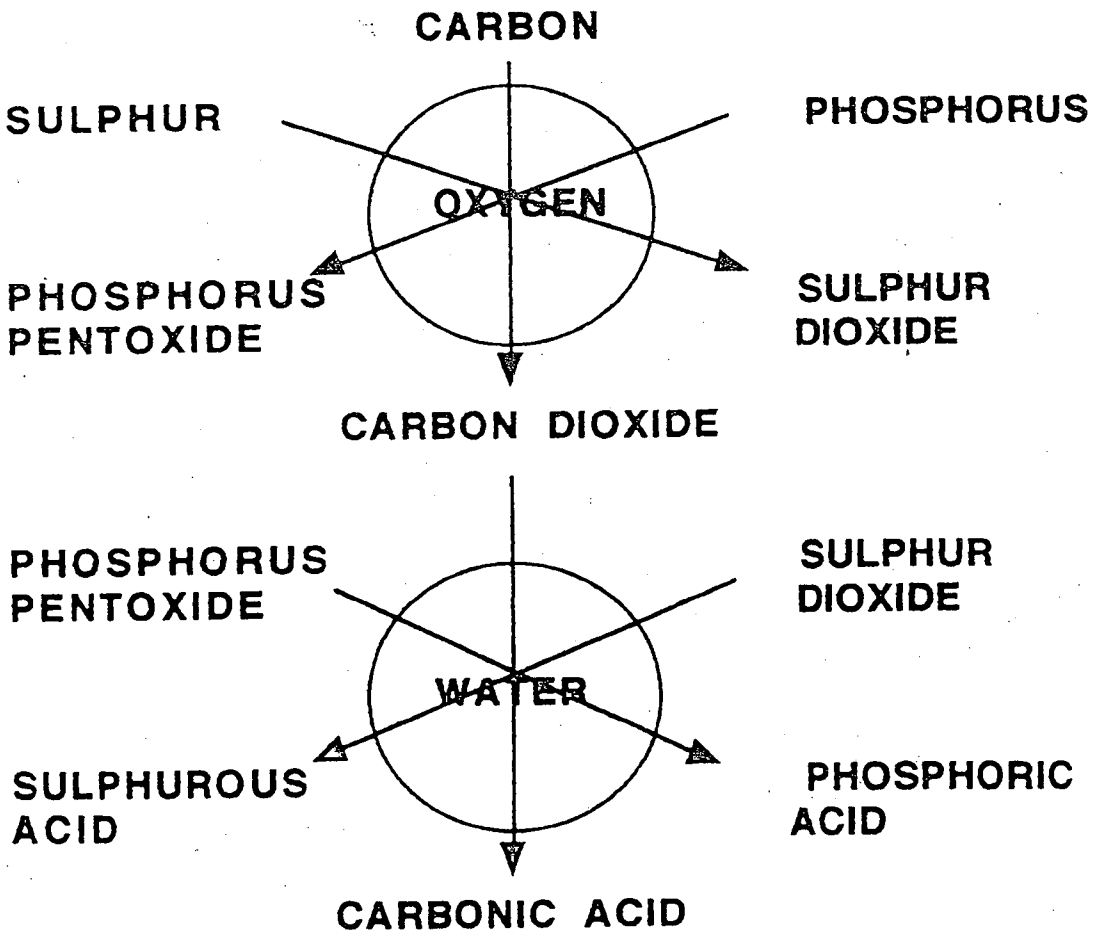
C	+	O_2	=	CO_2
Carbon	+	Oxygen	=	Carbon Dioxide
CO_2	+	H_2O	=	H_2CO_3
Carbon Dioxide	+	Water	=	Carbonic Acid

Concentrated hydrochloric acid releases hydrogen chloride gas whenever it is open to the atmosphere. This gas is highly irritant to the lungs, causing coughing. Avoid inhalation by carrying out operations in a fume cupboard whenever possible, or alternatively outside and down-wind from the students.

As with all acids, hydrochloric acid is extremely damaging to the eyes. Wear a face shield/goggles when carrying out pouring operations which might result in the splashing of the acid. Avoid skin contact. Wash with copious amounts of cold water any part of the body which has been in contact with the acid.

Dilution of hydrochloric acid with water releases heat. Always pour the acid into water when carrying out dilutions.

The following diagram shows the important position which OXYGEN holds in relation to the production of GASES and the second diagram shows the relationship of WATER to GASES in the production of ACIDS:



Before proceeding any further with this section, a little substitution would not go amiss! For the commencement of the next mornings lesson, substitute your laboratory prepared carbonic acid for one that is made commercially for public consumption and is therefore 'safe' top ingest, such as carbonated water.

Ask for a volunteer to 'taste' the acid! During the course of the last few days, you will have instilled in your students a great respect for the corrosive power of acids and therefore your suggestion will come as a shock! It is a great challenge for any student to overcome their natural fear and apprehension about ingesting this 'acid'.....it becomes a issue of 'trust'.. Have the student describe the taste.....first a drop on the tip of the tongue. Then a proper sip and perhaps finally half-a-glass!! Make sure that you have several full bottles to hand for the inevitable rush for a drink....once the students realise what the drink actually is!

Experiment #8

Repeat the procedure for producing Carbon Dioxide. Pass the gas through a rubber tube into an empty tumbler. Estimate when the flask is 'full'.

In a second glass tumbler, place a small lit candle. Carefully lift the tumbler containing the gas and tip over the edge of the second tumbler so that the gas is effectively 'poured' onto the candle flame. The flame should be quickly extinguished.

Try pouring the gas from one flask to a second and then into a third containing a burning candle. My students found this to be one of the most fascinating experiments!

A SHORTENED PERIODIC TABLE

It would be good for students to be made familiar with a shortened form of the Periodic Table. I expected my students to memorise the following list:

Ag	Silver	Fe	Iron	P	Phosphorus
Au	Gold	H	Hydrogen	Pb	Lead
C	Carbon	K	Potassium	S	Sulphur
Ca	Calcium	N	Nitrogen	Si	Silicon
Cl	Chlorine	Na	Sodium	Zn	Zinc
Cu	Copper	O	Oxygen		

SALTS

Days 8 to 10 Limestone and the Lime Cycle

In Grade Six, students will have had a morning lesson course on 'Geology" and should therefore be familiar with Igneous, Sedimentary and Metamorphic rocks. The most abundant of such rock types is 'sedimentary' in the form of limestone or CALCIUM CARBONATE ($Ca\ CO_3$). Calcium carbonate can be found in the form of chalk, marble, shells (see- and bird-); coral; teeth, bones amongst other things.

The formation of sedimentary limestone goes through a definite 'cycle'. It is absorbed by all living creatures to form bones and teeth, and in some cases shells. The discarded shells from dead sea creatures will fall to the bottom of the oceans to form sediments which over aeons of time, will become thicker and thicker. Eventually, the earth's crust, through the movement of the great shields, will be forced above the surface of the sea to form mountains and hills.

The bare surfaces will soon be covered with a blanket of green. The sun shines upon the surface and rain falls to eventually form creeks, streams and rivers.. On its journey, the water will take-up minute particles of limestone, some of which might be carried to places where it is absorbed by creatures in the process of drinking. Other particles may find their way back into the sea where they are consumed by fish and other sea creatures.

On its journey, water seeps through the surface of the earth into the hollows, crevices and caves below, where it trickles and falls in drops from the roofs of caves to form stalactites and stalagmites. Throughout nature, a continuous restless movement is taking place with the DISSOLVING and DEPOSITING of LIME.

Experiment #9

Prepare a piece of marble by subjecting it to intense heat (1000°C) over a period of time. This is best achieved in a pottery kiln. Failing the availability of such a kiln, a good effect can be obtained after using an enamelling kiln. An alternative would be to create your own 'kiln' from fire bricks and an intense heat source, such as a bunsen burner. It should be possible to get a reasonable result from this method.

Once the heating process is complete, the 'marble' should be allowed to cool down in a completely dry environment. This latter point is VERY important for the eventual success of the experiment. Water should now be allowed to come into contact with the 'marble' in a very controlled manner. The result will astound the students, for the 'marble' appears to 'come alive' as foam emerges from the seemingly lifeless lump of rock! It is as if the very life forces that were once part of this substance, have been reawakened and released.

Discuss with students the importance of limestone in industry and lead them to an understanding of the processes involved in the preparation of QUICK LIME, SLAKED LIME and LIME WATER *(ensure that students do not confuse 'lime water' gained from limestone with the beverage 'lime water' as obtained from the lime fruit!)*.

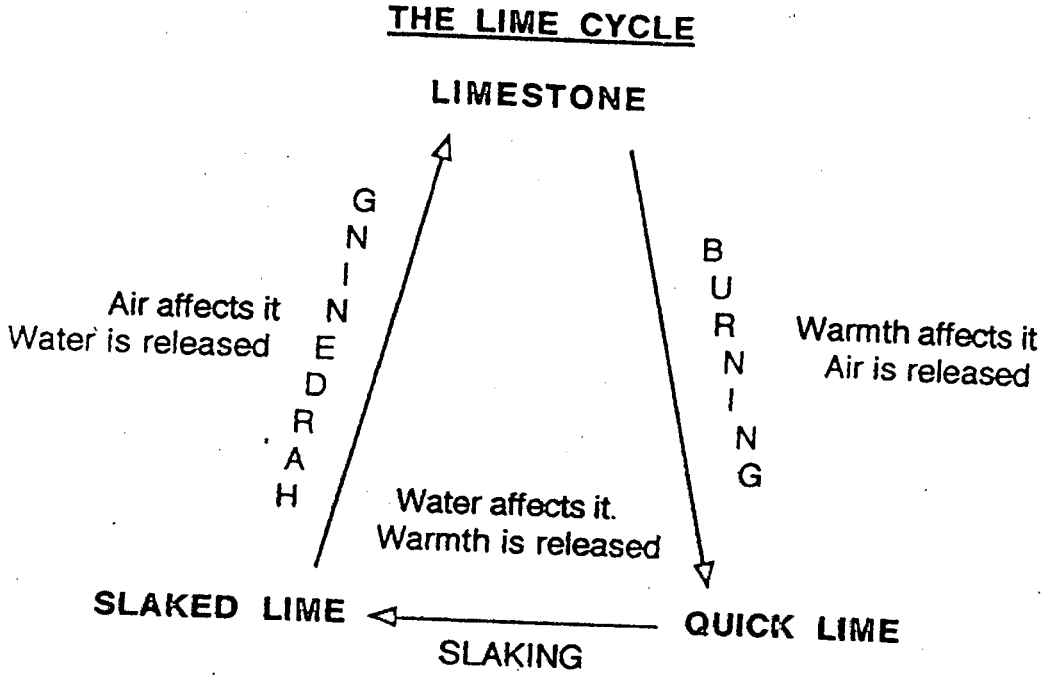
An effect similar to that which takes place in a limestone cave can be obtained by using white distilled vinegar (acid) and the so-called *'popcorn rock'* which is a form of limestone found in the Great Basin area of Western U.S. Place the rock in a clear glass container and add sufficient vinegar (or other mild acid) to entirely cover the rock. Leave the container to stand whilst the vinegar evaporates. This can take a couple of weeks, during which time aragonite crystals begin to grow from the rock. Allow the rocks and crystals to dry before removing from the container, for they are very fragile. *('Popcorn rock' is currently (2001/02) available from the US store "Hearthsong")*

Experiment #10

Students should be shown how cement is created from a combination of slaked lime, sand and water.

Take 1 part of slaked lime to 4 parts clean sand. Gradually add water whilst mixing the materials until a relatively thick paste is formed. Put the paste into a container and allow a couple of days to set. The result should be a hard mass of set cement.

Students should develop an understanding for the process of 'separation' of the elements of FIRE and EARTH when producing QUICK LIME:



Days 11 and 13 **Salts**

The separation of the FIRE and EARTH elements can be described as follows:

BASE (ALKALI)	ACID
The EARTH element	The FIRE element
The SOLID substance	The EVAPORATING substance

Experiment #11

It is important to be able to distinguish whether a substance is an alkali or an acid. The achieve this, it is necessary to use an 'indicator'. For our purposes, it would be preferable to begin with a self created 'indicator' from a plant such as 'red cabbage'.

Puree a few leaves of red cabbage so as to obtain the juice from the leaves which will be 'blue'.

Add a small amount of this liquid to carbonated water which will give rise to a purple-red color.

Add a small amount of the liquid to lime water which will turn green-blue.

This is the simplest of indicators and shows us that the carbonated water is an acid whilst the lime water is alkali.

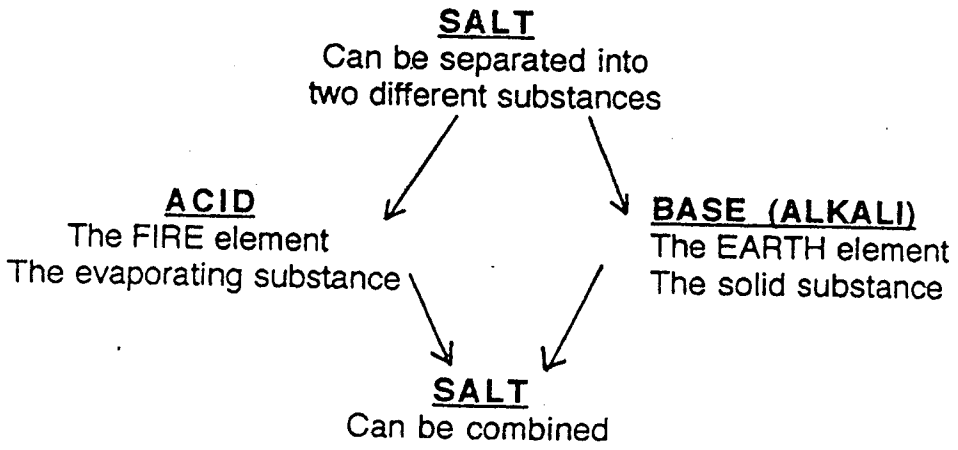
Give the students the task of identifying liquids which have been previously prepared by the teacher, such as: salt water; spring water; distilled white vinegar and other clear liquids.

After introducing the cabbage water 'indicator', one could progress to the use of Universal Indicator and litmus papers.

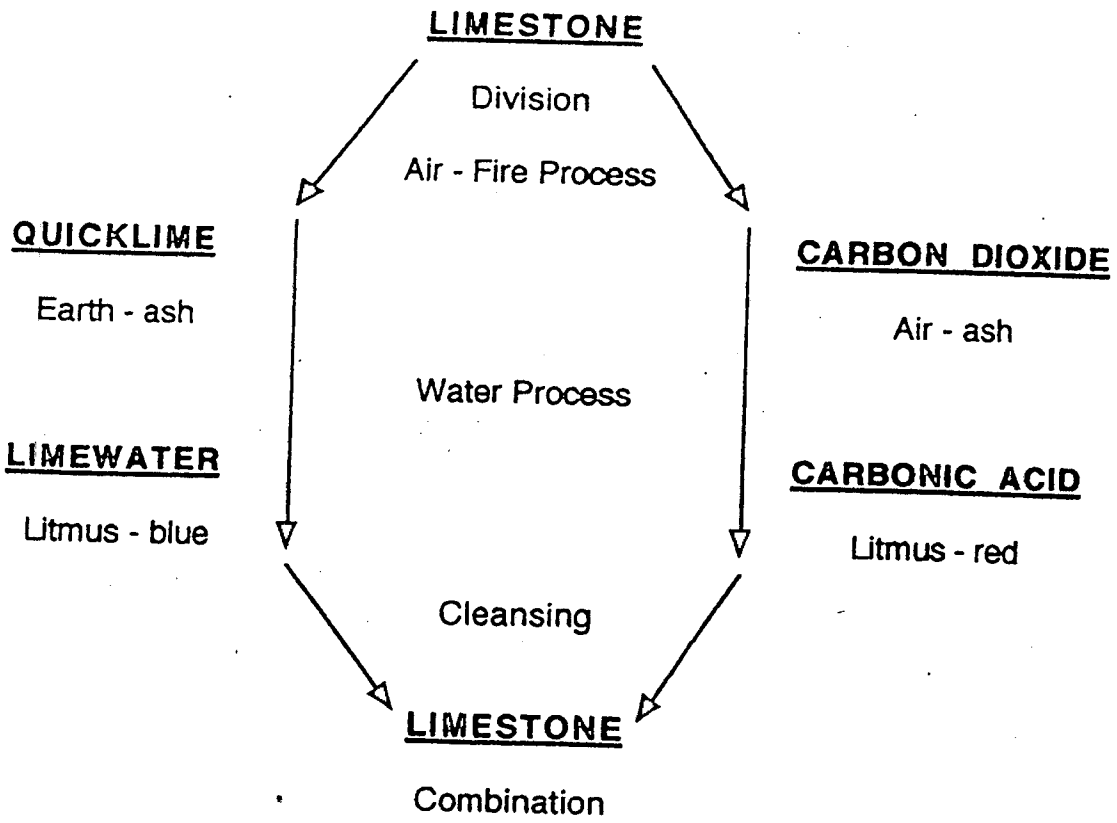
Each student should have the opportunity to 'test' their own saliva using litmus and explain how 'litmus' is obtained from a special lichen.

Experiment #12

Our next experiment will demonstrate to the students the effect of combining an acid and base to form a 'salt'. Take a quantity of carbonated water and slowly add lime water. Watch the result. It will be observed that small flakes of lime begin to appear in the water showing us that the two substances have once again combined.



THE LIME CYCLE



Returning once more to the separation of substances, we can now add a new element to our understanding:

Speak to the students about the importance of SALT in our diet.

Experiment #13a

This is another experiment which can show the separation of a salt into acid and base.

Pour a small quantity of common salt (SODIUM CHLORIDE - NaCl) into a flask. Carefully pour sulphuric acid onto the salt. A gas if given off (HYDROGEN CHLORIDE) which is extremely sour and penetrating.

If tested with litmus, this gas will indicate an acid *(alternatively, pass the gas through water containing Universal Indicator).* When this gas is collected in water, HYDROCHLORIC ACID (HCl) is obtained.

The BASE (Alkali) which remains is SODIUM HYDROXIDE (NaOH), more commonly know as CAUSTIC SODA, which will turn litmus paper 'blue'.

Experiment #13b an alternative to #13a

Mix together half a teaspoon of common salt and half a teaspoon of either powdered SODIUM BISULPHATE, FERROS SULPHATE or ALUM. Pour the mixture to a dry glass test tube.

Heat the mixture over a bunsen burner, spirit burner or candle flame, moving the about in the flame. *It would be good to have a wood clamp with which to hold the test tube as it will become very hot.*

Hydrogen Chloride gas will soon be given off as steamy fumes. Sniff the gas and test with blue litmus paper for acidity.

Experiment #14

We are able to see that CAUSTIC SODA is the BASE of common salt and is therefore an ALKALI.. But unlike the alkali of limestone, the alkali of salt reacts very differently. Add a small quantity of caustic soda to a test tube containing cold water.

Have a student wear protective gloves and ask her/him to hold the test tube between their fingers, over a 'safe' area. The student will quickly notice that the water becomes warm and quickly rises to boiling point forcing the students to release the test tube.

The reaction may be so fierce, that the substance may shoot out of the top of the test tube *(thus the need for gloves and a 'safe' area!).*

Experiment #15

Students should also be shown the interaction of caustic soda and hydrochloric acid.

This is best shown by using a glass petri dish into which has been poured a small measure of hydrochloric acid. Using long tweezers, carefully place a small piece of caustic soda directly into the acid. If the class are silent, then they should hear a sharp sizzling and immediately see the particles of salt rush in different directions.

Experiment #16

Although not a vital part of this lesson, students could be shown how to create a variety of 'crystals' (salts).

Boracic Acid Crystals:

Ingredients: BORAX and SODIUM BISULPHATE

Place about 1" (2.5 cm) of each of the above chemicals into separate test tubes and add 1" of warm water to each tube to enable the chemicals to dissolve.

Leave the tubes until the liquids are cold. Then gently pour the contents of one tube into the other, at the same time holding the receiving tube up to the light.

A beautiful precipitate of sparkling crystals should be seen falling through the liquid.

Potash Alum Crystals:

Ingredients: ALUMINIUM POTASSIUM SULPHATE

Obtain a small heat proof flask and half fill with water. Place above your gentle heat source and gradually stir in Potash. Alum until you have a saturated solution.

Leave the solution to cool for 24 hours. Crystals will have formed on the bottom of the flask. Select the largest of these and tie with a fine thread. Attach the other end of the thread to a wooden spill which is placed over the mouth of the flask, thus suspending the crystal in the potash. alum solution.

Observe over a period of days. The crystals should grow considerably.

Other crystals can be obtained from saturated solutions of either:

Copper Sulphate. Borax. Ammonium Phosphate. Sugar

AQUA VITÆ

Days 14 **Water**

Without water, life on Earth would not exist., just as we would not exist without the flowing, life giving blood within our veins and arteries. Water is the most important chemical on earth. It carries within itself the substances of the earth and air, carrying them in a constant cyclic movement from earth to sea to earth. Water has the ability to dissolve and absorb, for without this ability fish would not be able to survive in the depths of the sea, for it is the oxygen carrying water which gives them life.

Rain water from the atmosphere contains dissolved carbon dioxide which we know forms carbonic acid. This acid is strong enough to dissolve rocks as it moves over the earth's surface. As the water evaporates, beautiful crystals remain or dissolved minerals return to the sea to be used by sea creatures in building their bodies. Even land creatures, such as humans, absorb minerals through the substances they eat and drink.

Almost 75% of the Earth's surface is covered by water, some in the familiar liquid state and some as ice covering vast areas of land such as Antarctica in the southern hemisphere to a depth of 2 to 3 kilometers, or the Arctic in the northern hemisphere which is entirely composed of an enormously thick layer of ice.

Water also controls our climates. Living near the coast, we find that we have a much milder climate than those people living further inland. This is caused by the fact that more heat is required to heat water than land, and water retains heat far longer than solid earth.

There is a constant oscillation between the liquid and solid state of water. Of evaporation and condensation; of expansion and contraction. Water is constantly circulating the world in vast ocean currents, which can be compared to the movement of our life's blood through our bodies.

Experiment #17

The combining effect of water can be shown as follows. Mix together a dry quantity of CITRIC ACID crystals and SODA crystals. As a rule, nothing happens. Slowly add a quantity of cold water and observe the powerful reaction and the giving off of CARBON DIOXIDE gas.

THE FOUR ELEMENTS

Day 15 **Earth, Air Fire and Water**

As part of the conclusion to this lesson, it would be good to once again conduct our first experiment with the burning of organic materials.

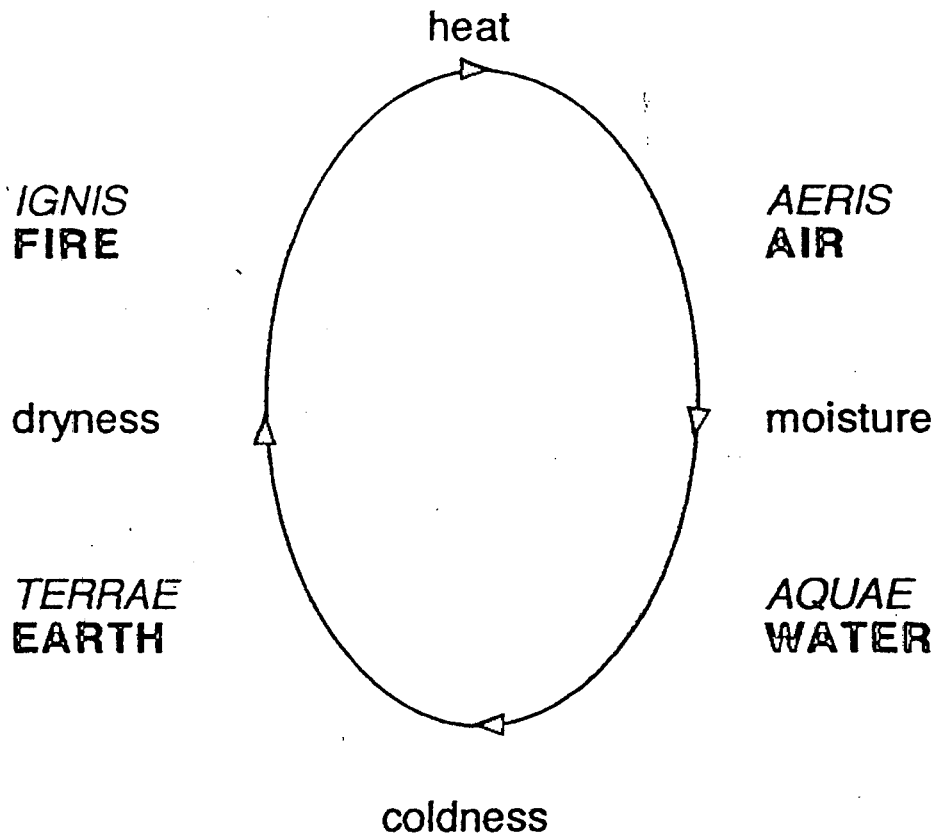
Experiment #18

Set up your apparatus so that it is possible to collect the 'smoke' from a very small fire and to pass it through water containing an indicator. The resulting color should indicate an acid.

Collect the ash from the 'fire', mix it with water and pass the water through filter paper. Test the filtered water with your indicator. The result should indicate an alkali.

Draw the student's attention to the phenomena that the acid would appear to belong to the "airy" realm, whilst the alkali belongs to the "earth" realm.

The Four Elements have an important role in the science of life and chemistry, and can perhaps best be shown in the following manner:



Additional Combustion Experiments

Care should b e exercised in the conducting of all of the following experiments. They are generally not for student experimentation.

1. **Potassium Permanganate and Glycerine**

   Grind 1 - 2 gms Pot. Perm. Tip out into cone form.
   Using a 'dropper', add 3 - 4 drops of glycerine.

2. **Potassium Permanganate and Glucose**

   Grind 3 - 4 gms Pot. Perm together with half the amount of glucose.
   Using a long pipette, add a **few** drops of hydrochloric acid.

3. **Potassium Nitrate, Sulphur and Copper Sulphate**

   Mix together 15 gms of each on a metal tray and ignite.

4. **Potassium Nitrate, Sulphur and Sugar**

   Mix together on a metal sheet: 5 gm Pot. Nitrate
   1 gm Sulphur and 3 gms Sugar *(Magnesium or Zinc can be added for colored effect).*
   Basis for gunpowder! Ignite with lighted wooden spill.

5. **Potassium Chlorate and Red Phosphorus** ***EXTREME CAUTION!!***

   Take a 'rice grain' size piece of Pot. Chlorate and a like sized piece of Red Phos. Mix well, but very gently on a piece of paper. Fold the paper and strike with a hammer!

6. **Glycol and Detergent**

   Blow 'gas' bubbles with a mix of 50/50 of glycol and detergent. Ignite the bubble with a long wooden spill. **Use eye protection**.

7. **Ammonium Dichromate** **Fume cupboard experiment only!**

   Pour out a generous amount of ammonium dichromate onto a metal sheet and form into a 'cone'. Use a bunsen burner to apply fire to on spot at the base of the cone. Close the fume cupboard and watch the volcano!

8. **Sodium Metal** **Extreme CAUTION required**

   A really BIG BANG can be obtained by exposing sodium metal to water. But this is dangerous and should only be conducted by a qualified science teacher.

Further 'volcanic' eruptions!

Create a volcanic landscape out of clay and allow to dry.

The following mixtures will allow for three to four eruptions, each lasting about 2 minutes.

1. White eruption:

30 gms potassium nitrate
10 gms sulphur
.5 to 1 gm of charcoal powder

2. Yellow eruption:

20 gms potassium nitrate
5 gm sulphur
10 gms charcoal powder
15 gms common salt

3. Purple eruption:

15 gms potassium nitrate
15 gms sulphur
15 gms copper sulphate

Weigh the ingredients and place them on a piece of paper to mix with a spatula.

To obtain powdered charcoal, break up a larger piece and grind to a fine powder in a mortar and pestle.

When the ingredients are thoroughly mixed, pour them into a volcano crater.

Ignite with a paper wick at least 3" (7 cm) in length which has been soaked in a solution of potassium nitrate and distilled water, and then left to dry completely.

If the 'volcano mix' does not light.....leave in a safe place for ten minutes before touching.

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PHYSIOLOGY

- THE MIRACLE OF LIFE -

'God created man in his own image,
In the image of God he created him;
Male and female he created them'.

From: **'GENESIS'**. Verse 27.

".....What a piece of work is a human being!
How noble in reason!
How infinite in faculty, in form and moving!
How express and admirable in action!
How like an angel in apprehension!
How like a god!

From: **'HAMLET'** by William Shakespeare.

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Any good text book devoted to physiology, will contain ample material for the teacher to present to his/her students, so why bother to write a section in this edition of *'A Path of Discovery'* devoted to the presentation of this particular subject?

One reason is that it affords an opportunity re-address the ideals which form the basis of the Steiner-Waldorf methodology. From the early years on, we have striven to maintain the Human Being in a central position with regards to everything which we have brought to the child. Perhaps this is nowhere of greater import than in the manner in which we present this subject.

If we consider the many and varied subject areas which we have been presented to the students in earlier years, we cannot help but notice that each has, in some way or another, been part of the preparatory ground work for this lesson. What then is our relationship to the animal world, the plant world, to the world of minerals, to the Earth?

Teachers should strive to bring 'life' into what can otherwise be a very 'dead' subject. When a teacher unthinkingly takes an organ, such as the eye, and presents it in a clinical fashion to his/her students, then they are depriving them of the possibility of having a deeper understanding of the intricate role which the eye, or any other organ, holds in the greater order of things.

It is the teacher's task to ensure that he/she addresses the heart forces of their students, so as to awaken in them awe and reverence for the Miracle of Life. This cannot be accomplished by the use of overhead projections of clinical diagrams or gaudy wall-posters! Teachers must instead find the inner inspiration and imagination to teach creatively!

Day 1:

AND GOD CREATED....Birth

It will be desirable from the outset of the lesson, to awaken in the students a real sense of awe for the Miracle of Creation, of Life. First a very special, quiet reverential mood could be created amongst the students, in preparation for a previously arranged visit by parents with their new born infant, although from an anthroposophical viewpoint it is deemed to be in the best interests of the baby if exposure to the world be confined to the child's immediate 'home' environment for the first months of life. However, not every parent subscribes to this philosophy and some are happy to share their joy of having a new child, with the wider community. My class were so blessed at the commencement of our Physiology block and we welcomed two week old 'Monique' into our midst, so that we could wonder and marvel at the tiny, vulnerable babe lying, as the Creator created her in innocent nakedness, upon a special 'bed' of white and gold cloth.

At first, the students were thoroughly over awed by the occasion, coupled of course by their embarrassed reaction to a very unusual happening in their classroom.....quite a challenging occasion, especially if you are 'macho' 12 year old boy soon turning 16!!!!! Monique's mother quickly put the children at ease by speaking to them about the 'spirituality' connected with pregnancy and how carrying a child and giving birth would be the most wonderful experience that any girl could ever have.....something that the boys would for ever miss out on!

Three students had prepared a short musical 'gift' for Monique which they played on descant and tenor recorders accompanied by a side-flute. Monique, who had been whimpering, immediately quietened down. At the end of the short piece, we all distinctly heard Monique sing two clear notes....we were convinced that our music had affected her in a positive manner!!! Prior to her visit, all students had drawn individual cards for Monique in which they had written their special "wish" for her...many taken from the 'knight's virtues' which had been shared with the class towards the close of the previous morning lesson on "Arthurian Legends". The wishes therefore followed this theme and included wishes such as: joy, hope, love, courage, beauty, humility, empathy, etc., etc.,.

As a conclusion to the visit, I shared the beautiful poem by Thomas Traherne (1636-74) with Monique, her mother and everyone present. The words of which follow on the next page. The visit lasted no longer than 30 minutes, but it had created in the class a very special mood which was carried over into the class work over the course of the next few days.

Salutations

These little Limbs,
These Eyes and Hands which here I find,
These rosy Cheeks wherewith my Life begins,
Where have ye been? Behind
What Curtain were ye from me hid so long?
Where was? In what Abyss, my Speaking Tongue?

When silent I,
So many thousand, thousand years,
Beneath the Dust did in a Chaos lie,
How could I Smiles or Tears,
Or Lips or Hands or Eyes or Ears perceive?
Welcome ye Treasures which I now receive.

I that so long
Was Nothing from Eternity,
Did little think such Joys as Ear or Tongue,
To Celebrate or See:
Such Sounds to hear, such Hands to feel, such Feet,
Beneath the Skies, on such Ground to meet.

New Burnished Joys!
Which yellow Gold and Pearl excel!
Such Sacred Treasures are the Limbs of Yours,
In which a Soul doth Dwell;
Their Organised Joints, and Azure Veins
More Wealth include, than all the World contains.

From Dust I rise,
And out of Nothing now awake,
These Brighter Regions which salute mine Eyes,
A Gift from GOD I take.
The Earth, the Seas, the Light, the Day, the Skies,
The Sun and Stars are mine; if those I prize.

Long time before
I in my Mother's Womb was born,
A GOD preparing did this Glorious Store,
The World for me adorn.
Into this Eden, so Divine and fair,
So Wide and Bright, I come his Child and Heir.

A Stranger here
Strange Things doth meet, Strange Glories See;
Strange Treasures lodg'd in this fair World appear,
Strange all, and New to me.
But that they mine should be, who nothing was,
That Strangest is of all, yet brought to pass.

Days 2 and 3:

AND GOD CREATED - Relationships

The day following Monique's visit, the class were involved in orally recalling their experiences and observations. This led to discussion about the infinite varieties of 'love' which humans are able to express or experience. That evening, they were given the task of writing down their thoughts with regards the nativity of such a child, what their experiences were when observing this or any other newly born baby and how 'love' emanates from the mother towards her child.

By introducing our first physiology lesson in such a manner over two days, I was able to awaken in the children an unconscious appreciation of the importance of 'love' as a prerequisite for human life, at the same time laying the foundations for speaking about procreation.

Days 4 and 5:

BE FRUITFUL AND MULTIPLY - The Reproductive System

It should be possible out of this mood to lead the class into considering the miracle of conception and birth. *If we had the choice of being reborn, out of which mood of soul would be wish to be conceived?* This question immediately opens up a wide ranging, uninhibited discussion of male/female relationships and the meaning of 'love', 'making love' and 'sex'..... There was little need for me as the teacher to moralise or otherwise with regards human behaviour, the class took this aboard themselves. Our discussion led naturally into the subject of procreation. This is of course very confrontational for the more physically mature in the class, most of whom were girls.

There was the expected discomfort manifested by giggles and grimaces. However, enough of the children were still young enough to be able to listen and participate in a quiet and attentive manner, enabling the lesson to proceed in an appropriate fashion.

Throughout the course of this presentation, I ensured that 'love' remained as a very integral and essential component of the process of reproduction. It was important to speak about the cosmic rhythm present in the female reproductive system by directing the student's attention to the work that they had undertaken in Year Six during our "Astronomy" morning lessons.

Question and answer sessions were all important, and I permitted the students to submit their written questions *(if they felt uncomfortable asking such questions in front of the class)* which I would consider answering the next day. The few questions submitted were both sensible and sensitive, and generally aired concerns about their own sexuality and relationships, such as: *"was it alright for a 12 year old to be interested in another 12 year old of the same gender?"*

To bring an artistic element into the lesson, the symmetry of the internal female **REPRODUCTIVE ORGANS** were compared with those of the male external organs. Rather than draw clinical diagrammatic sketches on the board, I had spent time prior to the lesson creating chalk pictures of the organs. Either my drawings were so bad that the children were unable to recognise what I had drawn, or....as I prefer to believe....my drawings were so colorful and unusual, that I had succeeded in depicting the organs as creations of exceptional symmetry and beauty, thus lifting them onto a different plane of consciousness.

Days 6 and 7:

THE BREATHE OF LIFE - The Respiratory System

Following on from the work of Days 1 - 4, active discussion could now take place centered on the infant's relationship to it's body. How, at the moment of birth, it has to learn to breathe. Emerging from a watery world, it has to immediately learn how to breathe air! It is comforting to hear the first sounds of a newly born baby. The baby is breathing and exercising both it's **LUNGS** and **LARYNX**.

Remind the children of their Plant Study in Year Five and the role that plants have in purifying the air which they breathe. Give an imaginative description of the lungs and how they reflect the plant world in their shape and form.

The process of **RESPIRATION** should be presented to the students in a manner which is easy for them to understand. *Much of what is dealt with in this session will be recapitulated in the chemistry morning lesson dealing with 'Combustion'.* The students will already be familiar with the gases **OXYGEN** and **CARBON DIOXIDE**.

They should learn to appreciate the role which the nose plays in our breathing, along with that of the mouth and the fluid called 'mucus'. It is also important for the students to hear about the **TRACEA, BRONCHI** and **AIR SACS** and how the latter are connected to the blood vessels which carry the oxygen to every part of our body.

Here mention could be made of the importance of having 'clean air' to breathe. Without becoming too political, one could re-examine the interrelationship of the plant world and the human being. What are our responsibilities regarding the preservation of plant life? How does our modern day life style impact on the earth and the air we breathe. What can we do?

Experiment #1: Measuring the Air in our Lungs

1. Chest expansion - have students work in (gender) pairs to measure how much their chests expand when taking a deep breath. First take a measurement after exhaling. Then measure after inhaling. How efficient are your lungs? Who has the greater lung capacity?

2. How many liters of air do our lungs hold? Measure this by first filling a large transparent bottle (5 litre/1 gallon)) with water. Carefully invert the bottle so as not to loose any water and immerse it into a l large bowl of water.

   A second person now slips a length of tubing into the neck of the submerged bottle, placing the other end into his/her mouth and blowing as hard and for as long, as possible. The air that is blown into the inverted bottle forces out the water. Be ready to mark the bottle when the"'blower" has expelled all the air in his/her lungs. How much water (litres/pints) has been displaced? This amount roughly equals the capacity (litres/pints) of the "blower's" lungs! Repeat the experiment with another student.

Experiment #2: How our lungs work

Materials: plastic bottle and screw lid
2 small balloons
2 elastic bands
sticky tape
drinking straw (or similar)
knife and scissors

First cut the base of the plastic bottle. Cut the neck off one balloon and stretch the remaining balloon over the open bottom of the bottle and fix in place with an elastic band or sticky tape.

Experiment #2 - continued

Next pierce a small hole through the screw-lid. Carefully push half the straw through this hole so that it fits tightly. On the inside end of the straw, attach a small balloon with an elastic band. Screw the lid onto the bottle so that the balloon is now inside the bottle. The remaining half of the straw now sticks out from the top of the bottle.

Using the balloon on the base of the bottle as a 'diaphragm', pull it gently downwards and observe the balloon. By pulling down on the base diaphragm, you have effectively lowered the air pressure inside the bottle. Air from the outside rushes in through the straw (mouth) to fill this space, which results in the balloon on the end of the straw expanding. Release the diaphragm and the air pressure is increase which expels the air from the balloon.

By using a 3-way hosepipe connection, it is possible to have two 'lungs' inside the bottle.

Days 8 and 9:

OUR LIFE BLOOD - The Circulatory System

Discuss with the students how 'the sun imbued air' enters our lungs and is carried to the very extremities of our body by the **RED BLOOD CELLS** in the **ARTERIES**, which flow in a never ending, never resting lemniscate of movement, taking no more than 28 seconds to circulate right around our body.

The blood carries the very 'life forces' which our existence depends upon. The blood is that which maintains our body at a steady temperature of 36.8°C (98.4°F).

If the blood flows too fast, our temperature rises and we feel unwell. If the blood flows too slowly, then our temperature drops and we feel cold and uncomfortable. It's circulation is unceasing and is affected to a greater or lesser extent by our emotional experiences.

How much faster the blood flows when we become excited. Watch how a baby's face becomes bright red in a matter of seconds when it is upset! This fluctuation in the flow of the blood into the **HEART** via the **VEINS**, affects the rhythm of the heart, which is at the center of our **CIRCULATORY SYSTEM**, causing it to beat faster.

This subject would also serve as the basis for a free-style painting of the heart and blood flow, with the arterial blood being painted in red, whilst that in the veins could be of a mauve or purple hue.

Experiment #3 Finding our Pulse

Materials: sticky-tack or plasticine
needle (or tooth pick)
stop-watch (or watch with a second hand)

Have the student find his/her pulse by placing the tips of the first two fingers of one hand on the wrist of the second hand below the thumb. It may be necessary to move the fingers around before a 'pulse' is detected.

Place a piece of sticky-tack or plasticine on the spot where the greatest pulsations have been found. Carefully insert a needle into the 'tack' so that it stands upright. Have the student place her arm on a flat surface. It should be possible to see the needle twitching slightly to and fro as the blood surges rhythmically through the artery. This is the 'pulse' which in 12 - 13 years will pulsate at the rate of around 80 - 90 pulses per minute. In adults this decreases to 60 - 80 per minute. Have the student count and time her pulse rate.

Make students familiar with other 'pulse' locations and their names *(a challenge is sometimes a good thing!)*:

Carotid artery	-	in the neck
Brachial artery	-	in the crook of the elbow
Radial artery	-	in the wrist
Femoral artery	-	in the groin
Popliteal artery	-	behind the knee
Anterior tibial artery	-	on the front of the ankle

Days 10 and 11:

LET THERE BE LIGHT! - The Nerve/Sense System

What is the baby's relationship to the world? Are it's movements purposeful? How does it view the world? Is it able to focus and follow another person's hand movements? How is the baby affected by sound? Whose voice does it first recognise? The child is very active in the region of the Nerve/Sense System.

Referring to the Geology morning lesson in Year Six, discuss the process of calcification and how our bones are composed of the same substance. The seat of our Nerve/Sense System is the **BRAIN** which is supported in **CEREBRAL FLUID**. By the age of twelve, it is protected by a hard shell of bone. For us to be able to think clearly, it is important for our brain to exist in a quiet and stable environment. One can discuss with the class the injurious and detrimental effects which sports such as boxing or soccer, can have upon the brain.

Our eyescan also be irreparably damaged by constantly flickering or intense light, such as disco lights, television, computer screens or looking directly at the sun. If we choose to wear sun glasses, then we should ensure that they are suitable for us. Glasses 'off-the-rack' can do untold harm to our sight. Discuss.

Our Sense Organs enable us to be active participants in the life of the World and appreciate the sounds, sights and smells which surround us. With our **EYES** we are able to distinguish between light and darkness, to stand in awe of the wonders of creation and to recognise those who interact with us on a regular basis.

Without using our eyes, we are aware of the different parts of our anatomy because of the messages being continually passed to our brain by nerves (proprioception). However, we sometimes need to know the exact position of our limbs, which requires us to look at them, especially if we need to use our fingers to perform a delicate task. This is known as 'hand-eye coordination'. Have the students conduct the following experiment in pairs:

Experiment #4 Hand-eye coordination

Stretch both arms out and cross them one over the other so that the palms of the hands are able to meet. Interlock the fingers of both hands.

Slowly bend the arms so that the interlocked hands so that the hands go through a rotation of 270 degrees.

Hold the hands steadily in this position and ask a second person to point (not touch) to one of the fingers. Without thinking, respond by moving that finger! More frequently than not, the participant will move the wrong finger. This is simply because the eye is not used to seeing the fingers in this position and therefore the message sent to the brain is the wrong one.

Through our **EARS** we are able to hear and recognise the sounds of family and friends, of bird and beast, of wind, rain, thunder and countless other sounds. Imagine a world without any sound! What irreparable damage is done to our hearing by excessive and prolonged noise, such as that emitted by a pneumatic drill or those sounds which we listen to for pleasure through earphones. Discuss.

Our **NOSE** ensures that we are able to detect and recognise those aromas which are sweet and pleasurable, or those smells which we have a dislike for.

Our **TONGUE**, although used primarily in the process of digestion or for speech, it is also an important sense organ in that it enables us to taste the world. The tongue is covered with minuscule **TASTE BUDS**, most of which are on the sides of the tongue. With the buds on the tip we are able to detect sweetness. With those at the back: sweetness. Sourness is detected by the edge of the tongue, whilst salt is identified by both the tip and the edge of the tongue. Have the students conduct numerous taste tests.

The teacher will best illustrate the above in greater detail by drawing colorful sketches on the chalkboard for the students guidance, thus avoiding the use of lifeless text book diagrams. Students will naturally create their own art work and this could include making wax models of the ear, nose or eye.

It comes as a surprise to the children when they realise that their **SKIN** is their greatest sense organ. The **NERVES** in our skin enable us to experience touch, to have enough sensitivity to be able to identify objects without seeing, hearing or smelling them! Sensitivity varies from one area of our body to another. Some areas are far more sensitive than others.

Have the students experiment with their sense of touch on the palm of their hand. Make records of the areas of sensitivity on different parts of the body. Discover the distance between touch receptors on the leg or arm.

Students should discuss the causes of skin cancer and the measures which can be taken to limit exposure of the skin to the harmful rays of the sun.

Throughout our discussions, we should take the opportunity to bring to our student's awareness their responsibility with regards to the care and protection of their sense organs.

Opportunity could be given for students to experience a world without one or other of their sense organs. It would also be good for them to interact with individuals who are blind, deaf or dumb. *(Field trip)*

Days 12, 13 and 14

BLESSINGS ON OUR MEAL - The Metabolic System

Having touched upon both the **Rhythmic System** and the **Nerve/Sense System**, we can now turn our attention to the **Metabolic System**. As any student will know, the process of metabolism is very active in the young child!! For the first weeks of a baby's life, it is almost totally dependent on it's metabolism, for it is here that the substance which the child ingests is broken down and then built up anew to form it's physical body.

The activity of our Metabolic System is involved in the transformation of worldly substance, an activity which is carried through to the later tasks which we undertake with our limbs, especially our hands.

The ceremony of eating a meal has gone through such a transformation in the last 50 years that little, if anything, remains of the devotional element which was part of every meal time in nearly every household. Our attitude with regards to the consumption of a meal is just as important as the make-up of the meal itself.

Rhythm too plays an important role in the process of digestion. Our digestive system is a very good time keeper and will remind us when it is time to eat! If we eat our meals at a regular time each day, then our body becomes accustomed to this routine and will react accordingly when we delay a meal. How does our body begin to react when a meal is due? Students can be reminded how slight stomach cramps occur around break and lunch times. Sometimes we even experience our mouth beginning to water as a meal time gets closer, or when we smell the aroma of something cooking. Our digestion appears to begin even before we have consumed anything!

The digestive process actually starts at the moment we place a particle of food into our mouths. Straightaway, we begin to masticate the food with our **TEETH**, moving it around with our **TONGUE** to ensure that every piece is properly chewed. Throughout this process, the **SALIVARY GLANDS** are exuding saliva which acts upon the food. Have the children chew a small piece of bread and observe how the saliva reacts and the taste which they experience. Saliva has other properties which has given it an honored place in many of the world's cultures. It even has healing qualities which we are unconsciously aware of: young children will frequently put 'spit' on a small cut or graze to assist the healing process. Observe how animals always lick their wounds!

When we have done with chewing, we swallow our food at which time it enters the **OESOPHAGUS**, from where it is forced down into the **STOMACH**. Here our **GASTRIC JUICES** react with the food, breaking it down further. All the time, the walls of the stomach are expanding and contracting in a rhythmical way, helping to turn the food around and aiding the mixing process of food and stomach juices.

Once this has been accomplished, the food sets out on the next stage of its journey which is via the **SMALL INTESTINE**. *(The 'small' refers to the diameter of the intestine, not to its length which is some 7.5 meters!!).* From here it eventually enters the **LARGE INTESTINE** and **COLON**. By the time it reaches the colon, all nourishment has been extracted from the food and absorbed into the blood stream which will carry the nutrients to every part of the body.

Finally, the waste product is expelled in solid form as **FAECES** via the **RECTUM** and **ANUS**. Fluids pass through the **KIDNEYS** to be expelled via the **URETHRA**.

The entire journey of the food has been via the **ALIMENTARY CANAL** and can take anywhere up to 24 hours for the digestive process to be completed.

For us to be able to lead healthy, active lives, it is of paramount importance that we consume the right kinds of food in balanced proportions. Of great importance to any diet is water, for water is needed for digestion, for the blood and for the inner cleansing of the body **(URINE)**.

The food that we consume needs to contain elements which will provide us with energy: **CARBOHYDRATES** and **FATS**. As our bodies require constant rebuilding, we need to consume substances which will aid this process in the form of **PROTEINS**.

This is known as a **BALANCED DIET**. We should try to ensure that we imbibe a mixture of the right kinds of foods are each meal. A well balanced meal would be one which contains:

Carbohydrates Fats Proteins	)))	For Energy
Proteins Minerals	))	For growth and repair of bodily tissues
Minerals Vitamins	))	To keep the metabolic system functioning and to prevent disease
Water	)	Required for the blood and digestion
Roughage	)	To aid metabolism (digestion)

As a small research project, the students could each create a balanced menu. Maybe it would be possible to finish this main lesson with a class meal

When you eat and take pleasure in the taste and sweetness of the food, bear in mind that it is the Lord who has placed in the food it's taste and sweetness. You will, then, truly serve God by your eating.

Baal Shem Tov.

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Day 15:

FORBIDDEN FRUITS - Drugs and Addictions

This is the age when students begin to experiment with smoking *(although some may have begun much earlier).* It is important that this subject is broached with the students, but one has to be careful not to moralise, for this will immediately put the students 'off-side'. What are the effects of smoking **TOBACCO**. What does cigarette tobacco contain, apart from addictive **NICOTINE**? Why do cigarette manufacturers *(and governments)* refuse to divulge the exact chemical components of cigarettes? Have students write questioning letters to the Health Department! Discuss and involve students in designing anti-smoking posters.

What of **MARIJUANA** *(also called cannabis, pot, weed, grass, etc,.)* which creates the *"illusion"* of well-being? It is known, but not widely publicised, that the imbibing of marijuana in any form has a long term affect on the memory and the power to think. It has been observed that individuals who have only smoked marijuana 'socially' suffer from long term weakness of will. They are very often unable to sustain working with a demanding program or in a demanding work environment, such as school!! Discuss.

Mention could also be made of drugs such as **AMPHETAMINES** which speed up the rate of the heart, giving a *"feeling"* of boundless energy. The after effect is depression which leads to the desire for more drugs to overcome the depression. One begins on a never ending cycle of increasing **ADDICTION**.

ALCOHOL, even if drunk in moderation, can lead to first light headedness and a feeling of gaiety and false confidence. After a short while, the drinker can experience a change in their emotions, which may result in joy and laughter, or sadness and crying.

Next the speech becomes slurred and vision is affected. The drinker no longer has control of her/himself and will say the most stupid and outrageous things, or worse still, he or she may even begin to act totally out of character. Finally, the person will collapse and drift into unconsciousness. Alcohol has a very detrimental effect on our long term memory and ability to think clearly. Continuous and excessive drinking of alcohol can result in a person becoming a **ALCOHOLIC.** Discuss

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SCIENCE

PHYSICS

"Teachers must have the necessary inner life forces so that through their personality, through what they put into their teaching, they can give the children something they cannot yet fully understand. A relationship exists between the teacher and the children through which the teacher can bring things to the children. Things can be brought to the children through the way in which they live in the teacher, because the children feel the desire to experience the world that is aglow within the teacher."

From: **"The Spirit of the Waldorf School"**.
Rudolf Steiner (1919/1920)

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In the thirteenth year, students are fast losing their connection with the world of myth and legend, and their interests now extend outwards into the world about them. They are ready to hear of historical happenings and the results thereof. Science should be brought to the students as a progression of historical events and discoveries brought about through humanity's incessant search for for Truth. This is in fact central to the teaching of science at this stage of a child's development. To teach science through history means more than just interspersing a few pertinent historical facts and references at convenient junctures along the route. The teacher should have an overview of the entire spectrum of scientific development, so that science lessons can follow a logical sequence of events and discoveries. It has sense to introduce the discovery of electricity by referring to the Ancient Greeks and their discovery of 'static electricity', through to the later discoveries of scientists such as Volta, Galvani, Oersted and others (see: *'A Path of Discovery'. Grade 6*).

The task of the teacher is to awaken the student's sense perceptions to the wonders of a new world being revealed to them. A world which can replace the one that they have lost and one which holds unimaginable wonders and secrets. In these early stages of the developing thought process, ideas which are presented to the student also need to be capable of change, of metamorphosis.

To teach in a dry 'text book' fashion would defeat this aim. The child does not need to fed a lot of 'facts', but rather 'thoughts' and 'ideas' which are alive and which come from a living reality. There are many 'good' educational toys which are directed at improving a child's scientific prowess, however, building complicated structures with Lego blocks does not promote the kind of imaginative thinking required by an mind intent on investigating the nature of phenomena.

What is taught to the Grade Seven student needs to have a direct connection with life, so that he/she is able to make a direct connection with what is being learnt and the social needs of humanity. Science teaching should engender in the student a desire to reach out to society, rather than viewing the world through a one-way mirror.

SUBJECT AREAS

Acoustics	3 days	)	
		)	
Optics	3 days	)	First
		)	Morning Lesson
Heat	2 days	)	Block
		)	
Electricity	4 days	)	
Mechanics	14 days	)	Second Morning Lesson Block

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ACOUSTICS

"If music be the food of love, play on;
Give me excess of it, surfeiting,
The appetite may sicken, and so die.
That strain again! It had a dying fall:
Oh, it came o'er my ear like the sweet sound
That breathes upon a bank of violets,
Stealing and giving odour. ...."

From: **'Twelfth Night'.**
William Shakespeare. (1564 - 1616)

The second strand of the Steiner-Waldorf 'acoustic' science syllabus as presented in Grade Seven, could follow the following format:

1. Recapitulate work undertaken in Grade Six:

   Animate and inanimate sounds
   Pitch, volume and quality
   How sound travels
   Creative/destructive power of sound
   The human voice

2. Pythagoras and intervals

3. The Monochord

4. Pentatonic and diatonic scales

5. Vibration and sound waves

The presentation of the above sub-strands would take place over a period of three Morning Lessons *(longer, if time permits)*:

Day 1 Begin with silence
Recall work from Grade Six
Listen to a piece of music played on a violin or 'cello
Pythagoras and Intervals

Day 2 Review/Recount
Monochord (experiment)
Relationship to xylophone, etc.,.

Day 3 Review/Recount
Pentatonic and diatonic scales
Resonance and vibration (experiments)

Day 1

As with the beginning of the first Acoustics lesson in Grade Six, it would be good for the students to first observe a period of silence before the lesson commences. This could then be followed by a review and recount of work accomplished in Grade Six, with special attention being drawn to the experiments involving Pitch.

Ideally, the teacher will have arranged for one or two students to prepare and play a short piece of music *(preferably on a violin or 'cello, or similar)* to the class. At the conclusion of the piece, ask the students (audience) for their observations, especially with regards to the pitch of different notes. How were the differences in pitch obtained?

The first investigations into the difference in pitch or 'intervals' was conducted by the Greek philosopher and mathematician Pythagoras, somewhere between the years 580 - 500 BC and the 'monochord' is attributed to him..

Have the students construct several monochords, the parts for which have been previously prepared either by the teacher or as part of the students woodwork lessons.

Day 2

Review and discuss the previous day's experiences.

We now need to turn our attention to work with the monochord. How are variations in tone achieved? If we pluck the string in between the two support bridges, we are able to determine what note it is *(try for middle C)*.

Determine the length of the 'string' *(possibly 30 cm in length, although 60 cm would be better)*. Next move the 'movable' bridge so that it stands exactly midway between the two bridges, effectively dividing the 'string' in half. Pluck the string on either side of the movable bridge. What note have we obtained? Write this down.

Have students work in groups to determine notes relative to the length of the string until they have created an 8 tone scale. They should keep a chart of their findings. One should emerge with a series of fractions similar to the following:

1 * 1/2 * 2/3 * 3/4 * 4/5 * 3/5 * 8/9 * 8/15

The discovery of this series, is also attributed to the Greek philosopher Pythagoras. It is said that: *".....Pythagoras experimented with stretched strings of different lengths under the same tension. Soon he found the relation between the length of the vibrating string and the pitch of the note. He discovered that the octave, fifth, and fourth of a note could be produced by one string under tension, simply by 'stopping' the string at different places: at one-half its length for the octave, two-thirds its length for the fifth and three-fourths its length for the fourth!"*

Pythagoras's greatest discovery was the tetrachord, *where the important harmonic intervals were obtained by ratios of the whole numbers: 1. 2. 3. 4. The secret Brotherhood gave this fourfold chord mystical significance and used to say: "What is the oracle at Delphi? The* tetrachord! *For it is the scale of the sirens."*

Day 3

Review work from previous day. What were the results of the research? Does this hold good with other musical instruments? Repeat the 'test tube' experiment first conducted in Grade Six incorporating columns of air. What are the results? Have the students investigate in groups of two and log their research results.

Speak to the class about pentatonic and diatonic scales *(it would be ideal for this to be followed-up by your child's music teacher).* The pentatonic scale, which all children first learn to sing with in the kindergarten and 1st grade of Steiner-Waldorf, dates back to Ancient Greek times and maybe earlier.

It is the oldest known musical scale once used in Chinese music as well as in middle Europe. It's use continues in Irish and Scottish folk melodies and in some Negro spiritual music, such as 'Deep River'.

The pentatonic scale is made-up of five notes, in what is referred to as a *'gapped'* scale, e.g:

D * E * G * A * B

In medieval times, church music was based upon a series of seven different modal scales, but only two of these 7-note scales have survived to be used in modern music. They are called the *diatonic* scales, based on two modes, the *Ionian* and *Aeolian.* The Scale of C Major is one such scale which can be spoken about in relation to Pythagoras:

		Fraction	Length
I	Prime	1/1	15 cm
N	Major Second	8/9	13.3 cm
T	Major Third	4/5	12 cm
E	Perfect Fourth	3/4	11.25 cm
R	Perfect Fifth	2/3	10 cm
V	Major Sixth	3/5	9 cm
A	Major Seventh	8/15	8 cm
L	Octave	1/2	7.5 cm

Each 'note' and 'interval' could be allocated a color, beginning with purple, followed by magenta; red; orange; yellow; green and finally blue.

Finally, we can refer the students once more to the phenomena of vibration *(remember the Chladni Plate experiments?).* They may remember that we are able to elicit a tone from an instrument of known pitch, by the simple expedient of creating a note on a piano or some other instrument. Experiment with this on the piano by first 'opening' the middle C and then striking the C one octave below. Release the peddle so that the lower C is dampened, but hold the middle C open. Listen for what happens. Ask the students to explain what they have heard.

Experiment with this phenomena. Is it possible to cause a lead crystal wine glass to 'sing" by sympathetic vibration? It is supposedly possible for a soprano opera singer to cause a wine glass to shatter by sustaining the fundamental note for a long enough period of time!

If at all possible, students should be given the opportunity to make a small wooden xylophone or marimba in their woodwork classes. This could be based on their earlier discoveries with the monochord.

It would also deepen the students understanding of this subject if the Music and Eurythmy teachers were able to incorporate work with intervals and scales, into their lessons.

Students should be brought to an awareness of the how the Pythagoreans belief that there was a direct relationship between, number, music and astronomy. They were convinced that *".....they had found the pattern that 'guided' the wandering planets through the heavens. They pictured the sun and the planets as geometrically perfect spheres, moving through the visibly circular sky on perfect circular orbits, separated by harmonic ratios - musical intervals....."*

'The man that hath no music in himself,
Nor is not moved with concord of sweet sounds,
Is fit for treasons, stratagems and spoils;....'

From: **'The Merchant of Venice'**
William Shakespeare. (1564 - 1616)

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OPTICS

Light

'The night has a thousand eyes,
And the day but one;
Yet the light of the bright world dies
With the dying sun.

The mind has a thousand eyes,
And the heart but one;
Yet the light of a whole life dies
When love is done.'

F. W. Bourdillon

Evening Prayer

'Only when I think the light
My soul begins to shine.
Only when my soul does shine
The earth becomes a star.
When the earth becomes a star
I am truly human.'

Herbert Hahn

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This is the second strand of the 'Light and Color' Syllabus first started in Grade Six and will deal primarily with:

1. The Path of Light
2. Reflection
3. Lenses

The presentation of the above sub-strands would take place over a period of three Morning Lessons:

Day 1 The Path of Light *(recapitulation of work in Grade 6)*
Experiment with pin-hole camera

Day 2 The Reflection of Light
Experiments with mirrors
A periscope and kaleidoscope

Day 3 Refraction
Magnification

Day 1

It would be wise to remind the students of the work and discoveries which they made in Grade Six.

This could be a starting point for discussion and recapitulation. The fact that light from the sun appears to surround us, is due to the fact that sunlight radiates out in every possible direction and is reflected by everything in it's path.

When light travels, it does so by following the most direct route This can be shown by experimenting with a simple pin-hole camera. A shoe box would be ideal for this experiment.

Remove a center square from one end of the box and in it's place attached a sheet of tracing paper with adhesive. thus forming a screen. Centrally in the opposite end of the box, pierce a small hole *(literally a pin-hole)*.

Finally, attached a large piece of dark piece of cloth to the screen end of the box which which you are able to drape over your head, thus given you the possibility of viewing the screen in total darkness. Observe the result.

The reason that the images appear inverted on the screen is that the reflected light from an object takes the most direct path (refer: *A Path of Discovery*. Vol. 5/Gd. 5).

The most important findings regarding light are that:

a. Light is invisible until it is reflected by an object,
and
b. Light travels in a straight line.

Day 2

This lesson could commence with students bouncing a tennis ball against a wall so that it rebounds into their hands. Have students orally describe what is actually happening and following-up the experiment with their own diagrams.

How does this relate to light? Students will have been asked to bring two small, pocket sized mirrors to school for the following experiments.

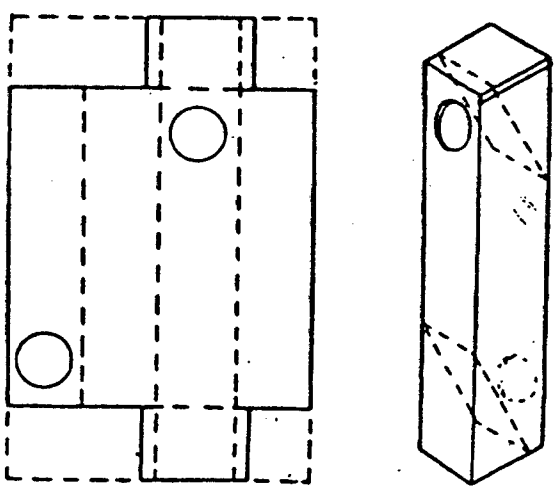
Firstly, obtain a piece of white card and draw a straight dotted line across the center. Next draw an unbroken straight line from the original line at any angle. Where the two lines converge, set-up a mirror so that the original dotted line is in line with the original. A reflection of the unbroken line will now be visible in the mirror. Take a rule and extend the reflected line by marking it on the white card. Measure the degree of angle of the original unbroken line and compare it to that of your extended line and the new angle which has been form with the dotted line.

Draw numerous other lines at variable angles to the mirror and record the angles. Draw extensions to each of the reflected lines. What are your findings? The conclusion of this experiment is that the angle of reflection is the same as the angle at which the light hits the mirror.

A second experiment can be carried out showing how light is reflected from one mirror to another by standing two mirrors side-by-side at a right angle on a piece of white card. From the outside bottom edge of each mirror, draw a connecting line. In the center of the connecting line, stand a lighted candle.

From the candle, draw a straight line to the two reflected candles. What do you observe?

Finally, it should be possible for the students to make their own periscope, using the two mirrors which they have brought with them. The dimensions of the periscope depend on the dimensions of the mirrors and will have to be calculated independently. The template could be based on the following design:



Day 3

Having reviewed the work of the previous two days, the attention of students should now be directed to the phenomena of Refraction.

Having obtained a small circular fish bowl or large circular glass jar, either of which have been almost filled with water, have a student partially immerse a pencil into the water so that it can be viewed from the outside of the glass container. What is the student's observation?

Set up a sheet of dark card next to the glass container. Pierce a small hole through the card and shine an intense light through the hole so that it strikes the water on the surface. Observe what happens to the beam of light.

Experiment with a coin lying in the bottom of a cup or beaker. Stand the cup in such a position that the coin is not quite visible to the viewer. Gradually pour water into the cup. The viewer should observe and explain what has taken place.

Has your fish bowl got a gold fish in it?! If so, observe the gold fish from the side and from the top. Alternatively, observe other items placed in the water of your bowl or jar. Stand a pencil upright in the water. What can be observed? How do the fish, other items or pencil appear from the different viewpoints?

Students will have observed that water contained in a circular glass container has the ability to magnify objects. This experiment can be taken a stage further by creating a very simple lens.

Wind a piece of fine copper wire around an average nail to form a loop. Dip the loop into the container of water so that a drop attached itself to the loop. Look carefully through the droplet at something really small. Observe the result.

Repeat the experiment by letting a drop of water fall upon some very small printed letters. Observe and then discuss the shape of the 'droplet lens'.

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This should be sufficient work and experimentation for this part of the Morning Lesson allocated to Optics. Further work will be carried out in Grade Eight, or in some instances in practice science lessons where a specific government syllabus so requires *(as in New South Wales, Australia).*

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HEAT

Summer and Winter

'Asleep is the soul of Earth
In Summer's heat,
While the Sun's outward Glory
Rays through the realms of Space.

Awake is the soul of Earth
In Winter's cold,
While the Sun's inmost Being
Lightens in Spirit.

Summer's day of joy
For Earth is sleep.
Winter's holy night
For Earth is day.

Rudolf Steiner

****

In this strand of the Grade Seven science syllabus, we will look at "Heat" and cover the following areas:

1. Expansion of Liquids and Gases (review)
2. Convection of Heat in Liquids
3. Convection of Heat in Gases

The presentation of the above sub-strands will take place over a period of two Morning Lessons:

Day 1
Introduction and review of Grade Six 'Heat' syllabus
Convection of Heat in Liquids
Hot water heating system and the importance of insulation

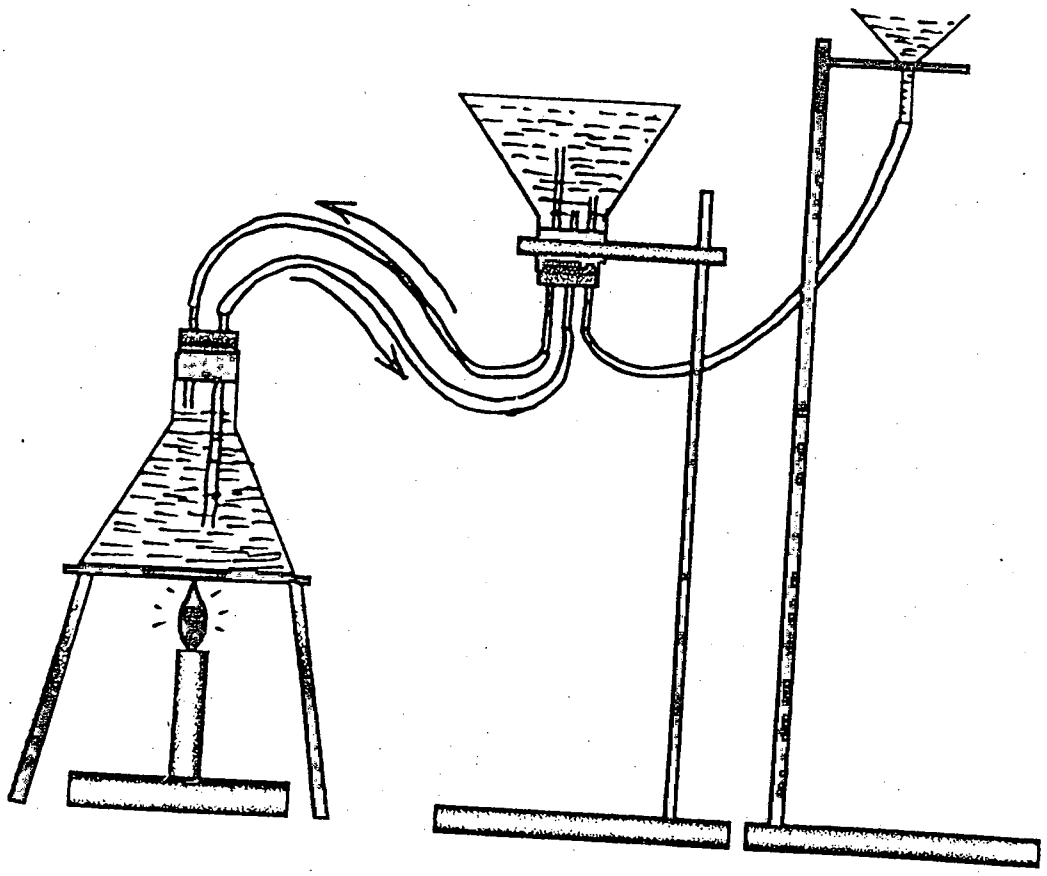
Day 2
Review
Convection of Heat in Gases
Convection and the Weather
Hot-air balloon

Day 1

It would be good to revisit the work undertaken in Grade Six, especially that of Conduction and Convection.

Convection is the most important method of heat transfer by liquids and gases; it cannot take place in solids. One very practical application of this scientific fact is the hot water system of a house. The hot water in the boiler rises to the hot water tank and cool water takes its place.

The students could experiment by constructing a laboratory sized hot water heating system by obtaining a **heat resistant** narrow neck bottle or flask; a goodly length of rubber or plastic tubing; a second glass flask; a funnel; glass tubing and 2 large corks. Assemble the apparatus as shown below:



To maintain the heat in a hot water heating system, the system and piping need to be well insulated. Fibreglass 'lagging' is frequently used for this purpose.

Day 2

Review the previous day's work and lead into the convection of gases. Explain to the students that convection occurs when heat is transmitted by the movement of liquid or gas from one place to another. This happens because the hotter material (liquid or gas) is usually less dense than the cooler material and thus lighter in weight. The hotter material therefore rises making room for cooler material to enter and take the vacant space.

We are able to experience this with the flow of air, especially if living close to the coast. During a good summer's day when the sun is shining, the temperature of the earth becomes higher than that of the sea. Therefore, the air immediately above the earth rises. When this happens, then the cooler air which is above the sea rushes into the vacant space. This gives us an 'on shore' breeze.

At night, the earth cools down quicker than the sea, resulting in the air above the earth becoming cooler than that above the sea. The sea air therefore rises and the air from the land rushes in the fill the space. This creates an 'off shore' breeze. *('Climatology' is part of the Grade Eight science syllabus).*

Having acquired some new knowledge about convection during the course of these two lessons, one could relate the story of the Montgolfier brothers to the students.

Joseph and Jacques Montgolfier were fascinated with the convection of air and experimented with inverted paper bags which they filled with heated air. The following year, they called the townsfolk together to witness the first hot-air balloon flight! The brothers had made a large balloon from linen Beneath it they lit a controlled fire of straw so that the heated air was captured within the balloon. To everyone's amazement, the balloon rose gently from the ground, soaring to a height of some 3,000 ft (1,000 meters). A gentle wind carried the balloon for a distance of around 1.75 miles (or 2.5 km) before returning to earth.

The news of the Montgolfier discovery quickly spread throughout the country and came to the notice of King Louis XVI who commanded the Montgolfier brothers to demonstrate their balloon to the royal household. So it was that on 19th September, 1783 the brothers launched a much decorated balloon...with passengers!! A basket had been attached to the underside of the balloon and inside were a chicken, a duck and one sheep. The balloon stayed aloft for all of 8 minutes before landing some 2 miles (approx. 3 km) away.

The following year, the brothers launched yet another balloon, but this time the cargo was human and the citizens of Paris were honored by seeing the first manned flight in history.

Day 2 - continued

A small balloon could be made from sheets of tissue paper glued together in a 'bulb' shape. A container to hold the heat source will need to be attached beneath the opening to the balloon. A methylated spirit burner would supply sufficient heat to raise a small balloon off the ground.

Do take simple, but necessary precautions when conducting this experiment.

This brings to a conclusion the section on 'Heat'. The Grade Eight syllabus will incorporate work with 'latent' and ' specific' heat, and the development of the steam engine.

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ELECTRICITY

'It is well known that the oscillations of certain electrical frequencies, in even small quantities and for short durations, have consequences that, although difficult to measure, are detrimental to health. But far less attention is paid to the question as to what extent electrical phenomena influence a human being's thinking, feeling and willing. Here is a source of danger for humans that is not to be underestimated."

'Electricity and Human Consciousness'. Markus Osterrieder
(Trans from German by Hilde Stossel)

****

One week had been allocated to this subject in Grade Six as a continuation of work with Magnetism and Electrostatics. Our studies in Grade Six took us from Galvani's discovery and the development of the Voltaic Pile and Voltaic Cell, through to Christian Oersted's discovery of the connection between magnetism and electricity, which eventually led to the development of the electromagnet.

It is at that point in time that we pick up the thread by recapitulating the development of the electromagnet before progressing to its use in driving a simple motor.

1. Magnetism from an electric coil (electromagnet)
2. Samuel Morse
3. Telegraph
4. Michael Faraday
7. Electricity from magnet and coil
6. Simple electric motor
7. Manually generated electricity (dynamo)

The presentation of this, the fourth strand in the Morning Lesson block, will take place over a period of four morning lessons:

Day 1
Introduction
Review of Grade Six syllabus
William Sturgeon and the electromagnet
Making an electromagnet (experiment)

Day 2
Review and recount
Practical applications of the electromagnetic coil
Samuel Morse and his Code
Electric sounder and telegraph (experiment)

Day 3
Review and recount
Michael Faraday
Electricity from a Magnet and Coil (experiment)

Day 4
Review and recount
Simple electric motor (experiment)
The electric dynamo

****

Day 1

The first task would be to review previous work undertaken in Grade Six. This would include the introduction to the electromagnet. The students should be reminded of William Sturgeon's participation in this discovery (1825), along with that of other imminent physicists of that time, including the American Joseph Henry who made the same discovery independently of Sturgeon.

Students could attempt to create a horse shoe magnet. They will require a length of iron rod which can be easily bent into a U shape and an ample supply of insulated bell wire.

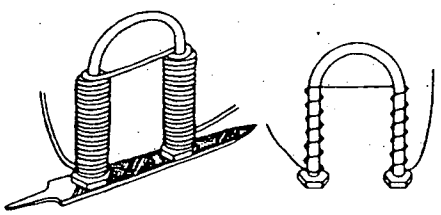
Day 1 - continued

Begin by leaving a 20 cm length of wire handing free. Then wind wire around of one arm of the U in a clockwise fashion to a thickness of three layers, always leaving the curvature of the magnet free of any wire. After the third layer has been wound onto the one arm, take the wire across the intervening gap, reverse the winding process so that the wire is now wound onto the second arm in an anti-clockwise direction. Apply three layers of wire as per the first arm. Leave about 20 cm of wire hanging loose from the end of this arm. Remove the insulation from the ends of the two freely hanging wires and attached them to a 6 volt battery.

Test the arms of your magnet to ascertain their polarity, which should be alternatively 'north' and 'south'. If both poles are the same, then the wire will need to be rewound on one arm in the opposite direction. When the polarities are correct, test the power of the magnet by picking up pieces of iron which increase in size. Ascertain the 'magnetic force' by the use of a spring balance/scale. (see: *A Path of Discovery.* Vol.6/Grade Six).

Students can be asked to try to increase the strength of their magnet by rewinding with increased layers of wire.

Time could be fruitfully spent explaining to the students the work of Frenchman, Andre Ampere in discovering the direction of flow of electrical currents and the implications of this discovery when applied to an electromagnet *(solenoid).*



Day 2

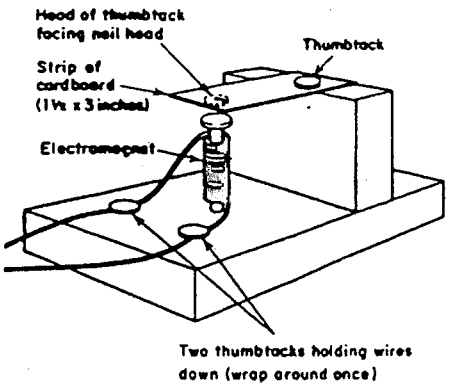
Review the previous day's work and discuss the implications of the invention of the electromagnet and it's ramifications with regards to the development of industrial technology.

As an introduction to the next segment, it would be good to relate some details from the life of *Samuel Morse (1791-1872), the inventor of the Morse Code. Samuel struck on the idea of sending messages via a wire whilst on a return trip from England where he had been on an art study tour, for Samuel was actually an artist rather than a scientist! However, electricity was the main topic of discussion amongst all levels of society during those early days following the invention of the electromagnet.*

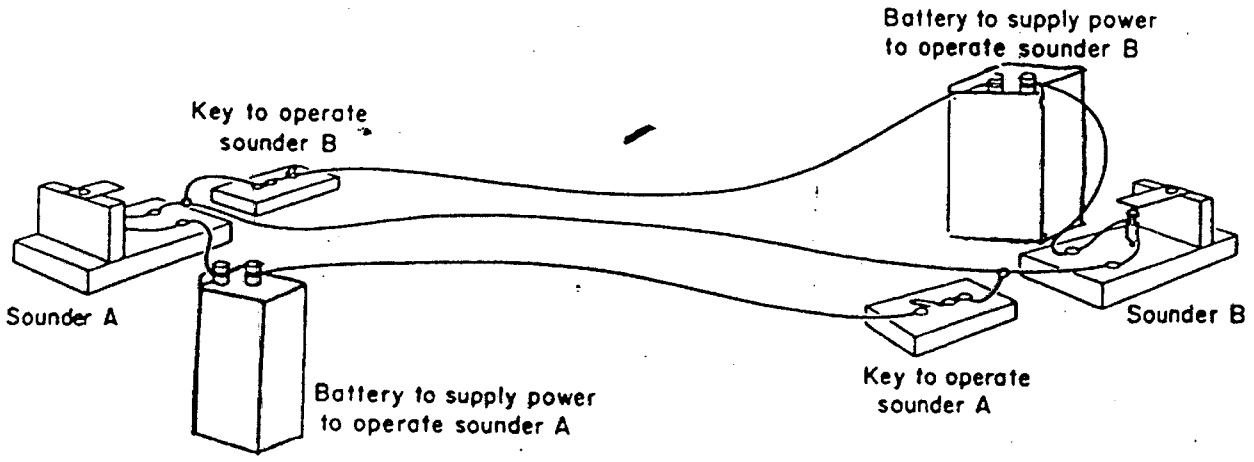
Day 2 - continued

Samuel Morse reasoned that it should be possible to send a a written message along a wire by controlling the the electrical pulses which could be generated by the manipulation of a magnet within a coil.

Samuel pursued his idea with vigor and it wasn't long before he had made a crude machine which enabled him to create pulses strong enough to move a pencil and have it leave marks on a piece of paper. Excitedly, Samuel approached many of his rich and influential friends for funding for his project, which he wanted to demonstrate on a large scale. So it was that in 1844, some twelve years after he first thought of the idea, that 40 odd miles of cable was stretched out between the US Capital City, Washington and Baltimore. Along this line, Samuel Morse sent the first message in his Morse Code, which read: " What God hath wrought!" . The determination of this one man had opened the way for communication on a grand scale never before dreamt of.



Students could now be shown had to make and assemble a simple telegraph system. How to construct a 'sounder' is shown clearly in the book 'Safe and Simple Electrical Experiments' by Rudolf Graf. and in "Physics is Fun' by Roberto Trostli, so I won't attempt to re-write what has already been written very clearly. If readers are unable to obtain either of the above mentioned titles, then a search in a local public library is bound to turn-up the information you require. However, I include diagrams of a functionable telegraph sounder and system.



Day 3

Recount the experiment of yesterday. Discuss: How the development of the telegraph shaped modern day society.

One of the greatest physicists of this period, was undoubtedly the Englishman, Michael Faraday. He was born in Yorkshire, England in 1791. His father was a blacksmith and one can well imagine the the young Michael must have been fascinated by the heat and noise of his father's smithy. He was often to be found helping his father in the creation of useful items out of iron. This stood Michael in good stead when he later became a scientist, for he was nearly always able to make his own apparatus. Although Michael's family was very poor, his parents insisted that the children should have an education. Michael was at school until the age of 13. He then left and became a bookbinders apprentice for 7 long years. During this time, he had access to numerous books. He was especially interested in those dealing with science.

It was during this period of time that Michael was given an introduction to the Royal Institute of London where impressive people of that day and age gave important lectures. Michael was given tickets to hear the famous Humphrey Davy speak. Afterwards he was able to meet with Sir Humphrey and this led to Michael eventually becoming an assistant to Sir Humphrey. Whenever Sir Humphrey visited other countries, Michael went along and thus he was able to meet such great personages as Volta and Ampere.

Michael became very intrigued with magnetism and electricity, and pursued it as his main area of interest. He pondered for ten long years over Oersted's discovery of the effect of an electric current on a magnetic field. He reasoned that if this could happen, then it should be possible to create an electric current by the use of a magnet. Reverse the process in other words.

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This would now be an opportune moment to have the students conduct Faraday's experiment!

Create a 'current detector' as per the instructions given for Grade Six. If this is not possible, then obtain a small and sensitive current detector from an electrical supply store. Attache a coil of about 50 turns of bell wire to the detector, leaving the connecting wires long enough so that the coil is well removed from the detector.

Obtain a permanent horse-shoe magnet (the stronger the better). Move the coil over one pole of the magnet and observe the current detector. Remove the magnet and observe. Experiment with either pole of the magnet and by placing both poles within the coil simultaneously. Record all the results.

Consider what the implications of this discovery could mean.

Day 4

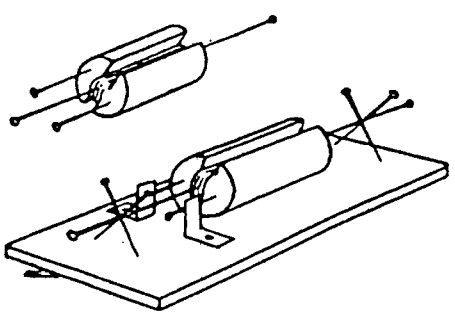
Review and recount the work of the previous day. Discuss the implications of Faraday's discovery. How would this impact on scientific progress?

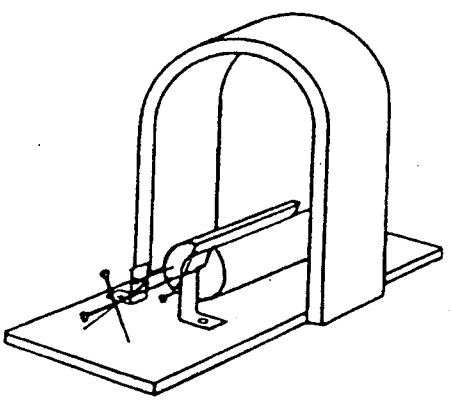
Faraday's initial discovery was so far reaching that it was impossible to imagine just how his invention would be utilised in the future. Even now, nearly 200 hundred years later, we are still discovering new ways of applying his knowledge of electricity. Let us imagine, if we can, the excitement that Faraday must have experienced when he first created a simple electric motor!

Students need to have a cork or a piece of styrofoam. Around the cork/styrofoam, wrap a coil of thin insulated wire. It would be wise to make a groove in the cork/styrofoam to ensure that the wire does not slip off accidentally. Stick a pin in either end of the cork/styrofoam to act as an axle.

Add two additional pins to one end of the cork/styrofoam to function as terminals. Into a soft board (balsa wood is ideal), stick four more pins, in twos so that they cross over one another to form a support for the axles at each end of the cork/styrofoam. Fixed two 'brushes' of thin tin/copper strips to the base with thumb tacks so that there is one strip on either side of the coil, the terminal pins of which, when turning, will brush against the metal strips. Connect the two lengths of bell wire to the strips and bare the ends.

Finally, take a strong horse-shoe magnet and place it over the coil and connect the wires to the power source (battery).





Discuss how this principle is applied to the simple dynamo as used on a bicycle or in a hand generated flashlight. Have students discuss the application of the dynamo to larger projects, such as the Hoover Dam (USA) or the Snowy Mountains Scheme (Australia).

This brings to a conclusion the first Morning Lesson Physics block for Grade Seven.

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MECHANICS

"Mechanical science is the most noble
and useful above all others,
for by means of it,
all animated bodies in motion
perform their operations....."

Leonardo da Vinci (1452 - 1519)

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The second Physics Morning Lesson in Grade Seven could be spread over a period of between 10 - 15 lessons, depending upon how deeply the teacher wishes to work with this subject. There is tremendous scope for creativity in the design and construction of simple machines, thru to a working scale model of a 'windmill' which was made some years ago my a colleague at my current school. However, I believe that it would suffice for the students to have a basic understanding for 'mechânics' with the focus being directed to **"The Mighty Five"**: *Lever, Pulley; Inclined Plane; Screw and Wheel.*

At the outset, the students could respond to the questions: What is FORCE? What is a MACHINE?

Lead on from here to the introduction of the three classes of LEVER. Each should be demonstrated in a very practical manner, the more imaginative and impressive the better! My class were given the task of moving a 1 tonne boulder from its inconvenient position in the maintenance area. The only equipment they had were varying lengths of wooden and metal poles. No instructions were given and it was interesting to observe how they set about solving the problem, teaching themselves about the importance of the *'pivot' (fulcrum)* and the various classes of levers.

The purchase of a couple of strong pulleys enabled us to hoist students of various weights and sizes. There was always the temptation of leaving the someone hanging high and dry! The use of pulleys was then put into practice by having our PE teacher supervise an organised session at a 'climbing wall'. Inclined planes, Wedges, Screw and Wheels were all taught as 'hands-on' experiences.

I made very good use of Roberto Trostli's book ***"Physics is Fun"*** and for that reason I will not include a detailed lesson plan for this particular area of study. Additional research would be most beneficial, along with an imaginative approach to the presentation of the various sub-sections.

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EQUIPMENT REQUIRED

General

Rulers/protractors/pencils/erasers

Acoustics

String instrument (violin/'cello)
Piano
Recorders (sopranino/descant/treble/tenor/bass)
Marimba or xylophone
Bow (violin or 'cello)
Monochord
Test tubes (8 for every 2 students)
Test tube stands (1 per every two students)
Chladni Plate
Salt (fine)
Wine glass (crystal)

Optics

Flashlight/torch (narrow beam)
Batteries for flashlight
Pinhole camera (camera obscura)
Tennis balls and/or table-tennis balls (1 for every 2 students)
Mirrors - small, pocket size (1 per student)
Plasticine (for mirror stands)
White and black card
Colored card (1 x A3 sheet per student)
Candles (small) (1 for every 2 students)
Matches
Fish bowl (preferably globular)
Cups/mugs (china or paper) (1 for every 2 students)
Coins (1 for every 2 students)
Copper wire (fine) (10 cm per student)
Nail (average size) (1 per student)
Print - sheets of fine print
Source of water

Heat

Glass flasks/bottles with narrow neck (heat proof) x 2
Plastic/rubber tubing (approx. 1.5 m)
Glass tubing (approx. 1 m)
Funnel
Large flask/bottle stopper/cork (with 3 holes for tubes)
Large flask/bottle stopper/cork (with 2 holes)
Stands for flasks x 2
Tripod
Gauze (heat conduction pad)
Bunsen burner
Matches
Tissue paper (A5 sheets)
Glue (UHU sticks)
Pencil
Ruler
Scissors
Cotton thread
Oil-burner candles (in aluminium containers

Electricity

Iron rods/bar (pliable)
Insulated bell wire (.5 m per student)
Compass
Horseshoe magnet (large)
Spring balance (sensitive)
Nails (average size) (1 for every 2 students)
Thumb tacks (box)
Cardboard (A3 sheet)
Wooden blocks x 15 (as per diagram for 'sounder')
Batteries - 12 v (1 for every 2 students)
Paper clips
Galvanometer/current detector
Cork (wine bottle size)
Pins (box)
Copper/tin - thin strips (10 cm of either)
Metal cutter
Wire cutter
Card (stiff) or balsa wood (10 cm x 5 cm x 1)

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VERSES and POEMS

MORNING VERSE

I look into the World;
In which the sun is shining;
In which the stars are gleaming;
In which the stones are lying.
The living plants are growing;
The animals, they are feeling.
In which the Human Soul,
Gives dwelling for the Spirit.

I look into the Soul
Which lives within myself.
God's spirit weaves in light
Of Sun and Human Soul;
In World of space, without.
In depths of Soul, within.
God's Spirit, 'tis to Thee
I turn myself in Thought ,
That strength and blessing grow
In me, to learn and work.

Rudolf Steiner.

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VERSE FOR THE END OF DAY

May wisdom shine through me,
May love glow within me,
May strength permeate me,
That in me may arise
A helper of humankind
A server of holy things,
Selfless and true.

Rudolf Steiner

******

SALUTATIONS

(Thomas Traherne. 1636-74)

These little Limbs,
These Eyes and Hands which here I find,
These rosy Cheeks wherewith my Life begins,
Where have ye been? Behind
What Curtain were ye from me hid so long?
Where was? In what Abyss, my Speaking Tongue?

When silent I,
So many thousand, thousand years,
Beneath the Dust did in a Chaos lie,
How could I Smiles or Tears,
Or Lips or Hands or Eyes or Ears perceive?
Welcome ye Treasures which I now receive.

I that so long
Was Nothing from Eternity,
Did little think such Joys as Ear or Tongue,
To Celebrate or See:
Such Sounds to hear, such Hands to feel, such Feet,
Beneath the Skies, on such Ground to meet.

New Burnished Joys!
Which yellow Gold and Pearl excel!
Such Sacred Treasures are the Limbs of Yours,
In which a Soul doth Dwell;
Their Organised Joints, and Azure Veins
More Wealth include, than all the World contains.

From Dust I rise,
And out of Nothing now awake,
These Brighter Regions which salute mine Eyes,
A Gift from GOD I take.
The Earth, the Seas, the Light, the Day, the Skies,
The Sun and Stars are mine; if those I prize.

Long time before
I in my Mother's Womb was born,
A GOD preparing did this Glorious Store,
The World for me adorn.
Into this Eden, so Divine and fair,
So Wide and Bright, I come his Child and Heir.

SALUTATIONS - continued

A Stranger here
Strange Things doth meet, Strange Glories See;
Strange Treasures lodg'd in this fair World appear,
Strange all, and New to me.
But that they mine should be, who nothing was,
That Strangest is of all, yet brought to pass.

****

THE LADY OF SHALOTT

(Alfred, Lord Tennyson. 1809 - 92)

Part One

On either side the river lie
Long fields of barley and of rye,
That clothe the wold and meet the sky;
And through the field the road runs by
To many-towered Camelot;
And up and down the people go,
Gazing where the lilies blow
Round an island there below,
The island of Shalott.

Willows whiten, aspens quiver,
Little breezes dusk and shiver
Thro' the wave that runs for ever
By the island in the river
Flowing down to Camelot.
Four grey walls and four grey towers,
Overlook a space of flowers,
And the silent isle embowers
The Lady of Shalott.

By the margin, willow-veiled,
Slide the heavy barges trailed
By slow horses; and unhailed
The shallop flitteth silken-sailed
Skimming down to Camelot:
But who hath seen her wave her hand?
Or at the casement seen her stand?
Or is she known in all the land,
The Lady of Shalott?

THE LADY OF SHALOTT continued

Only reapers, reaping early
In among the bearded barley,
Hear a song that echoes cheerly
From the river winding clearly,
Down to towered Camelot:
And by the moon the reapers weary,
Piling sheaves in uplands airy,
Listening, whispers 'Tis the fairy
Lady of Shalott'.

Part Two

There she weaves by night and day
A magic web with colours gay.
She has heard a whisper say,
A curse is on her if she stay
To look down to Camelot.
She knows not what the curse may be
And so she weaveth steadily,
And little other care hath she,
The Lady of Shalott.

And moving thro' a mirror clear
That hangs before her all the year,
Shadows of the world appear.
There she see the highway near
Winding down to Camelot:
There the river eddy whirls,
and there the surly village curls,
And the red cloaks of market girls,
Pass onward from Shalott.

Sometimes a troop of damsels glad,
An abbot on an ambling pad,
Sometimes a curly shepherd lad,
Or long-haired page in crimson clad,
Goes by to towered Camelot;
And sometimes thro' the mirror blue
The knights come riding two and two:
She hath no loyal knight and true,
The Lady of Shalott.

THE LADY OF SHALOTT continued

But in her web she still delight
To weave the mirror's magic sights,
For often thro' the silent nights
A funeral, with plumes and lights,
And music, went to Camelot.
Or when the moon was overhead,
Came two young lovers lately wed;
'I am half sick of shadows,' said
The Lady of Shalott.

Part Three

A bow-shot from her bower-eaves,
He rode between the barley sheaves,
The sun came dazzling thro' the leaves,
And flamed upon the brazen greaves
Of bold Sir Lancelot.
A red-cross knight for ever kneeled
To a lady in his shield,
That sparkled on the yellow field,
Beside remote Shalott.

The gemmy bridle glittered free,
Like to some branch of stars we see
Hung in the golden Galaxy.
The bridle bells rang merrily
As he rode down to Camelot:
And from his blazoned baldric slung
A mighty silver bugle hung,
And as he rode his armour rung,
Beside remote Shalott.

All in the blue unclouded weather
Thick-jewelled shone the saddle-leather,
The helmet and the helmet-feather
Burned like one burning flame together,
As he rode down to Camelot.
As often thro' the purple night,
Below the starry clusters bright,
Some bearded meteor, trailing light,
Moves over still Shalott.

THE LADY OF SHALOTT continued

His broad clear brow in sunlight glowed;
On burnished hooves his war-horse trode;
From underneath his helmet flowed
His coal-black curls as on he rode,
As he rode down to Camelot.
From the bank and from the river
He flashed into the crystal mirror,
'Tirra lirra,' by the river
Sang Sir Lancelot.

She left the web, she left the loom,
She made three paces thro' the room,
She saw the water-lily bloom,
She saw the helmet and the plume,
She looked down to Camelot.
Out flew the web and floated wide;
The mirror cracked from side to side;
'The curse is come upon me,' cried
The Lady of Shalott.

Part Four

In the stormy east wind straining,
The pale yellow woods were waning,
The broad stream in his banks complaining,
Heavily the low sky raining
Over towered Camelot;
Down she came and found a boat
Beneath a willow left afloat,
And round about the prow she wrote
The Lady of Shalott.

And down the river's dim expanse -
Like some bold seer in a a trance,
Seeing all his own mischance -
With a glassy countenance
Did she look to Camelot.
And at the closing of the day
She loosed the chain, and down she lay;
The broad stream bore her far away,
The Lady of Shalott.

THE LADY OF SHALOTT continued

Lying, robed in snowy white
That loosely flew to left and right -
The Leaves upon her falling light -
Thro' the noises of the night
She floated down to Camelot:
And as the boat-head wound along
The willowy hills and fields among,
They heard her singing her last song,
The Lady of Shalott.

Heard a carol, mournful, holy,
Chanted loudly, chanted lowly,
Till her blood was frozen slowly,
And her eyes were darkened wholly,
Turned to towered Camelot.
For ere she reached upon the tide
The first house by the waterside,
Singing in her song she died,
The Lady of Shalott.

Under tower and balcony,
By garden wall and gallery,
A gleaming shape she floated by,
Dead-pale between the houses high,
Silent into Camelot.
Out upon the wharves they came,
Knight and burgher, lord and dame,
And round the prow they read her name,
The Lady of Shalott.

Who is this? and what is here?
And in the lighted palace near
Died the sound of royal cheer;
And they crossed themselves for fear,
All the knights at Camelot:
But Lancelot mused a little space;
He said, 'She has a lovely face;
God in His mercy lend her grace,
The Lady of Shalott.'

****

SONNET

(William Shakespeare. 1564 - 1616)

When in the chronicle of wasted time
I see descriptions of the fairest wights
And beauty making beautiful old rhyme
In praise of ladies dead, and lovely knights,
Then in the blazon of sweet beauty's best,
Of hand, of foot, of lip, of eye, of brow,
I see their antique pen would have expressed
Even such beauty as you master now.
So all their praises are but prophecies
Of this our time, all you prefiguring,
And, for they look'd but with divining eyes,
They had not still enough your worth to sing:
For we, which now behold these present days,
Have eyes to wonder, but lack tongues to praise.

LA BELLE DAME SANS MERCI

(John Keats. 1795 - 1812)

O what can ail thee, knight-at-arms,
Alone and palely loitering?
The sedge is wither'd from the lake,
And no birds sing.

O what can ail thee, knight-at-arms,
So haggard and so woe-begone?
The squirrel's granary is full,
And the harvest's done.

I see a lily on thy brow
With anguish moist and fever dew;
And on thy cheek a fading rose
Fast withered too.

I met a lady in the meads,
Full beautiful - a faery's child,
Her hair was long, her foot was light,
And her eyes were wild.

I made a garland for her head,
And bracelets too, and fragrant zone;
She look'd at me as she did love,
And made sweet moan.

LA BELLA DAME SANS MERCI - continued

I set her on my pacing steed,
And nothing else saw all day long,
For sideways she would lean, and sing
A faery's song.

She found me roots of relish sweet,
And honey wild, and manna dew;
And sure in language strange she said -
'I love thee true!'

She took me to her elfin got,
And there she gazed and sigh'd full sore,
And there I shut her wild wild eyes
With kisses four.

And there she lulled me asleep,
And there I dream'd - ah! woe betide!
The latest dream I ever dream'd
On the cold hill side.

I saw pale knights and princes too,
Pale warriors, death-pale were they all;
They cried = 'La Bella Dame sans merci
Thee hath in thrall!'

I saw their starv'd lips in the gloam,
With horrid warning gaped wide,
And I awoke and found me here,
On the cold hill side.

And this is why I sojourn here,
Alone and palely loitering,
Though the sedge is wither'd from the lake,
And no birds sing.

****

From: ODE
(William Wordsworth. 1770 - 1850)

Our birth is but a sleep and a forgetting:
The Soul that rises with us, our life's Star,
Hath had elsewhere its setting,
And cometh from afar:
Not in entire forgetfulness,
And not in utter nakedness,
But trailing clouds of glory do we come
From God, who is our home:
Heaven lies about us in our infancy!
Shades of the prison-house begin to close
Upon the growing Boy,
But He beholds the light, and whence it flows,
He see it in his joy;
The Youth, who daily farther from the east
Must travel, still is Nature's Priest,
And by the vision splendid
Is on his way attended;
At length the Man perceives it die away,
And fade into the light of common day.

****

THE KING IN THULE
(Wolfgang Goethe)

There once was a king in Thule,
Who was faithful until the grave,
To whom dying his sweetheart truly
A golden goblet gave.

He kept it well in his keeping,
And at every feast-time come,
His eyes ran over in weeping
Whenever he drank therefrom.

And when he came to be dying,
He counted each well-walled town,
To his heirs he nothing denying
But this goblet of high renown.

THE KING IN THULE - continued

At the royal table reclining,
His knights all around him see,
In his father's high hall dining
In his castle by the sea.

Then raised he the last drink slowly,
He drank of the vine's life-blood,
And hurled down the goblet holy
Into the ocean's flood.

He saw it falling, drinking,
And sinking away from shore.
His eyelids also were sinking, -
He never a dropt drank more.

****

From: **AN ESSAY ON MAN**
(Alexander Pope. 1688 - 1744)

All are but parts of one stupendous whole
Whose body nature is, and God the soul,
That changed through all, and yet in all the same,
Great in the earth as in the eternal flame,
Warms in the sun, refreshes in the breeze,
Glows in the stars, and blossoms in the trees,
Lives through all life, extends through all extent,
Spreads undivided, operates unspent.

All nature is but art, unknown to Thee,
All chance, direction which Thou canst not see;
All discord, harmony not understood;
All partial evil. universal good,
And spite of pride, in erring reasons' spite
One thing is true:
Whatever is, is right!

****

KING ARTHUR'S CASTLE

(A.C. Harwood)

King Arthur's walls are strong and steep
By Western seas they stand;
Three sides sheer down upon the deep,
And one upon the strand.

And cliff and tower and crag resound
To hail or farewell shout,
As one that adamantine ground,
The knights ride in and out.

In Arthur's hall with bread and wine
The feasting board is laid;
And they who at that table dine,
With spirit strength are stayed.

While music like the cleansing sea
Does so renew their heart,
That who sits down in misery
In steadfast joy shall part.

The knight that rides from Arthur's court
Rests not save in the field,
'til friend or foe be all downfought
Or sorest quarrel healed.

And wild men see the armour gleam,
As through the wood they range,
And stand and gaze as in a dream
And feel a blessing strange.

Or when he wrestles, fiend beset,
At midnight hour malign,
He feels the splendour o'er him yet
Of Arthur's seven-starred sign.

Then round him shines that castle tower,
And in its might he stands;
And all King Arthur's men with power
Strike battling in his hands.

****

THE BALLAD OF SEMMERWATER

(William Watson)

Deep asleep, deep asleep
Deep asleep it lies,
The still lake of Semmerwater
Under the still skies.
And many a fathom, many a fathom,
Many a fathom below
In king's tower and a queen's bower
The fishes come and go.

Once there stood by Semmerwater
A mickle tower and tall
King's tower and queen's bower
And the wake man on the wall.

Came a beggar halt and sore:
"I faint for lack of bread."
King's tower and queen's bower
Cast him forth unfed.
He knocked at the door of the eller
The eller's cot in the dale,
They gave him of their oat cake
They gave him of their ale.

He has cursed aloud that city
He has cursed it in his pride;
He has cursed it into Semmerwater
There to bide.
King's tower and queen's bower
And a mickle tower tall,
By glimmer of scale and gleam of fin
Folk have seen them all.
King's tower and queens bower
And weed and reed in the gloom
And a lost city in Semmerwater
Deep asleep till doom.

****

FLAME SONG
(Nancy Byrd Turner)

Burn wood, burn
Wood that was once a tree, and knew
Blossom and leaf and the spring's return,
Nest and singing and rain and dew.
Burn, wood, burn.

Shine, flame, shine,
Woven of sunlight through and through,
Light of the centuries golden, fine,
Clear and exquisite, warm and true.
Shine, flame, shine.

Bless, fire, bless,
Play on lintel and wall and beam,
Touch our lives with your loveliness,
Fill our hearts with your singing dream.
Bless, fire, bless.

****

FIRE
(Wolfgang von Goethe)

And what the might of fire doth seize
No longer monstrous cumbering earth
Is whirling away and vanishing
To hasten up to where it had its birth.

****

A LIMERICK

There was a young lady called Bright
Who could travel much faster than light.
She set off one day
In a relative way
And came back the previous night.

****

DESERT

(Trevor Smith Westgarth)

Sand is to desert as water is to sea,
It rises, falls and onward goes
As far as the eye can see.
And the sun looks down like a staring eye
With fierce and angry glare,
All hotness in its temper,
From dawn to dusk beware,
For if a hot wind rises
It lifts the silken sand
And throws into face and eye
Like a cruel and bitter hand.
No grass or tree is seen there,
No sound from bird and beast,
But only sand and heat and sand
To North, South, West and East.

****

THE ELEMENTS

(Mark Scrivener)

In clarity of clear crystal
In depth of dark rock;
In weight of worlds matter
In moulding silent stone:
In bones of the bare globe's darkness
Is built earth's form.

The leaping, lashing oceans swell;
The lapping, lulling ripples wash
The glistening, swirling rapids flow.
The tumbling, twinkling falling drops
And the still lakes sunlit silence,
Weave the water's world.

Rolling in air-borne currents
Whirling in hurricanes wrath;
Whistling in the winter's wind,
Rustling through the raging storm
Breathes air's freedom.

Fury of enfolding flames
Flight of their dancing forms.
Heat of heaven's sun,
Fire of its celestial sphere
And the seeds shoot springing
towards the spreading sky
Flame with fire's force.

****

THE SEA

(James Reeves)

The sea is a hungry dog,
Giant and grey.
He rolls on the beach all day.
With his clashing teeth and shaggy jaws
Hour upon hour he gnaws
The rumbling, tumbling stones,
And 'Bones, bones, bones, bones!'
The giant sea-dog moans,
Licking his greasy paws.

And when the night wind roars
And the moon rocks in the stormy cloud,
He bounds to his feet and snuffs and sniffs,
Shaking his wet sides over the cliffs,
And howls and hellos long and loud.

But on quiet days in May or June,
When even the grasses on the dune
Play no more their reedy tune,
With his head between his paws
He lies on the sandy shores,
So quiet, so quiet, he scarcely snores.

****

CHILDREN'S READING LIST

AGE 13 - 15 and older (dependent on reading ability)

(ap = Australian Publication)

The Sword and the Circle King Arthur and the Knights of the Round Table	Rosemary SUTCLIFF
Light Beyond the Forest - the Quest for the Holy Grail -	ditto
The Road to Camlann - The Death of King Arthur -	ditto
The Legend of King Arthur	Robin LISTER
Tales the Harper Sang	Isabel WYATT
King Arthur & his Knights	Roger L.GREEN
Mary, Bloody Mary	Carolyn MEYER
Beware, Princess Elizabeth	ditto
A Voice from Japan: An Outsider Looks In	ditto
Voices of Northern Ireland: Growing Up in a Troubled Land	ditto
Young Joan *(Ed: Jeanne d'Arc)*	Barbara DANA
✓ The Diary of a Young Girl	Anne FRANK
Zia	Scott O'DELL
Black Star, Bright Dawn	ditto
The Serpent Never Sleeps	ditto
Songman	Allan BAILLE (ap)
The China Coin	ditto
Billy Thunder and the Night Gate	Isobelle CARMODY (ap)
The Obernewtyn Chronicles	ditto

Tiger in the Bush	Nan CHAUNCY (ap)
Skin and Other Stories	Roald DAHL
Umbrella Man and Other Stories	ditto
The Silver Pencil	Alice DALGLIESH
Smith	Leon GARFIELD
Black Jack	ditto
Devil in the Fog	ditto
Checkers	John MARSDEN (ap)
Dark Wind Blowing	Jackie FRENCH(ap)
Missing You, Love Sara	ditto
In the Blood	ditto
Somewhere Around the Corner	ditto
Castaway of the Flying Dutchman	Brian JACQUES
Tug of War	Joan Lingard
Me and My Shadow	ditto
Looking for Alibrande	Melina MARCHETTA
My Sister Sif	Ruth PARK (ap)
Playing Beatie Bow	ditto
The Harp in the South	ditto
A Fence Around the Cuckoo *(Ed: autobiography)*	ditto
The Felix Triology: Go Saddle the Sea Bridle the Wind The Teeth of the Gale	Joan AIKEN
The Wolves of Willoughby Chase	ditto

A Small Pinch of Weather	Joan AIKEN
The Shadow Guests	ditto
The Julia Taper	Emily RODDA
Watership Down	Richard ADAM
Momo	Michael ENDE
Dipper of Copper Creek	Jean CRAIGHEAD GEORGE
Goodnight Mister Tom	Michelle MAGORIAN
Eight Cousins	Louisa May ALCOTT
Sense and Sensibility	ditto
Rose in Bloom	ditto ?
Jo's Boys	ditto
Wuthering Heights	~~ditto~~
The Three Musketeers	Alexander DUMAS
The Count of Monte Christo	ditto
Robinson Crusoe	Daniel DEFOE
Wild Sargasso Sea	Jean RHYS
Wild Swans	Jung CHANG (ap)
Short Stories	Henry LAWSON (ap)
Dicey's Song	Cynthia VOIGT
Seventeen Against the Dealer	ditto
A Solitary Blue	ditto
Sons from Afar	ditto
Antartica - Escape from Disaster *(Ed: Novel)*	Peter LARANGES

Lord of the Flies	William GOLDING
The Spy Who Came in from the Cold	John LE CARRE'
The Hiding Place *(Ed: Dutch Resistance story)*	Carrie ten BOOM
A Room with a View	E.M. FORSTER
A Fortunate Life	A.B. FACEY (ap)
Roll of Thunder, Hear My Cry	Mildred D. TAYLOR
Twenty Thousand Leagues Under the Sea	Jules VERNE
Journey to the Center of the Earth	ditto
Three Men in a Boat	Jerome K. JEROME
Tales of Shakespeare	Charles & Mary LAMB
Moonfleet	J. Meade FALKNER
The Tale of Two Cities	Charles DICKENS
Oliver Twist	ditto
Great Expectations	ditto
A Christmas Carol	ditto
The Prince and the Pauper	Mark TWAIN
Mister Midshipman Hornblower	C.S. FORESTER
Lieutenant Hornblower	ditto
The Commodore	ditto
Lord Hornblower	ditto
Hornblower and the *Atropos*	ditto
The Happy Return	ditto

A Ship of the Line	C.S.FORESTER
Flying Colors	ditto
Hornblower in the West Indies	ditto
Hornblower and the *Hotspur*	ditto
Thirtynine Steps	John BUCHAN
Prester John	ditto
The Old Man and the Sea	Ernest HEMINGWAY
King Soloman's Mines	H. Rider HAGGARD
Allan Quatermain	ditto
Jess	ditto
She	ditto
The Mill on the Floss	George ELIOT
Ivanhoe	Walter SCOTT
Rob Roy	ditto

My Story Series:

A Banner Bold - The Diary of Rosa Aarons - Ballarat Goldfields, 1854 -	Nadia WHEATLEY (ap)
Surviving Sydney Cove - The Diary of Elizabeth Harvey - Sydney, 1790	Goldie ALEXANDER (ap)
The Tale of Two Families - The Diary of Jan Packard - Melbourne, 1974	Jenny PAUSACKER (ap)
Plagues and Federation - The Diary of Kitty Barnes - The Rocks, Sydney, 1900	Vashti FARRER (ap)

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4.	The Holy Grail - from the works of Rudolf Steiner	Comp: Steven Roboz
5.	King Arthur, Lohengrin, Merlin	Walter Johannes Stein
6.	King Arthur in Legend and History	Richard Barber
7.	King Arthur and the Knights of the Round Table	Roger Lancelyn Green
8.	The Sword in the Circle	Rosemary Sutcliff
9.	The Light Beyond the Forest - The Quest for the Holy Grail	Rosemary Sutcliff
10.	The Road to Camlann - The Death of Arthur	Rosemary Sutcliff

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1.	Occult Science	Rudolf Steiner
2.	Curative Education Course	Rudolf Steiner
3.	The Foundation of Human Experience (previously: Study of Man")	Rudolf Steiner
4.	The Kingdom of Childhood	Rudolf Steiner
5.	Anthroposophy and the Inner Life	Rudolf Steiner
6.	An Occult Physiology	Rudolf Steiner
7.	The Occult Significance of Blood	Rudolf Steiner
8.	Man as Symphony of the Creative Word	Rudolf Steiner

9.	Anthroposophical Medicine	Rudolf Steiner
10.	The Blood Drives The Heart	Eugene Kolisko 'Die Drei'. Dec. 1922
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13.	Children's Illnesses	Walter Holtzapfel
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18.	Physiology in Grade Seven (from a conference reports - Feb. 1978)	Manfred von Mackensen
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20	Looking at the Human Body	David Suzuki
21.	The Sacred Balance	David Suzuki
22.	Growing Up - adolescence, body changes and sex -	Susan Meredith
23.	A Concise Human Biology and Hygiene	P. M. Minett
24.	Basic Anatomy and Physiology	H. G. O. Rowett
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2.	The Kingdom of Childhood (Appendix to Lecture 5)	Rudolf STEINER
2.	The Pythagorean Theorem	Sidney J. KOLPAS
2.	Sacred Geometry	Miranda LUNDY

PHYSICS

1.	First Scientific Course - Light	Rudolf Steiner
2.	Supplementary Course for Teachers	Rudolf Steiner
3.	The Renewal of Education	Rudolf Steiner
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8.	Teaching Physics	Roy Wilkinson
9.	Introduction to Physics in the Waldorf Schools	Hermann von Baravalle
10.	Michael Faraday and the Electric Dynamo	Charles Paul May
11.	Science in Their Eyes	J. M. Brice
12.	A Path of Discovery (Vol. Six)	Eric K. Fairman
13.	String, Straightedge and Shadow (long out-of-print)	Julie E. Diggins
14.	High School Science Syllabus	Glenaeon R. Steiner School

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2.	Fundamentals for a Phenomenological Study of Chemistry	Frits H. Julius
3.	Goethean Science in the Waldorf Curriculum (1978)	Manfred von Mackensen
4.	Elementary Chemistry for Children	Eugene Kolisko
5.	Chemistry in Classes 7 and 8	Graham Kennish
6.	The Wonders of Waldorf Chemistry	David Mitchell
7.	Chemistry	Roy Wilkinson
8.	The Chemical History of A Candle	Michael Faraday
8.	From Alchemy to Chemistry	John Read
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11.	Alchemy, the Ancient Science	Neil Powell
12.	The Secret Art: ALCHEMY	Stanislas Klossowski de Rola
13.	The Secrets of Metals	W. Pelikan
14.	Living Metals	L.F.C. Mees
15.	Chemistry Experiments at Home for Boys and Girls	H.L. Heys *(long out of print)*

****

THE 'MORSE CODE'

Samuel Finley Breese Morse (Artist. 1791 - 1872)

International Code

A	* -	T	-
B	- * * *	U	* * -
C	- * - *	V	* * * -
D	- * *	W	* - -
E	*	Y	- * - -
F	* * - *	Z	- - * *
G	- - *	1	* - - - -
H	* * * *	2	* * - - -
I	* *	3	* * * - -
J	* - - -	4	* * * * -
K	- * -	5	* * * * *
L	* - * *	6	- * * * *
M	- -	7	- - * * *
N	- *	8	- - - * *
O	- - -	9	- - - - *
P	* - - *	10	- - - - -
Q	- - * -	Full Stop	* - * - * -
R	* - *	Comma	- - - * * - -
S	* * *	Question	* * - - * *

The DOT is the basic unit of length.

The DASH is equal in length to three DOTS.

The space between DOT and DASH is equal to one DOT.

The space between words is seven DASHES.

PHYSIOLOGY ASSESSMENT

Student's name:_____

Please attempt to answer **EVERY** question. 2 points for each correct answer.

REPRODUCTIVE SYSTEM:

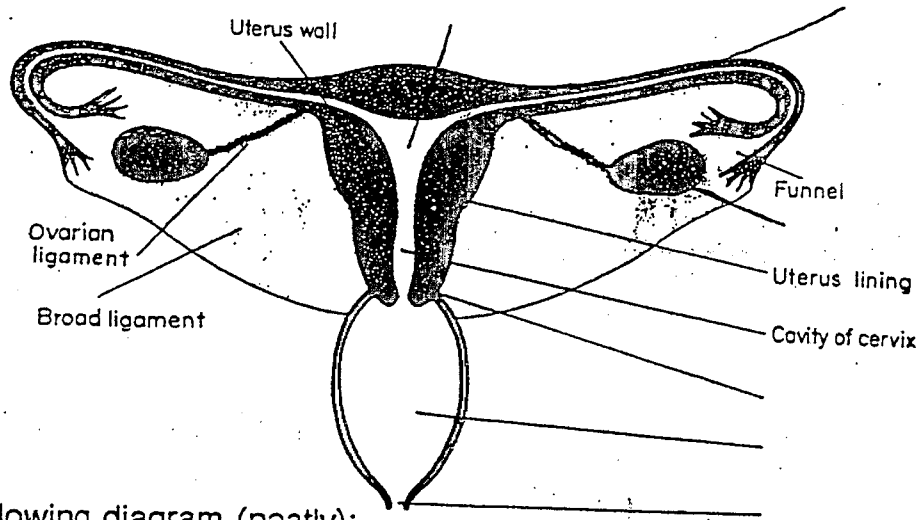
1. **Ova** are produced in the female reproductive system every (encircle ONE answer):

   14 days 21 days 28 days

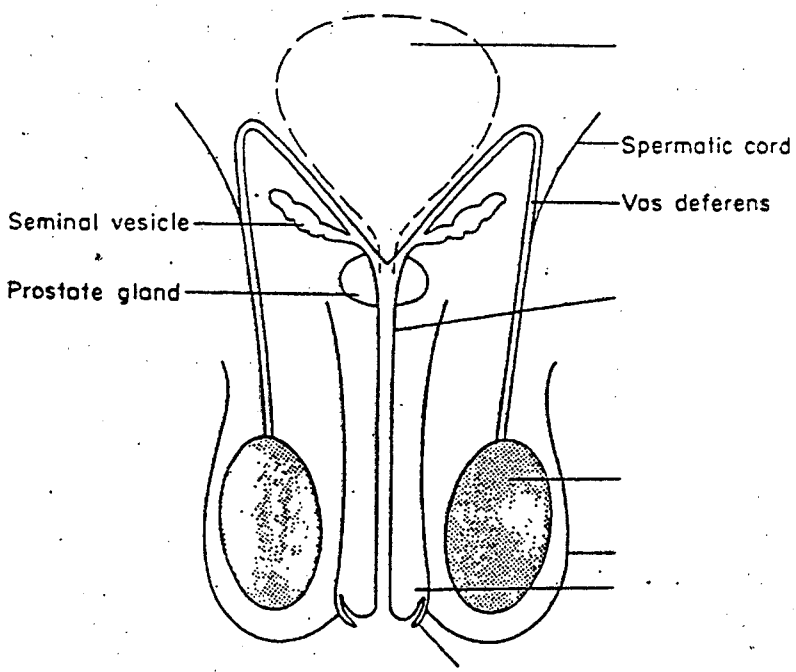
2. **Sperm** is produced by the male reproductive organ in the (write the correct answer):

   T_ _ _ _ _

3. Label the following diagram (neatly):



4. Label the following diagram (neatly):

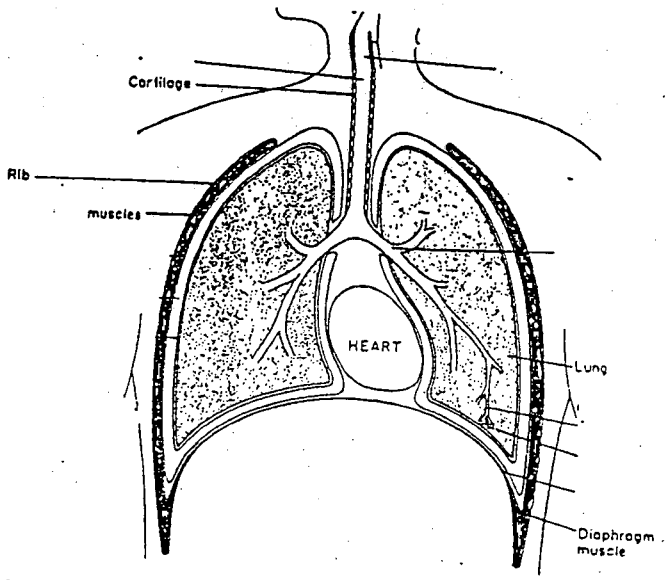


RESPIRATORY SYSTEM:

5. What do we 'inhale'? O _ _ _ _ _ _

6. What do we 'exhale'? C _ _ _ _ _ _ D _ _ _ _ _ _ _

7. Label the following diagram (neatly):



CIRCULATORY SYSTEM:

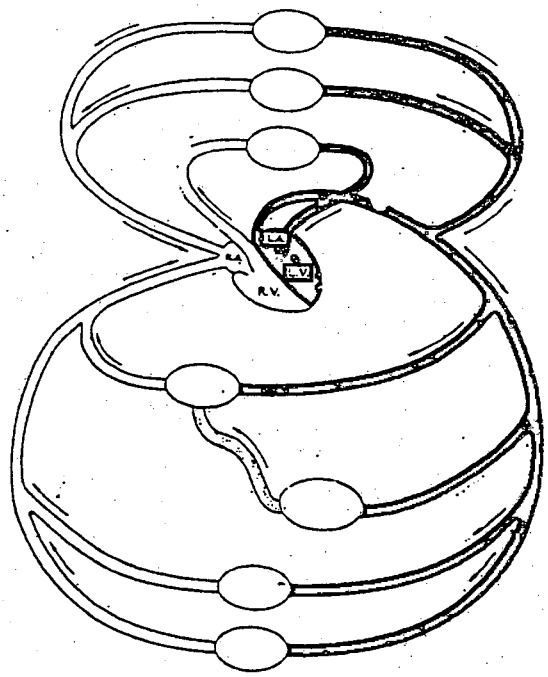
8. What is considered to be a normal bodily temperature for a human being (in degrees centigrade):

63.8° 38.6° 68.3° 36.8° (encircle ONE answer)

9. What do the RED BLOOD CELLS carry to the very extremities of our body?

(One word): O _ _ _ _ _ _

10. Label the following diagram (neatly)



METABOLIC (DIGESTIVE) SYSTEM:

11. Digestion begins in our mouth. What is the correct name of the fluid which begins to break-down our food when we chew it?

S _ _ _ _ _ _

12. Food is forced down our OESOPHAGUS into our .....*name the organ*:

S _ _ _ _ _ _ _

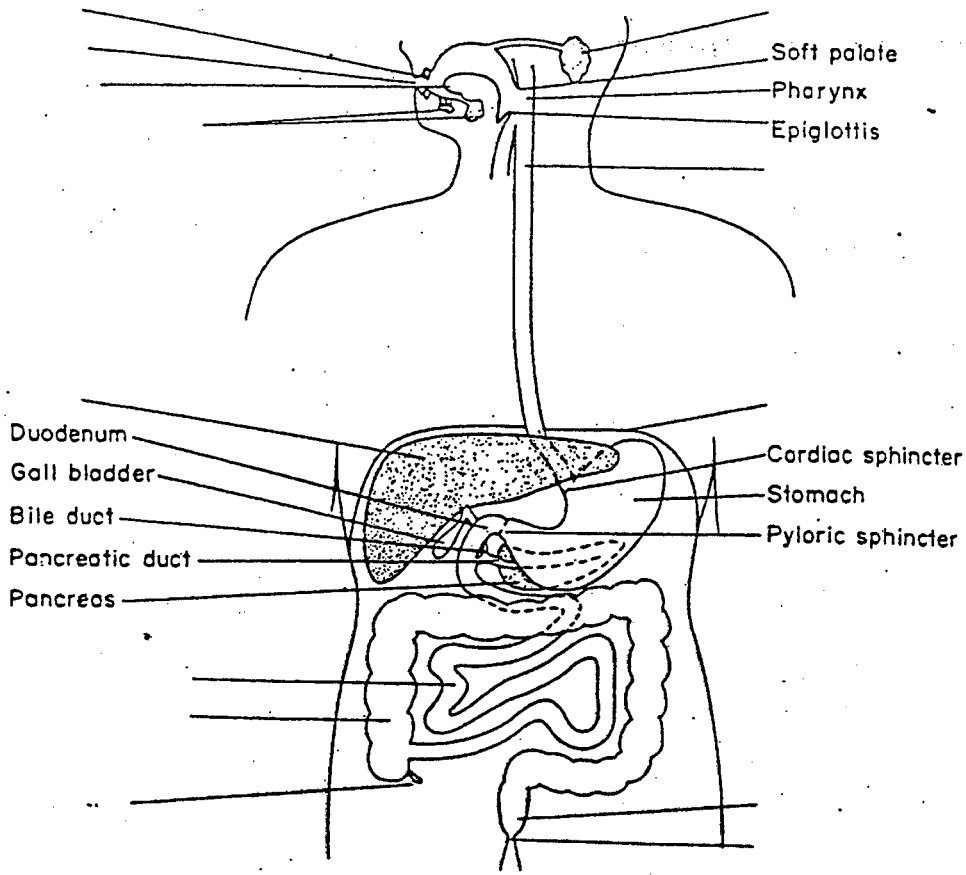
13. Name the two types of food which we require to give us energy :

C _ _ _ _ _ _ _ _ _ _ _ _ _ _ _ _ _ _ and F _ _ _

14. Name the substance which the body needs for 'rebuilding' :

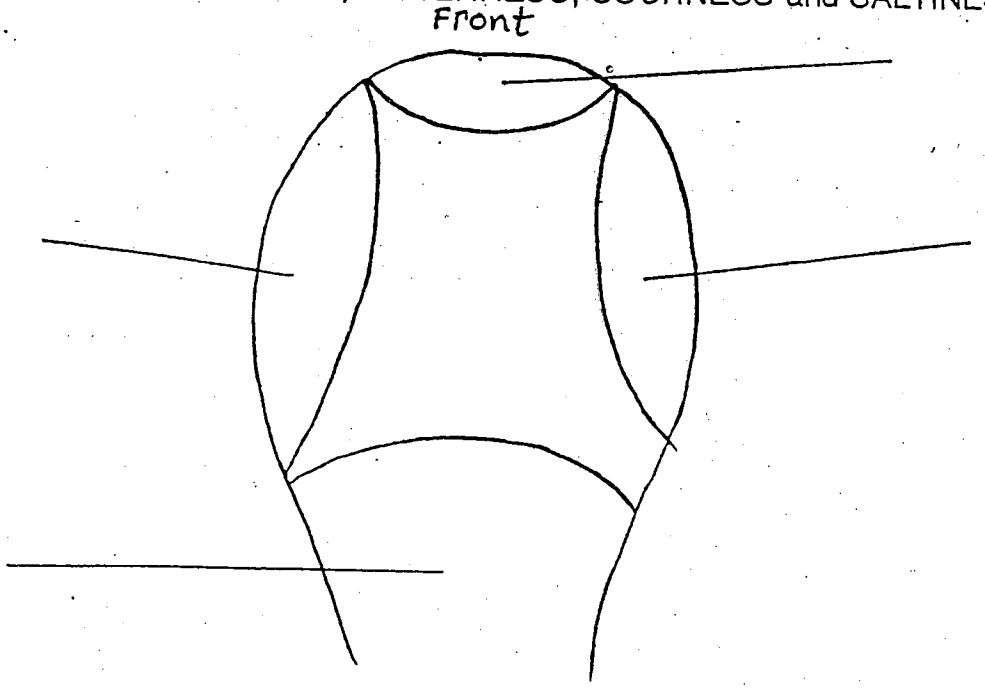
P _ _ _ _ _ _ _

13. Label the following diagram (neatly):



NERVE/SENSE SYSTEM:

14. Our 'taste buds' are located on our tongues. Label the diagram to indicate where you are able to detect SWEETNESS; BITTERNESS; SOURNESS and SALTINESS:



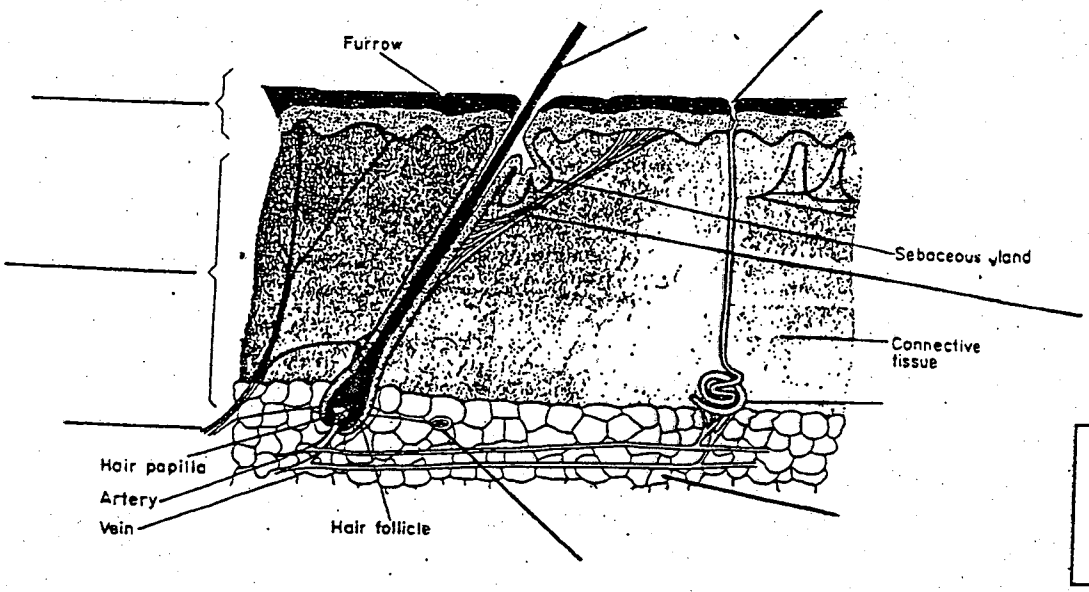
15. Our body is covered by layers of skin which assists in keeping out infection. Name the uppermost layer:

E _ _ _ _ _ _ _ _ _ _

16. What is the name of the second layer of skin?

D _ _ _ _ _ _

17. Label the following diagram (neatly):



PHYSICS ASSESSMENT

Student's name: _____

Please attempt to answer **EVERY** question

ACOUSTICS

1. In the scale of C Major, what are the names of the intervals between the notes as shown below? *(The first two and the last intervals, are written for you):*

C	Prime	
C - D	Major 2nd	
C - E	_____	5
C - F	_____	5
C - G	_____	5
C - A	_____	5
C - B	_____	5
C - C'	Octave	

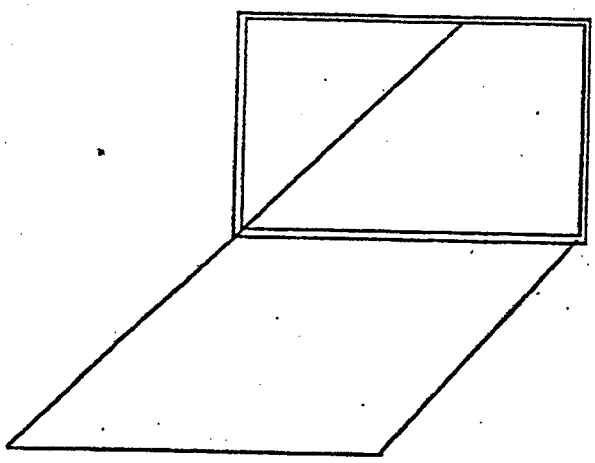
OPTICS

2. What is the **"Law of Reflection"**? Write your answer below:

The Angle of _____

_____. 5

3. Below is a diagram of a mirror and a sheet of paper. By adding to the diagram, show how the "Law of Reflection" can be proven. Use an angle of 20°.



HEAT

4. We conducted an experiment in the Chemistry Laboaratory which demonstrated hov "hot water home-heating system" worked. Below is a list of the main apparatus used in t experiment. Use each piece of apparatus in a diagramatic reconstrucion of the "hot wa home-heating system":

2 heat-proof glass flasks
2 retort stands
1 cork with 2 holes
5 glass tubes of varied lengths
1 wire gauze square
1 tripod
2 clamps
1 cork with 3 holes
3 pieces of rubber tubing of varied lengths
insulation board
1 glass funnel
red water
clear water
gas source
1 bunsen burner

Label your diagram clearly and very neatly!

3(

ELECTRICITY

6. Draw a diagram of a simple telegraph system (1 sounder/1key). Show how the apparatus should be connected to a battery. Label all parts of the diagram clearly and neatly.

25

Percentage: ☐

Grade: _____