

SPECIAL COURSES OF INSTRUCTION

BASIC PRINCIPLES OF SCIENCE

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SERIES TWO COURSE 4 A

LESSON ONE.

INTRODUCTION

STATEMENT OF PURPOSE OF COURSE

Until man can comprehend to some degree the interrelation of all grades of force and substance on the physical plane, he will find it difficult to arrive at an understanding of the action of similar forces and substances on higher or more interior planes. The true occult student in reality may be called a scientist; the science in which he is interested, is not, however, limited to merely the physical plane of manifestation, but extends to all planes of the Universe. It must be understood that the various divisions or planes of substance are not sharply defined; but interpenetrate one another to such an extent that any boundary between two of them is purely arbitrary. It is this correlation between various forms of matter and energy that enables us to explain the remote and indefinite by studying the clear and observable phenomena which go on about us constantly. "As above, so below," is an ancient axiom. "Man is a microcosm, a little universe in himself, and has actually or potentially represented in him all the forces of nature."

Anything which falls under a category as "illustrating the goodness of God, as manifested in the natural and moral world," is of interest to the occult student. Every person has a different viewpoint in life; different students are interested in dissimilar aspects of this great science. If one is disinclined to the scientific attitude, he may study Occultism as a religion. At the present time any mention of religion as applied to orthodox science is apt to be met with scorn on the part of the exoteric students. To anyone considering the question more than superficially, it must be evident that in any Divine Wisdom the two are inseparable.

Man is essentially a curious animal; he wants to know what is, and why it is. He must arrive at this knowledge by using either his faculty of reasoning, or his power of intuition. In the intuitional method the human race is at the present time not well developed, and there exist grave dangers in using this method exclusively in drawing conclusions. On the other hand, the method of reasoning, while exceptionally sure if borne out by experiment, is extremely slow, and fails completely when the element of experience or testing is omitted. It is this element of rationality, aided by and based upon observation of natural phenomena that the materialistic scientist uses. As the true path of Evolution is always the middle one, it would seem logical that safety in investigation would lie between the two faculties, one being tempered by the other, and extremes in either direction being less probable.

One of the main duties of science is the correlation of phenomena which are apparently disconnected and often contradictory. "She should have neither desires nor prejudices; truth should be her sole aim." Science may be defined basically, then, as the discovery and interpretation of truth.

The purpose of this course is to relate some of the work which has been done by materialistic science in interpreting the great riddle of nature to some of the knowledge which has been vouchsafed the world in the form of secret writings; learning obtained by experience must be correlated with that obtained from authority. This particular effort makes no claim to being either complete or entirely correct; it merely endeavours to point out that the task of science is by no means as hopeless as would sometimes appear, and that though at times mundane science and occult teaching

appear to be at widest odds, they are in reality very close together.

Apparently the close of a minor cycle of pure reason is at hand. In the tremendous strides made by material science during the past century, we find the results of the opposite pole awakened by the long reign of the intuitional faculties of the earlier times. The next step must be to correlate intuition and reason, or Occultism and Science, until from the two shall spring the wisdom destined for the Sixth Race.

The tendency of the occult student is toward indefiniteness of statement, due to his constant dealing with generalities. He is too inclined to define something he does not understand in terms of something else he does not understand. He explains the Ether as being the Breath of the Gods. This may be true enough, but it is not a sufficiently clear explanation of the properties of Ether to describe it to beginners who are familiar with neither the Gods nor their Breath. It is this indefiniteness which it is the duty of science to combat. Its plodding attention to details must furnish the tail to balance the kite of intuitional learning. We see, then, the necessity for scientific study.

From time to time, instructions are received of an extremely technical character which are very hard to comprehend, by scientific students because they understand so little of Occultism, and by Occultists because they have such a small scientific knowledge. A few of these facts this course will endeavor to supply; its necessary brevity will prevent any discussion of the purely occult aspects of physical science. To properly understand any instruction, the student must have a background of assimilated facts which are a part of his consciousness, to which he can attach any new knowledge. The occult aspects of physics must be the result of further study; if we can point out the presence of such correspondences and correlations and establish a scientific working background the task of the present course will be completed.

Of all the natural sciences, the most fundamental is Physics. All sciences on the material plane deal with matter and energy as fundamental elements, and the interpretation of the interrelation of matter and energy lies in the realm of Physics, or Natural Philosophy. From the occult standpoint, matter and energy exist in many forms, but the physicist is interested only in the manifestations of these two on the physical plane, leaving other planes or states of substance to the metaphysician. Frequent confusion arises in the minds of students who, reading of facts which are apparently untrue in an instruction on some familiar subject, are unable to realize that a different plane or state of matter is meant than the one to which they mentally refer. One should always hesitate to condemn as false a statement apparently contrary to facts already known, both because the previously learned facts may be wrong, and because a different meaning may be intended than the one assumed in the student's interpretation. The scientific method as a whole requires balance, precision, and open-mindedness. Let us then allow exoteric science to furnish the precision, esoteric religion the open-mindedness, and Occultism, or the two combined, the balance. The term Occultism is perhaps an unfortunate one to use in this sense, connoting as it does mystery and darkness; The words "Wisdom Religion" convey a better idea of what is meant.

DIVISIONS OF COURSE We will first consider one or two correspondences, merely as examples of the methods used in arriving at such results, and will then consider the properties of matter and energy as expressed in the following terms: Matter and Energy per se, Electricity and Magnetism, Light and Radiation, Sound and Heat, Radioactivity, and Vibratory Motion in general. Nature has filled the path with many stumbling blocks in the form of technical terms and hazy conceptions, yet even as the trail of scientific knowledge rises the canyon walls become more beautiful, forecasting the wonders far ahead.

A TYPICAL
CORRESPONDENCE

Let us take up an analogy, couched in terms of Physics, which, though one of the more exact sciences, lends itself very readily to the purposes of correspondence.

This will enable us to see how the most prosaic and uninteresting scientific experiment may be clothed by the imagination so as to become a thing of beauty as well as a source of information. While it is doubtful if new facts can be acquired by the process of analogy, the imagination is greatly stimulated by it, and ideas which are latent in the mind can often be brought into expression through its use.

We shall consider the human Ego as a pendulum bob. Suppose a weighted bob on the end of a cord, so arranged that it can oscillate back and forth or around in a circle, according to the force applied to it. The force which holds the string up and pulls it forward may be likened to the impelling force of Evolution. The force which causes the pendulum to move to one side is its desire to seek its ideal, or its innate desire for improvement. It is correspondingly drawn to the other side by the opposite pole of this desire, or the equal and opposite reaction set up by this action. Since this fundamental rule of mechanics applies equally well to Occultism, we see at once the importance of balance. When the beginning student of Occultism first experiences the joys of knowledge, he is apt to be carried away by his spiritual fervor, and the reaction may easily be disastrous. One should remember the caution to be moderate in all things, and to endeavour to relate his spirituality with the more tangible planes about him. So we must have a restraining force on our pendulum which will prevent it from disturbing its balance by over-violent oscillation. This, in mechanics, would be furnished by the force of gravitation and the viscosity of the air; it would be something which would keep the student's feet on earth while his head was in the clouds. This might properly be interpreted as his contact with daily life. First the bob swings to one side, carrying matter into the realm of spirit, and purifying it, as it were. But then comes the return impulse; the motion has set free a force pulling the bob in the opposite direction; the potential energy of the pendulum must again be transformed into motion, and again a particle of spirit is brought over to render the matter less dense. As our pendulum rises in its great arc, we find the matter on one side becoming rarer, while the spirit has been enriched by the experience it has undergone; the two gradually progress until they become one, and the cycle is complete.

On one side the pendulum has dipped into fire; a portion of its surface has been corroded and roughened; on the other it plunges into the tempering bath which cracks the scale and hardens the metal. Let us now consider that the pendulum, instead of merely vibrating from side to side, has its bob moving in a circular path, so that a cone of revolution is described. In the science of mechanics it is taught that when two equal motions at right angles to one another come together, uniform circular motion may be the result, assuming that the two original motions were of the type known as Simple Harmonic, and were in the proper phase relation. The uniform circular motion may be conceived of as being the resultant of an infinite number of simple Harmonic Motions. Now we have made room for all those external influences which beset one in daily life. So while the soul vibrates between Spirit and Matter in the larger sense, it is constantly contacting different pairs of opposites as Hope and Despair, Love and Hate, Good and Evil, etc. The resultant path of the pendulum will be the resultant

of all these forces. One can easily see the difference between an active life and a passive one. The chief lesson this analogy teaches is the law of Opposites; without Evil can come no Good.

The above correspondence wanders considerably from the case in point, and is extremely indefinite. It will be seen that merely watching a tree on the physical will not show how trees grow on the Astral plane; it will show, however, certain laws governing existence, on all planes of which each student's intuitional faculties will inform him as to the truth or falsity.

In what is to follow in succeeding lessons, emphasis will be laid in particular upon the following points:

- (1) The Universe is made up of entities moving under the influence of reacting forces, and the balancing of these forces governs events. The Law of Balance includes all other laws.
- (2) The forces acting upon the human entity, are as real as, though less tangible than, the forces which govern the motions of bodies on the physical plane.
- (3) By a study of the behaviour of those sections of Nature over which he himself has some control man can form for himself a picture of the Universe and his relation to it, which will enable him to live a more fruitful and happy life than would otherwise be possible.
- (4) As one sees more clearly the unified picture of the Universe which is obtainable by correlating the teachings of Science with those of the Wisdom Religion, things which appeared formerly incongruous now appear reasonable and clear, and it is seen that most of the doubts, apprehensions, and misunderstandings of the past have been due to ignorance rather than to absence of law and order in Nature.

Special Courses of Instruction
BASIC PRINCIPLES OF SCIENCE

SERIES TWO

COURSE 4 A

LESSON TWO

MATTER AND ENERGY. I.

According to occult teaching, if we penetrate far enough into the unknown, matter and energy are derived from the same root substance. Our problem is to determine whether or not this union occurs on the physical plane, or on some more interior plane. If we must penetrate the upper boundary which mundane science, in its incompleteness, has determined for the physical plane, to find this basic substance, we shall be justified in considering matter and energy as separate entities in this discussion. Science has recently, however, recognized that matter can be converted into energy, and is in fact constantly being so converted in the interiors of the stars. While the reverse process, the transformation of energy into matter, has not yet been found, there appears to be no objection on the part of scientists to considering it true. We must recognize, therefore, that matter and energy are manifestations of the same fundamental property of Nature. The Occultist symbolizes this dual expression by the terms Being (Matter) and Doing (Energy).

For convenience, we may divide the physical plane of manifestation into seven sub-planes. Since energy functions in many forms on each of these sub-planes, matter furnishes a better guide in forming arbitrary divisions between them. For brevity we will in the future merely call these divisions of matter planes, and the student should remember that these seven planes are all on the physical, or exterior plane of objective existence.

"The chief and most fatal mistake and fallacy made by Science, in the view of the Occultist, lies in the idea of the possibility of such a thing existing in nature as inorganic or dead matter. Is anything dead or inorganic which is capable of transformation or change?"# Compare this statement from The Secret Doctrine with one taken from Harper's Magazine for July, 1906. The author states that, "whereas the difference between living and non-living matter is commonly assumed to be that the former is endowed with a mysterious something called life, Radium has shown that matter is by no means inert. It displays the most potent, ceaseless and stupendous activities with which we have become acquainted, and we must now regard even lifeless matter as displaying ceaseless, self caused activity. When we look through a spinthariscopes and see radium apparently endowed with what suggests eternal life we find incredible the theory of a special vital force. Thinking men of today hesitate more and more to believe that there is a difference between living and non-living matter and incline toward a belief in the continuity of the universe. Yet in our own present state of knowledge there seems to be a great gulf fixed between the organic and the inorganic worlds."

The two quotations given above would be criticised by many scientists because of inexactness of expression. But both writers were trying to counteract the prevalent impression that inanimate objects are not governed by vital forces. Scientists are perfectly justified in defining as living only those objects which ----- but what shall we take as our definition of a living object? It is becoming in-

(The Secret Doctrine, H.P.B., Vol.1, p.533.)

creasingly apparent, that an exact line of demarcation between animate and inanimate matter cannot be definitely fixed. It will be apparent that "aliveness" is a relative term, and those things are most alive which show the greatest ability to fit in with, adjust themselves to, and cooperate with, their environment. It should become apparent in the course of these lessons that the measure of the progress of an entity on the path of evolution lies in its fluidity of adjustment to the external world. This is summed up in and lies back of, the expression "At one with the Infinite", "In tune with the Universe", "Attaining true indifference."

Let us begin our discussion on the most external plane of matter on the physical; the plane of everyday existence, wherein we fashion tables, grow cabbages, and build ships. It would be a hopeless task to count the many forms of matter which exist on this external plane. Matter having passed through so many differentiations, countless forces are brought into play, disguising the true structure of such forms. But we shall find as we pass into the more interior planes, that the number of forms is gradually reduced, the physical plane being in fact an externalized replica of the seven major planes or divisions of substance.

Let us examine a block of ice. To all appearances it is a bluish, solid mass, filled with small bubbles of air, but otherwise as smooth in one place as it is in another. Touching it, we find that it is cold. It has, then, certain properties; it has the property of abstracting heat from bodies at a higher temperature than itself, and it has the property of absorbing certain colors of light. To find the origin of these properties, we must pass into inner planes.

If we imagine that the block of ice has been magnified 100 times, we will find that its appearance has changed tremendously, and instead of a single homogeneous mass, we see many crystals. The ice still exists as ice; it is still cold and still blue in color, but its form has changed. We are in a realm where geometrical laws determine the form taken by the ice crystals. Let us penetrate into one of them. Our imaginative body must now shrink to 1/100,000 of its former size, and it is difficult to recognize that we are perceiving the same substance in a finer form. The geometrical shapes are no longer visible, and we are apparently in a universe of round balls. We cannot resolve these balls into their components, as yet, for our consciousness is still too rough and indistinct. We can see, however, that the masses are rapidly vibrating from side to side. We are on the plane of the molecule, and the rapid vibratory motion which we observe in each molecule is the heat which we formerly were able to feel as a sensation on the exterior plane.

We may now penetrate into one of the molecules, and after doing so we observe that it is made up of lesser bodies, much as is our solar system. The molecule was not ice; it ceased to be ice when we left the plane of the crystal, but is now the water which entered into the formation of that ice. In other words, ice as such could only exist on the two most exterior planes; once we have penetrated to the point where we can look at an individual molecule, ice, steam, and water all have the same appearance. We recognize, then, that the form of molecular aggregation was what determined the difference in properties of ice, water, and steam. Inside the water molecule we find it composed of three nuclei or central suns, with their attendant planets. One of the central suns is sixteen times as heavy as either of the other two, and has many more planets surrounding it. Each sun with its planets is an atom, and the two solar systems which consist only of a small sun and a single planet each are hydrogen atoms, while the large sun surrounded by eight planets is an atom of oxygen. These solar systems within the molecule of matter are held in their configurations by certain fixed laws, exactly as are the greater solar systems in the

heavens of the external plane. The water has ceased to exist as such; we are on the plane of chemical action, and find our ice, after having been resolved into the water forming it, now divided into its constituent parts on the atomic plane, hydrogen and oxygen.

We know that for any system of bodies to be in equilibrium there must be certain forces holding the bodies together, and at the same time other forces keeping them apart, if they are not to touch. On the molecular plane we had the force of cohesion which kept the molecules together, and the only force which kept them from actually remaining in contact was the vibratory motion given them by the heat and sound energy contacting them. Similarly on the atomic plane, the force of heat may still act, but a more refined force than that of cohesion holds the units together, and this force we term chemical affinity.

Proceeding a step further, if we examine these planets surrounding the central sun of the atom, we find that each atom consists of a positive nucleus, surrounded by electrons, or fundamental electrical charges. What the positive nucleus is, we do not know; it is merely a hypothetical something which exerts a force on the electrons similar to the gravitational pull of the sun on the planets. The positive nucleus has the property of repelling others of its kind and of attracting electrons similarly, electrons repel one another. All electrons are of the same size, since they are the ultimate divisions of electricity on the physical plane. Since the electron is considered as negative electricity, it will be clear that positive electricity will merely be a lack of the requisite number of electrons to keep an atom in electrical equilibrium. Since positive and negative charges overcome one another, and together produce a balance, the atom is almost electrically neutral. Suppose that for some reason or another an atom captures one electron more than its normal number; negative electricity will predominate, and the atom will be called electro-negative. If it lose two electrons now, it will be electropositive. The terms positive and negative have unfortunately been interchanged in this ~~connection~~ connection due to a misunderstanding connected with the discovery of electricity, and hence the term negative here signifies a preponderance rather than a lack.

We find that what constitutes the difference between different substances is the number of electrons around the nucleus, together with the mass of the positive nucleus in the atom, for the heavier elements apparently get most of their weight by having a heavier positive nucleus. We know at present of ninety-two elements on the atomic plane, which in various combinations form the many thousands of forms of matter which we know on the molecular plane. That there is a limit to the number of elements we may have on the atomic plane will soon be evident.

Matter on the external sub-plane of the physical exists in three principal forms, namely solid, liquid, and gaseous. The two last forms are those we term fluid. The differentiation between these does not exist within the molecular plane, since it is purely dependent for its existence upon the distance between molecules, together with the forces exerted between them. The molecules of paraffin do not exert such a great cohesive force as those of steel. Molecules must be very close together to come within each other's sphere of attraction. Once the vibration which they undergo in the form of heat becomes too great, they fly apart. We may tie two baseballs together with a rubber band; when they vibrate, they stretch the band, and if the motion is too great, the band will break, and nothing will remain to hold them together. In a gas the molecules are not restrained to any fixed position, but fly around at will until they bounce from the walls of the

containing vessel, or from one another. In a solid they are apparently constrained from much migration by their close proximity, but in a liquid, considerable freedom of path is possible.

If we take a paraffin candle and place it on a warm stove, the vibration of the atoms of the stove sets the molecules in the paraffin into greater rapidity of vibration. As this vibration becomes greater the cohesive attraction between molecules is no longer sufficiently strong to hold them together, and they move apart. The paraffin softens as this occurs, and finally liquifies. If the vibration is increased further, the molecules will be so separated that the paraffin is forced into the gaseous state. This will become clearer in the lesson on heat.

Certain schools of scientists believe that the electrons as well as the positive nuclei are merely centers of strain in the Ether. While very little is known about this Ether, it is what is left when all matter is taken out of a given space; It is Perfect Vacuum. Yet we cannot say that there is nothing in a perfect vacuum, because light waves and other radiations will pass through it and we cannot conceive of a wave motion without something to carry the waves. It has recently been discovered by science that electrons and protons have wave motions connected with them, and as all matter is composed of these two types of entity, this connotes that all matter possesses a wave character. Here again we must wonder what the medium is which supports these waves; it may be something more interior than matter, but still physical, or it may be just over the threshold of the plane next above that which we call material. In any case, all of the countless forms of matter found on the physical plane reduce to manifestations of a single primordial substance, which we may call the root substance of the physical, differentiated into millions of aspects by the action of energy.

Accepting this doctrine, we find one substance as the base of all matter on the physical plane if we begin at the etheric sub-plane. This substance is formed into protons, electrons, which are held together by the electrical strains they produce. These forms combine in various ways on the plane of the atom to produce the ninety-two elements. The atoms again combine on the plane of the molecule to produce the thousands of physical substances with which we are familiar, which manifest in various ways in the form of cells, crystals, vapors, liquids, gases, etc. according to the unbalanced electrical forces which may remain in them. The important part that the electrical attraction plays in the formation of matter is evident; in our discussion of these various forms of energy we shall see that cohesion, adhesion, chemical affinity, magnetism, light, radiant energy, and in a sense heat, are all forms of electrical manifestation.

The student should remember that in this course, whenever a force, or form of matter or energy is mentioned, reference is made to the externalized aspect of that force on the physical plane, unless it is definitely stated to be on another plane. When electricity is mentioned in certain teachings it is generally electricity of a higher and more subtle form that is referred to, rather than common or mundane electricity. By first understanding the lower forms, we may hope to appreciate the action of the higher.

SPECIAL COURSES OF INSTRUCTION

BASIC PRINCIPLES OF SCIENCE

SERIES TWO COURSE 4 A

LESSON THREE

MATTER AND ENERGY II.

THE ETHER In a Theosophical glossary, Ether is defined as follows:
 "In Physics, a hypothetical medium of extreme tenuity diffused throughout space, which is supposed to be the medium for the transmission of light, and in a sense the basis of form. It corresponds almost exactly to the Astral Light of the Kabalist, which is an aspect of the Akasa, but should not be confused with the Aether of the ancients, which was the Akasa itself."

The word Aether means literally, "Breath of the Gods." The Ether is for the purpose of the scientist an ideal, incompressible substance, having no rigidity of the ordinary type, yet having inertia and rigidity of a super-physical order. It is, according to the exotericist, not made up of discreet particles, but is a uniform presence penetrating all material substance. The homogeneity of the ether cannot, of course, be accepted by the occult student. The scientist does not deny the possibility of a structural form to the ether; it is merely not necessary as yet for his purpose, and he must confine himself to particular phenomena on which he can experiment, or he will become confused. The life of science depends upon her ability to relate every observed fact to the groundwork which she has built up in explanation of other facts. She need not, however, refuse to allow others to consider forces and laws which are not directly testable.

Until a few centuries ago, the only energy which was known to pass from star to star was light. Since then we have added other forms of energy manifesting on the etheric plane, until we now know of light, gravitation, electricity, magnetism, radiant heat, and several other forms of vibratory motion such as the X-ray. The Secret Doctrine states that Ether is the source and cause of all cohesive, chemical, thermal, electric, and magnetic forces. Science is now tracing all of these forces to a common origin which manifests on the etheric plane, as we shall see. The Ether does not now have the meaning to scientists that it had a decade or two ago, because of certain facts which have grown out of Einstein's theory of relativity. But we must conceive of some medium to carry waves of light and the pull of gravitation, and even if we insist on labelling this "empty space", it is still the fundamental root-substance of the physical plane.

ENERGY. We have seen that the more externalized the plane of matter upon which our consciousness is functioning, the greater number of forces and forms of energy come into play. In Occult parlance, the term force generally corresponds to what the physicist calls energy, which is an inherent power to overcome Inertia, or resistance to change, in Matter. To the scientist the term force denotes a static pressure, and is one of the unmanifested expressions of energy. On the outer form-plane we have seven principle forms of energy, namely Mechanical, Sound, Heat, Radiant, Magnetic, Electrical, and Gravitational. Any other form of energy will be found to come in a sub-head under one of these terms.

Each one of these forms of energy continues to exist as such until we come to the molecular plane, when mechanics and sound drop out. It will be seen that these forces manifest on all planes below their plane of origin, but not as such on

planes above. Since physical sound requires molecules to vibrate, it cannot exist on any plane which is intramolecular. Similarly, heat cannot exist beyond the atomic plane, for the atom must vibrate as a whole to produce heat. Light travels as a wave motion on the etheric plane; it can manifest on all planes of the physical below this. Magnetism, light, and electricity are all akin in their action on this plane, and hence are also found on all lower planes. It is the study of the interaction of these forms of energy that constitutes the science of Physics, and as such we must consider them in detail.

The student should not think that because sound does not exist on the physical plane in any sub-plane within that of the molecule, it cannot exist on higher planes. There is apparently a cyclic law governing this action; the energy is merely unmanifested on certain portions of a given plane, yet may reappear on a still higher plane. Sound, then, while disappearing on the three interior sub-planes of the physical, may reappear as Astral sound or Spiritual sound on still higher planes. While sound and light may be energy manifestations in different media on the physical, on some higher plane they coalesce into one; hence the frequent confusion arising when we read of the occult interrelation of Sound and Color. Reference to the diagrams appended to this lesson may make this clear.

We divide energy into two major classes, the manifest and the unmanifest, or active and passive. It is the active or manifest form that we term energy in the strictest sense; the other we call entropy. When a body is hotter than any other body around it, its energy may be transformed into motion of a different order, and work, we say, can be done by it. If, however, all bodies in a system are at the same temperature, while more energy may actually be present, it is not in a position to be used, and we call it entropy. It will be seen that the so-called running down of the universe is merely the constant conversion of energy into entropy. Cold bodies are becoming hot, while hot bodies become colder; hence eventually, in any system, all the energy must be converted into entropy unless some influence from another system intervenes.

Active energy may again be divided into two parts. If a body is moving, it possesses the power of moving other bodies, and this is termed kinetic energy. A bullet fired from a gun possesses a certain amount of kinetic energy of the mechanical form, i.e. it possesses the power of overcoming the inertia of other bodies by its own inertia. Suppose that the bullet is fired vertically from the gun. It starts its journey with a great velocity, but this velocity is gradually being cut down, both by the friction of the air and by the retarding force of gravity, which is attracting the bullet in the opposite direction. Finally the influence of these two forces will cause the bullet to stop, and for an instant it will remain poised in space. At this instant, all its kinetic energy has been exhausted, but something must have become of it. It has, in fact, been transformed into potential energy. While the bullet moves no longer, it now has the inherent power to fall towards the earth, and it is this latent energy which we term potential. The bullet will fall; its velocity will gradually increase at the rate of 32.2 feet per second, or every succeeding second it will be travelling 32.2 feet per second faster. Finally, as it touches the earth, it will have just as great a velocity as it had when it started from the gun, minus a small amount used up in overcoming the friction of the air. When the bullet strikes the ground the energy is not lost, but passes on to the atomic plane in the form of heat.

One of the most important physical laws, which applies equally well to all forms of manifestation, is that of the conservation of energy. This law states that energy can neither be created nor destroyed; it may be transformed, dissipated, or changed

ed into another form, but the total amount in the material universe remains the same. It will be seen that energy may move from sub-plane to sub-plane on the physical with perfect ease; if cornered on a certain plane, it will disappear immediately on to another. Within the last few years science has been forced to amend this law slightly, since we now know that matter can be converted into energy. If this be true, we must restate it to read "The total quantity of matter and energy in the Universe remains constant." But we cannot consider it as proved; we have only an instinctive feeling that it is true, for intuitively we reject the idea of making something out of nothing. This feeling is termed belief in the "Continuity of Nature."

Let us consider the old, prosaic, example of the transformations which energy may undergo. The sun, being an intensely heated body, is constantly radiating into luminiferous ether waves of various wave lengths, from thousands of miles down to billionths of an inch. This energy, then, manifests on the etheric plane, or seventh sub-plane of the physical, until some of it strikes the atmosphere of the earth. Here the waves set the material atoms into greater vibration, and heat results, so the energy is now manifesting on the atomic plane. This heat, let us suppose, is transmitted through the atomic plane to the surface atoms of the ocean, where it causes them to vibrate faster, so that some of them have their cohesive forces completely overcome and are able to fly off as vapor, mingling with the atoms of the air. They ultimately collect together as clouds, and now their energy, while still manifesting to some extent on the atomic plane, has passed to a more interior one, changing into potential energy of gravitation, the drops now possessing a power to fall. They do so; the potential energy is changed again into kinetic energy of falling, this time of the mechanical type. We will suppose that the drops collect together into a lake. This lake feeds a stream, which in turn moves a water wheel. The rapid motion of the water is changed into a mechanical stress in the belt of the water wheel, which turns an electric dynamo. The energy thus passes into the magnetic form in the armature of the dynamo, forcing electrons out through the wires. The original energy is now on the sixth subplane, or that of the electron. These electrons may flow through many machines, and have their energy transferred on to any plane of the physical; hence the cycle is never ending. Yet, attending all these operations of changing the form of the energy, a small amount was dissipated; not entirely lost, for such could not be, but lost for useful purposes. When the dynamo was turned, some energy was lost in friction of the bearings; when the electrons flowed, some energy was lost in heating the wire, etc. Hence the fewer operations we use in getting our energy into its final useful form, the less we stand in danger of losing.

By a process of analogy, we may reason that since energy may be transferred from sub-plane to sub-plane, it may also be transferred from plane to plane. The moving of matter by mental power does not seem such a miracle once we understand the method of connecting up mental energy to material substance. Until Joseph Henry and Micheal Faraday discovered the interrelation between electricity and magnetism, no scientist could have invented an electric locomotive. We must see through and around a subject before we can determine the many ways in which it may be used.

In the next lesson, we shall take up one of the most important forms of energy on the physical plane at the present time, namely electricity, and its always-attendant sister, magnetism. In consulting the diagrams on the following page, the student should remember that the sub-plane divisions are purely arbitrary, the number seven not being a determining factor.

DIAGRAMS - LESSON THREE.

Block of Ice.	External physical sub-plane. Plane of mechanical forces. Countless physical forms of matter. Organic and Inorganic Worlds. Solids, liquids, and gases.	Magnification 1
Ice crystals.	PLANE OF CRYSTALLISATION or cellular structure Second plane of mechanical forces. Plane of geometrical structure and form. Cells, crystals, fluids, etc. First remove from externalization.	100
Single crystal	Plane of the crystal or cell. Third and last plane of mechanical forces. Last plane where physical form may exist. Single aspect of plane above. Thousands of forms of physical structure.	1000
Water molecules.	Plane of the molecule. Force of Cohesion between molecules. Vibratory motion of Heat and Sound. Physical form no longer exists as such. (Ice, steam, and water same form.)	1,000,000
2 Hydrogen and 1 Oxygen Atoms	Plane of the Atom. Force of chemical affinity. Vibratory motion of Heat. 92 Elements of exoteric Science. Chemical substances of last order.	10,000,000
Positive nucleus surrounded by its electrons.	Plane of the Electron. Two basic stuffs; proton and electron. Plane of electricity, light, magnetism, and radiant energy. Orbital motion of electrons.	1,000,000,000,000
Ether.	Plane of the Luminiferous Aether. Basis of all form on the physical. Last plane of physical known to science. Enters into formation of protons and electrons, and hence of all material substance.	10,000,000,000,000
THE SEVEN SUB-PLANES OF THE PHYSICAL.		

SPECIEL COURSES OF INSTRUCTION

BASIC PRINCIPLES OF SCIENCE

SERIES TWO COURSE 4 A

LESSON FOUR

ELECTRICITY.STATIC ELEC-
TRICITY.

The subject of electricity may well be divided into two parts according to the way in which it manifests, and these we shall consider as electricity under strain or Electrostatics and electricity in motion, or Kinetic electricity.

We have seen that electricity, per se, is a substance which enters basically into the formation of matter on the physical plane, and hence partakes of the nature of both matter and energy. An electron was described as a nucleus of strain in the ether, which has the property of straining the ether around it in such a way as to make others of its kind move away. We may speak of an electrostatic strain in the ether, due either to the presence of an electron or a number of electrons, when the ether will be strained in one direction, or to a lack of the normal number of electrons, when it will be strained oppositely. For convenience, in the future we will merely speak of such a strained condition as an electric charge; when the charge is due to a surplus of electricity a negative charge, and when due to a lack, a positive charge.

Care must be taken not to confuse the terms ion and electron. An ion is any small charge of electricity, while an electron is the basic unit of electricity. Hence an ion may be one electron or a thousand, or a positive nucleus without its normal number of electrons. (In occult literature the following terms are generally used as synonyms for electron: ion, corpuscle, particle, atom of electricity. The context generally furnishes a clue as to what is meant. (*Scientists have measured the weight, size, charge, and velocity of an electron.)

When we rub a glass rod with a piece of flannel the friction causes electrons to be rubbed off one onto the other so that one becomes negatively charged, and the other positively. This frictional method is the one generally used to generate static charges. Certain substances are termed conductors and others insulators of electricity, merely according to whether electrons flow through them or not. Conductors appear to have that property because they contain free electrons which can move about between the atoms of the conducting substance; in insulators the electrons are held by the atoms and prevented from moving away.

A conductor positively charged attracts one with a negative charge, if the charge on either conductor cannot otherwise move than by carrying the conductor with it. This is natural, because whenever a positive charge is created a negative charge equal in size must also have been created; hence the two are constantly striving to return to their original balanced condition. The strain between them is what we have termed the electrostatic strain; it exists in the Ether (or more strictly speaking, we call the medium in which it exists, the Ether), and since the electrons involved are attached to material bodies in their atomic structure, the strain is also communicated to these bodies. It is difficult to collect electrons upon conductors because they may escape too easily; hence the use of flannel and glass which are both excellent insulators. Any substance such as rubber, rosin, sulphur, glass, shellac, is a good insulator, while all of the metals are excellent conductors. Since the difference between metals and non-metals lies on the atomic plane, we see that the conduct-

ing properties of substances depend upon their atomic structure, i.e. upon the forces which they can exert on electrons.

There is one method of collecting electrical charges upon a conductor which illustrates well one of the basic Occult laws. This process is termed electrostatic induction. If we take an insulator with a charge collected upon its surface and bring it close to a conductor which is in turn insulated from the earth, we find induction occurring. Let us suppose that we have a ball of sulphur upon which are collected a number of electrons above its normal amount, (i.e. the number which entered into its atomic structure as sulphur), and place this close to a metal pipe which is mounted on a stick of hard rubber, so that whatever we may do the electrons cannot escape. We have a negative charge upon the sulphur ball, but this negative charge strains the ether which permeates all substance, to the extent that many of the free electrons in the metal pipe are repelled. They will endeavor to get as far away from the charge on the sulphur ball as possible, and hence will collect on the far end of the pipe. They have left a few of their number on the end close to the sulphur ball, but there is a deficit of electricity there and we say that this end is positively charged. The center of the pipe has no charge whatever for it is still balanced, but the two ends have opposite charges. We see that nothing has passed between the sulphur ball and the metal pipe, yet the latter has a charge of opposite sign on each end. Let us touch the far end with our finger; the electrons now flow over the skin to the ground and escape to the great ocean of electrons in the earth. If we remove the finger and take away the ball of sulphur afterwards, the metal pipe is found to be positively charged, for some of its electrons have escaped. If we touch the pipe after the ball of sulphur has been removed from the immediate vicinity, electrons will flow back from the earth into it, for there is no longer any force driving them out. We see that by this process, if we had two sulphur balls and two metal pipes properly arranged, we could gradually build up a positive charge on one pipe and a negative charge on the other, merely by separating the electrons from one and putting them through a conductor into the other. By this means we can store up a charge of electricity as great as we please until the limit of insulation is reached, when the tremendous charge will disrpt the air and a spark results. We must not lose sight of the fact that the energy of the spark is not an inherent part of the electrons, but is the result of the work we have done in separating the electrons from their original positive charges. The charge of positive sign on one pipe could never be anything but the same in magnitude as the negative charge on the other, for one is made by the lack of the other, and the two combined would produce neutrality.

The electrons which we used in the preceding experiment were not electrons which entered into the formation of the sulphur atoms, but were what we term free electrons; i.e. they were vagabonds away from home, and did not enter into the formation of matter but existed as electricity proper. An electrical current is merely a number of electrons in motion, as a stream of water is a number of water molecules in motion. It is this form of electricity with which we all are most familiar; electrons in a state of rest have few commercial possibilities, and we have not exploited them to the extent that we have used their properties when in motion.

The scientist recognizes a number of ways of producing electrical currents. Each one of these methods will be found to have its seat in some one of the numerous forms of energy which manifest on the physical plane. The principal ones may be termed the mechanical, magnetic, frictional, thermal, radiant, chemical, and crystal-

line methods. Any plane wherein an unbalance of electrical energy is possible may be utilized as the place for the production of an electric current. All that is necessary to produce an electric current is to apply a force to electrons which causes them to move. Such a force is called an electromotive force, or a potential difference. It is usually measured in terms of volts, and is commonly referred to as voltage. High voltage wires are those in which large forces are being applied to electrons.

The most easily understandable method of producing an electric current is that of chemical action. If we take two substances in the solid form and one in the liquid form, such that the liquid will dissolve one of the solids faster than the other, we may produce an electric current. In a common dry cell or battery we have a plate of zinc and a rod of carbon, with certain liquids which attack the zinc at a faster rate than they do the carbon. The forces of chemical affinity come into play, and an excess of electrons is piled up about the zinc plate. In order for balance to occur again these electrons must flow through the wire connecting the two poles, which we will term the external circuit, and a current results. As long as the acid may eat the zinc the current of electrons will continue, provided the external connection is present. The intensity of the force produced will depend entirely upon the difference in the rate with which the liquid attacks the two solids. Since it is purely a differential effect, we might also construct such a battery with two liquids and one solid, such an arrangement not being so simple as the other, however.

Although two electrons when at rest repel one another, and attract oppositely charged ions, when they are in relative motion new forces enter. These are called magnetic forces. The more rapidly a charged body moves the greater the magnetic force between it and another charged body moving relative to it. A current of electricity consists of moving charges, so two currents will exert magnetic forces on one another. Hence if we move a conductor, such as a copper wire, which contains many free electrons, through a region where there are magnetic forces, the free electrons in the conductor are forced into motion and a current results. This is the magnetic method of producing an electric current, and is the one most commonly used. Generators and dynamos utilize this principle.

When we say that electricity is being generated, and sold by the power companies, we are speaking very loosely. The electricity is always there, in the wires, but it is not moving unless it is forced to do so. The generator allows magnetic forces to make the electricity flow, and energy is then being transferred electrically. We are paying the power companies for energy; all the electricity they send us has been sent back to them again on the second wire of the electrical circuit.

Quoting from an occult teaching: "We are told that electricity is a combination in equilibrium of radiant and magnetic energy. When the ions of radiant energy, or protyle (ether), and the electrons of magnetic energy are in synchronous vibration, there is no exterior manifestation, no fire or flame. But if the electrons of magnetic energy are in excess of the ions of radiant energy a current of electricity may be generated and maintained as long as the armatures are kept in motion, and fire, flame, and heat may be maintained. It is the increased motion of the armature which breaks up the combination of radiant energy and magnetic energy, and sets free the electric energy so created. If the motion is stopped, the current is also stopped." In this quotation lies the key to the generation of the electric current by the magnetic method. The language of the quotation is veiled by any number of blinds, especially in the use of terms.

If we make a loop of two different metals, such that their attractive powers for electrons are different, we have an apparatus for the generation of electrical currents by the thermal method. We fit them so that the first metal occupies one side of the loop and the second the other, and a ring is formed. If we heat one junction and cool the other, a current of electrons will be set up due to the irregular vibration of the atoms on opposite sides of the ring. Similarly if we set up a current in the loop by some extraneous means one junction will become cold and the other hot, showing that the process is reversible.

We have considered the three principal methods of generating electrical currents; and under static electricity we considered a fourth. The remaining three methods are of too complex a nature to be considered here. It is sufficient to realize that all of these processes of transforming energy are interchangeable, and involve applying forces to electrons.

MAGNETISM. When an electron is moving a strain is produced in the ether which is of an entirely different nature than the strain resulting from the mere presence of the electron as mentioned above. When an electron is moving in a straight line the magnetic strain is in circles around it. Since we have seen that the electrons in the atom are moving about the nucleus in circular orbits, a magnetic strain must be generated in the ether along the axes of these orbits, and in consequence every atom must be magnetic. Such is apparently the case, but in most cases the electrons do not rotate in the same directions nor in the same plane, so that the resulting magnetic strains interfere with one another, and no external magnetic effect is produced. It may be that the magnetic elements, i.e. iron, nickel, and cobalt, have their electrons rotating about the atomic nucleus all in approximately the same plane. Since the electrons rotate in this plane in the same direction, the magnetic strains produced will reinforce one another, and we will have an atom which is externally magnetic. But, asks someone, why, then, are not all masses of iron magnetic all of the time? They are, in fact, but the arrangement of the atoms is so irregular in most cases that one magnetic strain overcomes another and no external effect is produced. But as soon as we swing the molecules and atoms around into the same direction, the magnetic strain is all along a certain path, and where this path ceases to be in iron and must pass through air, we say a magnetic pole is present. The attraction of one magnetic pole for one of the opposite sign is merely the endeavor of the ether strain to get a closed path through iron, for it would much rather pass through iron atoms with their axes all in the same direction than through any other substance.

There is a limit to the amount of magnetism which may be given to any bar of iron, for when all of its atoms are swung around into the same direction, no further external magnetic effect will produce results. Steel bars have tremendous cohesive forces between their molecules; it is difficult for the atoms to take any position they desire as they are restrained by their fellows. Steel thus forms permanent magnets when once magnetized. But a bar of soft iron will allow its atoms to take any positions they may desire at the slightest mechanical jar, and this renders such material worthless for permanent magnets. It may be very useful, however, where a material is desired to reinforce a rapidly changing magnetic field, as may be set up by a current of electrons flowing through a wire. We may thus produce magnetic effects in two ways; by arranging the atoms of a substance so that their magnetic effect is externalized, and by setting electrons into motion so that they strain the ether.

SPECIAL COURSES OF INSTRUCTION

BASIC PRINCIPLES OF SCIENCE

SERIES TWO

COURSE 4 A

LESSON FIVE

LIGHT, HEAT, and SOUND.

LIGHT To the Occultist, light is both, energy and substance, or spirit and matter. To the esoteric scientist, light on the physical plane is the reflection of spirit acting upon the phenomenal aspect of matter. To the materialistic scientist, light is merely radiant energy. All are the same, yet how difficult, from the terminology used, is it for the student to recognize this fact. Light is an undulation of the etheric medium, but the Occultist recognizes that behind this undulation is the true light, the Noumenal aspect, which the physical scientist can never approach with his present methods. Material science considers the forms of energy under discussion as causes of certain other phenomena; esoteric science realizes that they themselves are effects of more interior causes. Particular reference is made to this point because of the apparent conflict between the teachings of interior and exterior science in this regard. The conflict is more apparent than real, for where one leaves off the other begins.

The exact mechanism by which light is produced is still a mystery to the scientist, but much is known about how to control the process. Light is emitted by atoms when the electrons in them are moved about in such a way that they can return to their original condition and lose a certain amount of energy. Ordinarily atoms do not emit radiation because their electrons are in stable states; let anything happen which moves an electron to another state, and when it returns to the stable position the atom will emit a quantum of energy. This quantum of energy has certain wave characteristics associated with it, and the lengths of the waves in any particular case depend on how much energy the quantum contained. X-rays, for example, are very large quanta, and have very short wave-lengths; visible light consists of quanta much smaller than those of X-rays. Blue light consists of larger quanta than does red light; in general, the larger the quantum of radiation emitted by an atom the shorter its wave-length. X-rays, etc. are all forms of light, using the word in its broadest sense.

Three principal means of causing an atom to emit light are known. An electron may be shot with high speed into an atom, knocking one of the electrons in the atom to the new position from which it can fall back and emit a quantum. Or a quantum of light may strike the atom, be absorbed by it, and its energy used to displace an electron, which when it falls back emits another quantum. Or the atom may be shaken violently (i.e. made very hot) when electrons in it will be shaken out to new positions from which they can fall back. The light from the stars is produced by all three of these means; in an incandescent lamp only the third method is important, while in a neon lamp such as is used in advertising signs the first method is the chief one.

We know of ether waves of all lengths from thousands of miles down to trillionths of an inch. They are electro-magnetic, that is, possess both electric and magnetic properties. The longest, from thousands of feet down to a few inches, are easiest to detect magnetically and are termed radio waves; they are the ones used

in wireless telegraphy. The next set down to a small fraction of an inch in length, acts directly upon the molecules and atoms of matter and sets up the vibration of heat in them, so we term these thermal or heat waves. Decreasing the wave length all the time, we pass through the infra-red into the region which affects the optic nerve, and we have what we strictly term light. Those waves which are six millionths of a meter in length we call red, while those three millionths of a meter long we recognize as blue. Passing down through the ultra-violet, we finally reach the X-rays, which have wave lengths so inconceivably short that the length has little meaning when measured in inches.

All of these waves move through the etheric plane, when no denser matter is present, at the uniform rate of 186,000 miles per second. The sun is continually sending them off; they are what we commonly term radiant energy. The sun is continually shooting these etheric vibrations into our atmosphere, together with electrons which increase the electric charge of the earth.

The human eye can only recognize as light one octave of these waves. Sunlight, or what we commonly term white light, contains seven principal divisions of color, each of which is made up of many wave lengths. What appears to the eye as white is in actuality a synthesis of all colors, and may be differentiated into them. When a body does not radiate light, we see it by reflection. A piece of green wall paper appears green, because it has the property of absorbing red, orange, yellow, blue, indigo, and violet light, and reflecting green. Look at it when nothing but red light or blue light strikes it, and it will appear black, because it absorbs them completely. This property of reflection lies on the molecular plane, as do its attendant properties of refraction, absorption, and transmission. Generally the surface of matter is so rough in respect to the length of the rays that they are scattered when reflected, but in the case of a mirror we find a surface which is smooth down to its molecular constitution, and the rays are regularly reflected. When such regular reflection occurs we may form images of the source of the light by means of mirrors of various shapes, utilizing the law that the light will be reflected from the mirror at an angle equal to the angle at which it struck it. Light also possesses the property of moving at different velocities through substances in which the ether is modified. For instance, in glass light travels only two-thirds as fast as in free space, due to the increase of the density, not of the ether entering into the constitution of the glass but of that remaining in the interstices. If we retard one side of a beam of light while allowing the other side to continue at an undiminished rate of speed, we may change the direction in which the beam travels, since it will always travel in a straight line unless acted upon by some external force. It is this property which we term refraction, and which governs the action of lenses, prisms, etc. By means of this property we may separate white light into its constituent colors, for one wave length may be retarded more than another. In a prism, the violet light is bent most while the red beam is affected the least; hence we may have the violet off at one side and the red at the other, with the various other colors scattered in between. The water drops in the sky act as just such prisms in producing the phenomena attendant upon the production of the rainbow. The properties of reflection and refraction of light, and the production of color, are worthy of the most careful study on the part of the Occult student.

Since light waves are so short they do not tend to bend around large corners, as do sound waves, but travel in straight lines. Yet when we get down to the etheric plane some bending is in evidence, and it is this bending which we term diffraction. When diffraction takes place, the light as a whole continues to travel in straight lines, but on the edge of an object casting a shadow certain irregularities may be noted due to bending of the lesser rays. "One of the very interesting findings of a famous scientist and microscopist is that the utmost attainable limit of resolving power (magnification) by which life in minutiae is observable is 1/140 000 of an inch, and that such restriction is caused by diffraction. This means that the ray of light which enters the microscope at its axis bends around the object and enters the eye exactly as though the object did not exist." It will be seen that where this point is reached, for further observation we must pass to another sub-plane of the physical, or to a still more interior plane.

Light exists, then, on the most interior plane of the physical known to science, and as such, manifests on all more external planes. It is an electrical phenomenon, since it is produced by the motion of electrical charges, and may move electrons. It also is magnetic in its nature, being truly a product of magnetism. It is a readjustment of strains in the ether of the magnetic type, and is a long series of etheric undulations.

HEAT. We have seen that physical heat is merely a vibration of the atoms and molecules of material bodies. Since the force of cohesion is what holds the molecules together there must be some force to keep them from actually touching, and it is the vibration of heat that performs that function. If we conceive of an absolute lack of vibration for the molecules, there must be such a thing as an absolute zero of temperature. This actually does exist at -273 degrees on the Centigrade scale, and at this point many interesting things apparently occur. Science has successfully reached to within less than one degree of this low temperature, by the liquifaction of helium, and at this point electrical resistance apparently frequently ceases. Hence many substances would be perfect conductors of the electronic flow if it were not for the vibration of the atoms in their masses.

An interesting fact, from the occult standpoint, is that heat must always pass from a hot body to a cold body, or in other words if all bodies are at the same temperature, no exchange of energy in the form of heat can take place. This is quite evident if we realize that the heat consists intrinsically in a vibratory motion, for we could not expect to add the motion of one body which was vibrating slowly to that of one which vibrated much more rapidly without some return of the energy, the two being necessarily connected. Since by means of mechanical forces, e.i. friction, we may set the atoms and molecules into more rapid vibration, it is evident that heat may be produced by friction. Since when a body is heated its molecules press each other farther apart, we should expect an increase in temperature to result in an expansion of the body, and hence heat energy may be reconverted into mechanical work.

Care must be taken to distinguish between the terms heat and temperature. Heat consists merely of the energy in the motion of the atoms and molecules. temperature is a relative quantity, depending upon the specific heat of the substance considered. Water, for example, requires more heat to raise it to a given temperature than most other substances; wood requires very little.

On a hot day, if we touch a piece of metal and a stick of wood at the same time, the metal feels warmer than the wood. Both are actually at the same temperature, but since it required more heat to raise the metal to that temperature, it has more to give out, and hence more heat is transferred to our hand.

The unit of heat, as measured by the scientist, is the calorie. A calorie is defined as the quantity of heat required to raise one gram of water one degree Centigrade. The specific heat of water being one, we see that the specific heat of any substance may be defined as the number of calories taken up by one gram of a substance when its temperature rises through one degree.

Heat is transmitted through bodies in two ways, conduction and convection. In conduction, the motion of the atoms is transmitted from one to the next in the ordinary manner. In the process of convection, which may occur only in liquids and gases, the lower heated layers, having expanded, become lighter and rise to the surface, warming up the colder layers as they pass through them. We have already seen that certain electromagnetic vibrations in the ether have the property of heating matter when contacting it, and this is the form known as Radiant Heat.

SOUND

Sound arises from the motion of matter in its molecular form.

It is again a vibratory motion, but not in the sense that light is. Heat is a vibratory motion which remains in one place and travels about through the substance very slowly; sound is similar but has a translatory motion as well, which makes it a wave motion. In light, the vibratory motion was at right angles to the direction of propagation, while in sound it occurs in the same direction as propagation, so that condensations and rarefactions occur. It is thus sent out in regularly defined waves, and the wave length is the distance between two successive points of maximum condensation or maximum rarefaction. An important distinction should be noted between musical sounds and mere noises. Only those sounds possess a musical quality which come from sources capable of sending out pulses or waves at absolutely regular intervals. The pitch of a musical note depends upon the number of pulses which strike the ear per second; hence if the sound comes from a vibrating body, the pitch of the note given out depends upon the rate of vibration of the body. The loudness of the sound, on the other hand, is determined by the distance of the source and the amplitude of the vibration. A piano string lightly tapped sends out waves of very small amplitude; when struck with some force the vibrations are greater, and a correspondingly greater motion is communicated to the molecules of the air. The speed of sound in air is about 1100 feet per second, in water about 4300 feet per second, and in iron about 16,000 feet per second. The speed of sound in air is found to increase with increase of temperature, which is what we should naturally expect if it were due to a vibratory motion of the molecules. It should be understood that the molecules do not have a translatory motion; they merely vibrate, and as one impinges upon the next, the motion is communicated and hence the wave travels at a high rate of speed.

Resonance is the reinforcement or intensification of sound because of the union of direct and reflected waves. When we hold a sea-shell to the ear, a low murmuring note is heard. This is not the imprisoned sound of the sea, but is due to the selective action of the shell as a resonating tube. It sorts out certain wave lengths of the sounds which strike it, and amplifies

them by building up with the reflected energy. The closed tube of any resonator responds to a wave length four times its own length; an open tube chooses those twice its length. If two tuning forks which have the same number of vibrations per second are placed close together, and one of them is struck, we have what are termed forced vibrations in the other. The successive impulses strike the second tuning fork at exactly proper intervals to set it into motion, and it gives out a corresponding tone.

When two musical tones are a full octave apart, one consists of twice as many vibrations per second as the other. Tones which harmonize with one another must have frequency ratios consisting of small whole numbers. If one tone vibrates 256 times per second and the other 384 they will harmonize, for the ratio of these numbers is 2:3. 256 would not harmonize with 400, however, the ratio here being $2:3 \frac{1}{8}$.

If a string (i.e. a tightly stretched wire) vibrates as a whole, it will give out what is known as its fundamental tone. It may vibrate in two or more parts, however, and wherever a region exists wherein there is no vibration, as must occur whenever the string vibrates in more than one part, we have what is termed a node. When the wire is made to vibrate in two parts it gives forth a note an octave higher than the fundamental. This is called the first overtone. When the wire is made to vibrate in three parts it gives forth a note corresponding to three times the vibration number of the fundamental, namely sol', being three-halves as rapid as the vibration of the first overtone. This is called the second overtone. These overtones, from the fundamental to the highest, are often called harmonics. They bear the vibration ratios 2, 3, 4, 5, 6, 7, etc. to the fundamental. We see that the note emitted by a string plucked at random is a complex one, consisting of the fundamental and any number of overtones which may be present. If we pluck the string at a point where the node of a given overtone would be, that particular overtone cannot be present, because we have set its nodal point to vibrating. Hence piano wires are commonly struck about one-ninth their length from one end, to cut out all overtones above the ninth, for these higher harmonics become very discordant.

If two tones are not quite of the same rapidity of vibration, they reinforce one another frequently, and may produce what are known as beats, or undertones. If we have a string vibrating 100 times a second and one vibrating 105 times a second, they will produce five beats a second, and a secondary tone, having a frequency of five vibrations per second will result. Discord is merely a phenomenon of beats. If the vibration numbers do not differ by more than five or six, the effect is not particularly unpleasant, but when a difference of thirty beats per second is reached the discord becomes extreme.

The human ear can only hear vibrations which are more frequent than 16 times per second, and then the range extends upward for over thirteen octaves, varying with the ear. While the eye is more acute to light than the ear is to sound, its range is only one thirteenth as great, being only about one octave. Whether future races will develop both a greater range of color vision and a greater intensity of hearing is a matter for conjecture. It will be seen that pitch and color, and intensity and brilliance correspond. The relation between sound and light is a very basic one, but requires functioning on higher planes for its unravelling.

Special Course of Instructions

BASIC PRINCIPLES OF SCIENCE

SERIES TWO

Course 4 A

Lesson VI

RADIANT ENERGY

Radioactivity and the Structures of Atoms. The discovery of radioactivity is of special interest to students of occult science. Much information as to the structure of the atom has been obtained by a study of the radiations sent off by these atoms when they explode, which is the phenomenon called radioactivity.

Only ninety-two kinds of atoms are known, and these contain from 1 to 92 electrons surrounding a positive nucleus in each case. The question might well be asked, Why are there not more kinds of atoms? For example, why do we not find atoms containing 100 electrons around the nucleus? A suggested answer comes from a study of those atoms which are unstable, i.e. radioactive. For we find that the principal radioactive atoms are those which are heaviest and most complex; the simpler atoms appear in general to be much more stable. This suggests that in the present state of affairs on the physical plane any atoms which were more complex than those having 92 electrons around the nucleus have long since exploded, being no longer stable, but that perhaps in previous times they might perfectly well have existed. And in future times we may find that the most complex atom contains only 80, say, electrons, all the heavier ones having disintegrated.

This is very suggestive to the occult student, familiar as he is with the occurrence of great cosmic cycles, where simplicity evolves into complexity, which in turn involves into simplicity. We are apparently now somewhat past the crest of such a cycle on the physical plane, and may perhaps expect increasing simplicity in the forms of matter which are stable. Such a cycle would be very long in its period, so that untold aeons of time would be required to produce any observable change in the stability of an atom of any given type.

In 1896, while performing some experiments on uranium, the heaviest of all the elements known to exoteric chemistry, Becquerel found that it possessed the property of spontaneously emitting rays of some sort which have the power of penetrating objects opaque to light and of affecting photographic plates. He found that these rays are emitted by all uranium compounds, and judged them to be electrical in nature because they had the property of dissipating the charge which had accumulated on any insulator; i.e. of rendering the surrounding atmosphere conducting so that the charge could escape. It was but a few months after Becquerel's discovery that the Curies began an investigation of all the known elements to find whether any of the rest of them possessed the remarkable property which had been found to be possessed by uranium. They found that one of the remaining elements, namely thorium, is capable, together with its compounds, of producing the same effect. After this discovery the rays from all this class of substances began to be called Becquerel rays, and all substances which emitted such rays were called radioactive substances. In investigating pitchblende, which is a variety of uranium ore, the Curies found a substance which had the property of emitting such rays more powerfully than either uranium or thorium. They named this new element Radium.

In order to consider this phenomenon, we shall refer again to our concept of the atom. We have seen that it is made up of a positively charged nucleus surrounded by negatively charged electrons. The forces holding the electrons near the nucleus are electrical in nature, strains in the ether, so to speak. If the electric strains can be overcome, some of the electrons will fly out of the atom. This can be readily done, and does not particularly affect the atom, since it quickly picks up other free electrons to replace those lost. But the nucleus of the atom is also a complex structure, containing basic positive charges, the protons, in addition to negative electrons. When this nuclear structure is disrupted the particles of which it is made are sent out with tremendous velocities, and these form the radiations given out by radioactive atoms.

When we take a gram of radium, if we could examine the individual atoms we would find that the nuclei of a great many were exploding; that is, becoming unstable, so that a portion of the nucleus was expelled with high velocity, the remaining part of the nucleus forming a new kind of atom. The laws of probability appear to govern these explosions; if we watch a given atom, it may explode at once or not for billions of years. But on the average a sufficient number of atoms will explode in any given time so that at the end of about 1700 years half of the gram of radium will be gone. At the end of another 1700 years half of the remainder will be gone, and so on.

A uranium atom has 92 electrons around its positive nucleus. Let us suppose that the etheric strain becomes so great that the nucleus becomes unstable; it disintegrates, at least partially, and shoots out a positively or negatively charged particle, or both. In any of these cases its ability to hold electrons changes, since the charge of the surrounding electrons must balance the charge on the nucleus, and so it must perforce become a different kind of atom.

From a disintegrating mass of radium three forms of radiant energy are sent out, known as the alpha, beta, and gamma radiations. The alpha particles are positively charged helium atoms, with their external electrons missing. If we collect a large number of alpha particles, we gradually accumulate a quantity of helium gas. The beta particles, on the other hand, are electrons pure and simple. They are projected from the atom with velocities ranging from 60,000 to 180,000 miles per second. Since the alpha particles are positively charged, and the beta particles are negatively charged, both must be surrounded by magnetic fields when moving, and hence both are deflected by a magnet, though in opposite directions. One alpha particle weighs 7000 times as much as a beta particle.

The gamma rays are not particles at all, but are merely short etheric vibrations sent out by the explosion of an atom, being in fact a form of X-ray. They are not deflected by a magnetic field in the ordinary way, but are essentially electromagnetic waves, similar to light but of shorter wave length. The tracks of alpha, beta, and gamma rays have been successfully photographed with the aid of the electric spark. Radium is continually evolving heat at the rate of about one hundred calories per hour per gram. This result was to have been anticipated from the fact that the particles which are continually flying off from the disintegrating radium atoms subject the whole mass to an incessant internal bombardment, which would be expected to raise its temperature. Radium evolves three hundred thousand times as much heat per unit weight as does coal. It should be remembered that the whole of a mass of radium or other radioactive substance does not disintegrate at once. One atom explodes at a time, so to speak, so a constant bombardment is occurring, freeing a quantity of energy undreamt of by material scientists in former times. If science

can find some way of artificially causing the explosion of an atom, the dynaspheric force may be available. Is it possible for man to gain control of any such store of sub-atomic energy? To the occult student, believing that this energy has been under the control of the human race in ages past, it does not seem improbable that when the proper evolutionary wave returns, such will be the case.

X-RAYS. An electrical discharge takes place more readily through a partial vacuum than through air at ordinary pressure. If we partially exhaust the air from a glass tube and pass a current of electrons through it at high pressure a brilliant glow may be observed in the tube. Certain invisible radiations called cathode rays are found to be emitted by the cathode (the terminal of the tube where the electrons enter.) These cathode rays are merely streams of electrons moving at speeds up to 80,000 miles per second. These rays manifest themselves first by the brilliant fluorescent effects which they produce in the glass walls of the tube or in other substances upon which they may fall; second by a powerful heating effect, and third by the sharp shadows which they cast, thus showing that they travel in straight lines. Since the cathode particles are electrons moving with high velocities, we see that they are similar to the beta particles shot off from radioactive substances. They are deflected by a magnetic field, as are the beta particles.

In 1895 the German physicist Roentgen first discovered that wherever the cathode rays impinge upon the walls of a tube, or upon any obstacle within the tube, they give rise to another type of invisible radiation which is known under the name of X-rays. While X-rays are like cathode rays in producing fluorescence, they nevertheless differ from cathode rays in several important respects. X-rays may penetrate many substances which are quite impervious to cathode rays and light waves. They are not deflected by a magnet or by an electric charge. They are waves in the ether, of the same nature as light, but of very short wave length, being apparently somewhat similar to the gamma rays sent out by radium.

Since a substance sends out X-rays whenever cathode particles strike it, and shoots out cathode particles whenever X-rays strike it, we must look to the atom for the explanation of this phenomenon. Whenever an electron enters an atom and is stopped suddenly, a wave of energy is sent off through the ether, and this is the X-ray. Conversely, whenever such a wave strikes another atom, it may accelerate one or more of its electrons so that they may fly off. X-rays may be used to photograph through objects opaque to light, on account of their penetrating ability.

THE EVOLUTION OF WORLDS. We are now prepared to build up a picture of the creation of a Universe on the physical plane. And it should be remembered that the same picture applies to a certain degree to inner planes. Suppose that we stand at the beginning of a manvantaric cycle, when the physical plane does not exist, all manifestation being indrawn to the astral and higher planes. Astral matter exists, and from it we must fashion the physical universe. We may call this astral matter protyle; from the standpoint of the physical-to-be it is a uniform tenuous substance having no structure, but perfectly uniform and continuous. We affect this matter with mind-substance or other matter, and fashion from the mixture the basic substance of the physical plane, call it Ether or what you will, exactly as a child makes mud from sand and water. Now we take this physical basic substance and differentiate it into two types of thing; to get a definite picture we may say that we form whirlpools in it. Those vortices whirling one way we call electrons; those whirling in the opposite direction we call protons.

Now we take an electron and a proton and put them together, forming an atom of hydrogen. Then we take four protons and two electrons and mold them closely together ~~together~~ to form the nucleus of a helium atom, to which we add two external

electrons and have a complete atom of helium gas. So we proceed up through the more complex atoms until we have synthesized all of the chemical elements. In uranium we must take over two hundred protons and an equal number of electrons to form a single atom. And we must constantly keep in mind the fact that all of these atoms contain only two things, electrons and protons, which in turn are different aspects of the same fundamental Ether or Protyle.

We are now ready to pass further into differentiation by combining the different kinds of atoms into molecules, from which we can form matter as we know it. But before the atoms can be stable hanging together as molecules the proper physical conditions must be obtained. To do this we proceed to evolve stars and then worlds.

Visualize a vast mass of hydrogen gas formed of the kind of atoms we constructed first. This is floating in space extending over unfathomed reaches of our new Universe. But the hydrogen atoms attract one another by the force of gravitation, so that the vast mass slowly shrinks. As it does this the energy set free by the shrinking turns into heat, for the atoms, as they get closer together, will collide more often and harder, and the whole mass will warm up. Finally we get a vast sphere of hydrogen; other atoms may have synthesized in the meantime, and our mass of matter, now red or white hot, has become a star. It is possible to see in the heavens stars in various stages of evolution; some still in the cold nebular stage; others only beginning to warm up; still others vastly large but becoming spherical and red hot; finally a great number which have reached maturity and are the white-hot globes with which we are so familiar, like our sun.

In time, however, the star shrinks less rapidly and begins to cool off. It is ready to fulfill its function, however, which is to furnish radiant energy to some cooler body, a world, where physical life, as we know it can evolve. Smaller masses of matter, which may have been pulled from the star as our earth was doubtless pulled from the sun, will cool off much more rapidly than the parent body. So the next requirement of evolution is provided, a world cool enough so that atoms can exist as stable molecules.

Now two atoms of hydrogen and one of oxygen will combine to form a molecule of water, and thousands of other combinations of the ninety-two atoms will take place until millions of substances will be formed. In the original star or sun these substances would all be dissociated into their constituent atoms by the intense heat, so that the low temperature of the world is a necessity for their existence. More and more complex molecules will be formed as the earth cools off, until finally some of them are complex enough to form the vehicles for ensoulment by higher principles from the astral plane ready to produce, with their aid, what we call living entities. When the physical substance has evolved with increasing complexity and hence capability to the point where it can be directly ensouled by higher principles from inner planes its advancement in evolution becomes much more rapid. Where trillions of aeons were required for the synthesis of electrons and protons, trillions of years probably suffice for the synthesis of atoms, and billions for the building up of molecules. With the coming of the helping hand from above, that is the ensouling of the inanimate organism with the life principle, evolution proceeds at such a rapid pace that the period of a few hundred million years produces tremendous increases in capability, and finally man is evolved.

The thing that differentiates man from the higher animals is that now another helping hand has come down from still further above or within, and the organism is still further ensouled, this time with mental and spiritual matter. Here evolution becomes still more rapid as capabilities increase; we have reached the point where the study from the physical aspect may well stop. But it is evident that without the physical and emotional bodies the mental and spiritual bodies of man could not obtain the experience which they appear to need in manifestation; the emotional body, possessed by all animal creatures, required the physical body. This in turn needed a world on which to exist, since it was formed of very complex molecules which would only be stable under certain limited conditions of temperature, etc. And it needed a sun to give it warmth. Both things were provided by the properties of the atoms, which in turn were formed from electrons and protons, which in turn were nothing but protyle.

So we see the interdependence of all forms, at least on the physical plane, and by analogy on all planes. The doctrine of Karma, or the Law of Cause and Effect, becomes obvious in its necessity, for within a closed system such as we have been discussing every change produces some compensating change; a man cannot swim ahead without moving the water.

Why can we not extend this picture clear back through the origin of all Things? "In the beginning was the Word, and the Word was God, and the Word was of God." What is this but a picture of the Creation; of the beginnings of manifestation on inner planes? As increasing complexity is built up on one plane, the most complex structures formed on it are used to form the basic matter of the next lower plane, and so on down through the spiritual, mental and astral planes until we finally reach the physical, where the same thing is reproduced on a lesser scale.

We see now the justification for exact science in building up its structure of fact on the basis of experience. Exact scientists are apt to be impatient with occultists, and the impatience is mutual. The Mystic wishes to go direct to the basis of things by intuition, the scientist in a more roundabout way by observation. Both methods must be combined if truth is to be ultimately arrived at. Much less friction is now occurring between occult and orthodox science than was occurring when the Secret Doctrine was first written; there has been much advancement on both sides. But a quotation from this great work is very apropos by way of explanation.

CONCLUSION. Let the Secret Doctrine "define, once and for all, the position which Occultism intends to maintain with regard to material Science. So far as Science remains 'organized common sense'; so far as its inferences are drawn from accurate premises, its generalizations resting on a purely inductive basis, every Theosophist and Occultist welcomes respectfully and with due admiration its contributions to the domain of cosmological law. There can be no possible conflict between the teachings of occult and so-called exact Science wherever the conclusions of the latter are grounded on a substratum of unassailable fact. It is only when its more ardent exponents, overstepping the limits of observed phenomena in order to penetrate into the Arcana of Being, attempt to wrench the formation of Kosmos and its living Forces from Spirit, and to attribute all to

blind Matter, that the Occultists claim the right of disputing and calling in question their theories."

Much aggravation is furnished the student, who, in studying occult literature, would relate his knowledge of material science to what he finds. There is a purpose back of this; if the meaning be laid bare upon the surface, the student will not have such an appreciation of his findings. We find in the Secret Doctrine the statement that sound and heat, as well as light, are all motions of the Ether. Since science claims that heat and sound are motions of material substance, which are we to believe? Both; if we analyze our own conceptions we see that material substance is composed of ether in its basic form; all motion of material substance is motion of ether. The two doctrines now coincide exactly. Neither has been changed, but we have penetrated more deeply into the true meaning. Nothing was more natural than to believe that ether was meant as what we commonly consider ether to be, and not a differentiation of that substance. The error was in our own conception, however, and if in most cases where we are convinced of the falsity of some Occult teaching we analyze the statement, we generally find the error to be in our own assumption of the meaning, and not in what was actually said.

We find that science is working directly along the lines laid down in Occult teachings, as any true search for Truth must, even though science itself may not admit it. Her shortcomings need not prevent us from profiting by her benefits, however.

In some future day we may hope to see Science consciously working with Religion. Until then

"The knowledge of this nether world -
Say, friend, what is it, false or true?
The false, what mortal cares to know?
The true, what mortal ever knew?"

