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[ijirset@gmail.com](mailto:ijirset@gmail.com)

[www.ijirset.com](http://www.ijirset.com)

# Recent Advances in Chemical, Physical And Biological Sciences

<sup>1</sup>Dr. Ashutosh Tripathi & <sup>2</sup>Dr. Punita Srivastava

<sup>1</sup>Associate Professor, Dept. of Chemistry, K.S. Saket P.G. College, Ayodhya, Uttar Pradesh, India

<sup>2</sup>Assistant Professor, Dept. of Chemistry, K.S. Saket P.G. College, Ayodhya, Uttar Pradesh, India

**ABSTRACT:** Over the past years, the Royal Society of Chemistry (RSC) has gathered expertise and views from its members and the wider community from around the world. Through a series of workshops and online consultation, they have identified priority areas and opportunities for the chemical sciences, physical and biological sciences. EuReK@ChemSoc, an initiative by Royal Society of Chemistry London, North India Section, is a student Chemical Society which aims to represent and encourage the views of young chemical scientists through its scientific or career themed outreach programs including lectures, meetings, industry visits, academic conferences and fun science activities. Nanotechnology is a relatively new area of science that has generated tremendous excitement worldwide. With the latest advancements in this field, scientists are developing state-of-the-art tools and products to address pressing needs in various fields of research including health, environment and sustainability. The aim of this seminar is to disseminate the current advancements and challenges in the development of multidisciplinary nanotechnology tools. The present initiative will provide a platform for discussion about the potential changes and how nanotechnology partnerships in the academic and industry fields could lead to innovation and invention, ultimately leading to Entrepreneurship. This platform will also bring together all the common stakeholders who will brainstorm on the crucial issues pertaining to theory process, and practice of innovation and entrepreneurship in the nanoscience and nanotechnology fields.

**KEYWORDS:** chemistry, physical, biological, nanotechnology, activities, entrepreneurship, innovation, invention, research, consultation

## I.INTRODUCTION

It is well known facts that plasma is universal property for material and space. Plasma science and technology is one of most important fundamental aspect for advances in physical science. The role of plasma science which has mostly concerned about the entire field of science and technology. Today is the age of plasma science which has related to society, socioeconomic, industrial, micro-electronic, medical and surgery treatment, tele-communication, remote sensor, fiber optics, GPS, stars, interstellar space program, agriculture and harvesting, pesticides-medicine, chemical engineering, potential and current, semi conductor, p-n junction, energy bandgap. [1,2] Research of all around field such as fusion energy, impurity water, cancer detection, ores mineral, petrol chemical, new species on the earth and planets. The important point has been focused on the crisis of energy as population increases. But the source of energy does not fulfill the demand of nation. So, it is challenging problem for physical science. The different manifestation of plasma are responsible for all technology revolution, green revolution, nano-technology to check up density and temperature rise and fall orderly in free environment in india. The aim of this paper mainly focused on the application of plasma science and technology to new way methodology and research, technique and programme, skill and mindset of future science and technology in recent advances in physical science. The application of plasma build up chips, IC, clean of toxic waste in environment. [3,4]

Nowadays chemical science emerged as a basic and latest tool for all kind of technical research, education and allied subjective collaborative work among various leading branches of the science. Chemistry plays a key and vital role for all basic branches of science. Day by day various techniques and instrumentations encompassing innovations are rapidly emerging in the field of science and technology. Modern sophisticated instrumentation techniques play a key and reliable role for the characterization, structure determination and identification of the new molecules. On the basis of these inventions researcher can modify his work according to the need of the industry and serve for the betterment of the society. [5,6]

There is a number of recent advancement taking place to study the anatomy of brain; few of them are listed below:

**(i) Magnetic Resonance Tractograph (MRT):**

MRT is a non-invasive imaging tool used for studying the human anatomy. The MRT methods and techniques have the potential to yield new illuminating information on brain activity and connectivity. Thus emerging technology offers a new window into human brain anatomy.

**(ii) Functional Neuroimaging:**

It is a technology used to measure the aspects of brain function after with a view to understand the relationship between activity in certain brain area and specific mental functions.

**(iii) Diffusion Tensor Imaging (DTI):**

It is used to evaluate the white matter anatomy (layer found beneath the outer layer of brain). Based on the pattern of color change, we would somewhat predict whether white matter tracts were displaced. Evaluation of white matter anatomy is usually not possible with any other imaging method.

**(iv) Cancer:**

In many types of cancer, the original tumor itself is usually not deadly. It spread of tiny sub-population of cells from primary tumor to other parts of the body, process known as “metastasis”.

Dr. Condeclis and his team identified 2 molecules (P<sub>190</sub> RhGEF and P<sub>190</sub> RhOGAP) that regulates the activity of RhOC an enzyme that plays crucial role during tumor metastasis and is been identified as a bio mark for invasive breast cancer.

**(v) Metal Organic Frame Works (MOF’s):**

They are the new types of materials with nano scale pores developed by Bioscience engineers from KU Leuven and Belgium. They produced the materials in the form of a very thin film, so that they can easily be used for high tech applications such as “Microchips”.

## 2. Embrology:

**Surrogacy:**

It is where another woman carries and gives birth to a baby for the couple who want to have a child.[7,8]

**It is of two types:**

(A) Gestational Surrogacy (Full)

(B) Traditional Surrogacy (Partial)

**(A) Gestational Surrogacy:**

**Involves the implantation of an embryo created using either:**

(i) The eggs & sperms of the intended parents.

(ii) A donated egg fertilized with sperm from the intended father.

(iii) A embryo created using donor egg & sperm.

**(B) Traditional Surrogacy:**

Involves sperm from the intended father and an egg from the surrogate. Here the fertilization is usually done by artificial insemination and Intra Uterine Insemination (IUI).

**(i) IVF:**

In Vitro Fertilization involves the fertilization of an egg outside the body, performed by using the egg and sperm of intended parents or using either donated sperm or donated egg or both.

**(ii) ICSI:**

It is a technique where the embryologist selects a single sperm to be injected directly into an egg, instead of fertilization taking place in a dish where many sperms are placed near an egg.

**(iii) IUI:**

It is a laboratory procedure to separate fast moving sperm from more sluggish and non-moving sperms. This can be performed with partner’s sperms or donor sperms.

**(iv) GIFT:**

Gamate Intra-Fallopian Transfer. It is the preparation and monitory of the growth of egg.

Instead of the egg being fertilized ‘invitro’ in the laboratory. The healthiest eggs & sperms are placed together into the woman’s fallopian tubes and fertilization takes place in the body as it would, if conception had occurred naturally.[9,10]

### 3. *Biotechnology:*

(a) From a spit test for cancer to a shot that helps your body re-grow nerves along your spinal cord, these new advances in the world of medicine blur the line between biology and technology to help restore, improve and extend our lives.

(b) Cancer spit test – detects oral cancer from single drop of saliva.

**(c) Prosthetic Feedback:**

A device that stretches and amputee's skin near the prosthesis in ways that provide feedback about the limbs position and movement.

**(d) Smart Contact Lens:**

This is a wireless device that helps the doctor better understand the cause of disease.

**(e) Speech Restorer:**

For people who have lost the ability to talk a new "phonetic speech engine" which helps to produce speech.

**(f) Absorbable Heart Stent:**

After six months of installation the stent begins to dissolve, and after two years it's completely gone, leaving behind a healthy artery.

**(g) Muscle Stimulator:**

In the time of broken bones to heal, nearby muscles often atrophy from lack of use. Myospore a battery operated device that uses electrical stimulators small enough helps to exercise muscles and keep them strong during recovery.[11,12]

**(h) Nerve Regenerator:**

It is a nanogel that helps in the growth of hex axon up and down the spinal cord.

**(i) Stabilizing Insoles:**

It helps to diagnose balance problems in elderly patients before a fall occurs.

**(j) Smart Pill:**

It is used for recording the exact time of drug ingestion.

**(k) Autonomous Wheelchair:**

This wheelchair that can take people where they ask to go.

**(l) Portable Dialysis:**

The machine is fully automated, battery-operated, water proof and at less than 5 pounds, portable.

**(m) Walking Stimulator:**

Patients not only walk faster and farther, but experience less pain while doing so.

**(n) Rocket Powered Arm:**

Adding strength to prosthetic limbs has typically required bulky battery packs.

(o) Milestone in life science to combine genomics, drug discovery, and other approaches to fight human disease or aging.

**(p) Human Genome:**

The value of automation, micro arrays, micro fluids and other technological advances that drive life science.

(q) CRISPR, can be used to fight diseases.

**Behavior and Computer Research Advancement:**

(a) Biological process and system behavior can be modeled on a computer.

(b) Computer Biosimulation is in its infancy for life science. Computer biosimulation plays a great role in understanding qualitative and quantitative differences in biological processes between for instance mice and man and helps scientists to make better decisions.[13,14]

### 4. *Genetic Engineering:*

In Genetic Engineering the Gene-Editing technique called CRISPR- Cas9. CRISPR is the ionic culmination of a variety of technology breakthroughs allowing us to read and write genomes on any living things.

Gene-drive is a method of gene editing that allows a particular gene to spread through an entire population in a given area.

Research is going on application of Gene-drive to eliminate malaria & Lyme diseases, improvement of crops to improve health (like golden rice) Engineering Pigs as organ donors for millions of patients in need of transplants.



## II.DISCUSSION

### Stem Cells:

Scientists are already using stem cells in the laboratory to screen new drugs and to develop model systems to study normal growth and identify the causes of birth defects. Research on stem cells continues to advance knowledge about how an organism develops from a single cell and how healthy cells replace damaged cells in adult organisms. Stem cell research is one of the most fascinating areas of contemporary biology.[15,16]

### 5. Biology (Feb, 2015):

A new method that used human pluripotent stem cells, to create new cells capable of initiating human hair growth is successful in the lab.

(a) Iranian chemist 3<sup>rd</sup> Jan, 2015, created biodiesel fuel from soya oil to decrease pollution caused by fossil fuel.

(b) Feb 2015- Researchers used biodegradable nano-particles to kill brain cancer cells in animals and lengthen their survival.

(c) Feb 2015- Scientists have genetically reprogrammed plants to be drought tolerant in response to already existing agrochemical.

(d) March 2015- A pioneering therapy using bone marrow stem cells to treat lung cancer patient is announced in UK.

(e) March 30, 2015- Eating pesticide ladden food is linked to remarkably low sperm count (49% lower) says Harvard scientists in a landmark new studying. Connecting pesticides residues in fruits and vegetables to reproductive health.[17,18]

(f) April 15, 2015- American scientist claim to have found a potential cause of Alzheimer's disease in the behavior of immune cells, which may be possible to target with drug treatment.

(g) April 16 2015- A major advance in artificial photosynthesis is achieved with system able to capture CO<sub>2</sub>, using solar energy and then use it to produce valuable chemical products.

(h) 23 July 2015- An Ebola vaccine developed by the Public Health Agency of Canada is found to be 100% successful in an initial trial.

(i) 28 Jan 2016- A new study reveals that Octopuses frequently communicate with each other in challenging displays that includes posturing and changing colour.

(j) Williance Campbell and Santoshi Omura received Nobel Prize in 2015 concerning a novel therapy against infection caused by round worm parasite.

(k) You You Tu won Nobel prize in 2015 for his discovery concerning a novel therapy against malaria.[19,20]

### 6. Usage of Solar Energy:

#### (i) Photo Voltaic System:

It is a Solar PV Power System designed to supply usable solar power by means of photo voltaic. It consists of an arrangement of several components, including solar panels to absorb and convert sunlight into electricity. A solar inverter changes the electric current from DC to AC.

#### (ii) Rural Electrification:

India currently has around 1.2 million solar home lighting systems and 3.2 million solar lanterns. Also India has been ranked number one market in Asia for solar off-grid production nearly 3,000 villages of Orissa were lighted with solar power by 2014.

#### (iii) Agricultural Support:

Solar PV water pumping systems are used for irrigation and drinking water. Solar drives are used to harvest before storage.

#### (iv) Solar Water Heaters:

Bangalore has the largest deployment of roof top solar water heater in India. These heaters generate an energy equivalent of 200MW. Pune has also recently made installation of solar water heaters in new building mandatory.

### 7. Automation:

#### (i) Automation:

It is the use of various control systems for operating equipment's such as machinery, processes in factories, switching on telephone networks, steering and stabilization of ships and other application with minimal or reduced human intervention.

**(ii) Automatical Retail:**

The food retail industry has started to apply automation to the ordering process. Some cafes and restaurants are utilizing mobile and tablet 'apps' to make the ordering process more efficient by customers ordering and paying on their device and food delivery to customers tables using a conveyor belt system.[21,22]

**(iii) Automated & Video Surveillance:**

The Defense Advanced Research Projects Agency (DARPA) started the research and development on automatically Visual Surveillance and Monitoring (VSAM) Program. The purpose of it is to record properties, trajectories of objects in a given area generate warnings or notify designated in case of particular events.

**8. Greatest Recent Nutrition Discoveries:**

**(i)** Folic acid prevents birth defects.

**(ii)** Direct relationship between diet high in trans fat content and LDL (bad) cholesterol level and therefore, an increased risk of heart disease.

**(iii) Nutritional Regulation of Gene Transcription:**

How the availability of nutrients, like fat, glucose, cholesterol, protein impacts the activity and expression of genes is slowly unfolding. For example saturated and trans-unsaturated fatty acid lower LDC cholesterol via gene transcription.

**(iv)** Progress in measuring energy/calorie intake. Doubly labeled water technique is now used for accurately estimating energy, calories expenditure and intake.

**(v) Fat tissue as an endocrine gland:**

Leptin is the most important hormone, which regulates appetite and body fat levels, is secreted from your fat cells.

**(vi) High Pressure Food Preservation (Pascalization):**

It refers to the use of food preservation techniques, that makes use of high pressure pressed inside a vessel exerting 70,000 pounds per square inch (480mpa) or more food can be processed so that it retains its fresh appearance, flavor, texture and nutrients, while inhibiting the growth of harmful M.O's & preventing spoilage.[23]

### III.RESULTS

Life science comprise of topics like Biochemistry, Microbiology, Biotechnology Ecology etc. All exploring the scientific study of living organisms. Chemical Science is the branch of natural science dealing with the composition of substances and their properties. Both the branches are interdependent, each are necessary for complete understanding. Current advances in chemical analysis and biological interpretation have led us to understand life better. Agricultural science or entomology or cancer biology all have advanced into interdisciplinary work. **Chemistry**, the science that deals with the properties, composition, and structure of substances (defined as elements and compounds), the transformations they undergo, and the energy that is released or absorbed during these processes. Every substance, whether naturally occurring or artificially produced, consists of one or more of the hundred-odd species of atoms that have been identified as elements. Although these atoms, in turn, are composed of more elementary particles, they are the basic building blocks of chemical substances; there is no quantity of oxygen, mercury, or gold, for example, smaller than an atom of that substance. Chemistry, therefore, is concerned not with the subatomic domain but with the properties of atoms and the laws governing their combinations and how the knowledge of these properties can be used to achieve specific purposes.[23]

The great challenge in chemistry is the development of a coherent explanation of the complex behaviour of materials, why they appear as they do, what gives them their enduring properties, and how interactions among different substances can bring about the formation of new substances and the destruction of old ones. From the earliest attempts to understand the material world in rational terms, chemists have struggled to develop theories of matter that satisfactorily explain both permanence and change. The ordered assembly of indestructible atoms into small and large molecules, or extended networks of intermingled atoms, is generally accepted as the basis of permanence, while the reorganization of atoms or molecules into different arrangements lies behind theories of change. Thus chemistry involves the study of the atomic composition and structural architecture of substances, as well as the varied interactions among substances that can lead to sudden, often violent reactions.

Chemistry also is concerned with the utilization of natural substances and the creation of artificial ones. Cooking, fermentation, glass making, and metallurgy are all chemical processes that date from the beginnings of civilization. Today, vinyl, Teflon, liquid crystals, semiconductors, and superconductors represent the fruits of chemical technology. The 20th century saw dramatic advances in the comprehension of the marvelous and complex chemistry of living organisms, and a molecular interpretation of health and disease holds great promise. Modern chemistry, aided by increasingly sophisticated instruments, studies materials as small as single atoms and as large and complex



as DNA (deoxyribonucleic acid), which contains millions of atoms. New substances can even be designed to bear desired characteristics and then synthesized. The rate at which chemical knowledge continues to accumulate is remarkable. Over time more than 8,000,000 different chemical substances, both natural and artificial, have been characterized and produced. The number was less than 500,000 as recently as 1965.[24,25]

Intimately interconnected with the intellectual challenges of chemistry are those associated with industry. In the mid-19th century the German chemist Justus von Liebig commented that the wealth of a nation could be gauged by the amount of sulfuric acid it produced. This acid, essential to many manufacturing processes, remains today the leading chemical product of industrialized countries. As Liebig recognized, a country that produces large amounts of sulfuric acid is one with a strong chemical industry and a strong economy as a whole. The production, distribution, and utilization of a wide range of chemical products is common to all highly developed nations. In fact, one can say that the “iron age” of civilization is being replaced by a “polymer age,” for in some countries the total volume of polymers now produced exceeds that of iron.

### *The scope of chemistry*

The days are long past when one person could hope to have a detailed knowledge of all areas of chemistry. Those pursuing their interests into specific areas of chemistry communicate with others who share the same interests. Over time a group of chemists with specialized research interests become the founding members of an area of specialization. The areas of specialization that emerged early in the history of chemistry, such as organic, inorganic, physical, analytical, and industrial chemistry, along with biochemistry, remain of greatest general interest. There has been, however, much growth in the areas of polymer, environmental, and medicinal chemistry during the 20th century. Moreover, new specialities continue to appear, as, for example, pesticide, forensic, and computer chemistry.

### **Analytical chemistry**

Most of the materials that occur on Earth, such as wood, coal, minerals, or air, are mixtures of many different and distinct chemical substances. [20] Each pure chemical substance (e.g., oxygen, iron, or water) has a characteristic set of properties that gives it its chemical identity. Iron, for example, is a common silver-white metal that melts at 1,535° C, is very malleable, and readily combines with oxygen to form the common substances hematite and magnetite. The detection of iron in a mixture of metals, or in a compound such as magnetite, is a branch of analytical chemistry called qualitative analysis. Measurement of the actual amount of a certain substance in a compound or mixture is termed quantitative analysis. Quantitative analytic measurement has determined, for instance, that iron makes up 72.3 percent, by mass, of magnetite, the mineral commonly seen as black sand along beaches and stream banks. Over the years, chemists have discovered chemical reactions that indicate the presence of such elemental substances by the production of easily visible and identifiable products. Iron can be detected by chemical means if it is present in a sample to an amount of 1 part per million or greater. Some very simple qualitative tests reveal the presence of specific chemical elements in even smaller amounts. The yellow colour imparted to a flame by sodium is visible if the sample being ignited has as little as one-billionth of a gram of sodium. Such analytic tests have allowed chemists to identify the types and amounts of impurities in various substances and to determine the properties of very pure materials. Substances used in common laboratory experiments generally have impurity levels of less than 0.1 percent. For special applications, one can purchase chemicals that have impurities totaling less than 0.001 percent. The identification of pure substances and the analysis of chemical mixtures enable all other chemical disciplines to flourish.[21]

The importance of analytical chemistry has never been greater than it is today. The demand in modern societies for a variety of safe foods, affordable consumer goods, abundant energy, and labour-saving technologies places a great burden on the environment. All chemical manufacturing produces waste products in addition to the desired substances, and waste disposal has not always been carried out carefully. Disruption of the environment has occurred since the dawn of civilization, and pollution problems have increased with the growth of global population. The techniques of analytical chemistry are relied on heavily to maintain a benign environment. The undesirable substances in water, air, soil, and food must be identified, their point of origin fixed, and safe, economical methods for their removal or neutralization developed. Once the amount of a pollutant deemed to be hazardous has been assessed, it becomes important to detect harmful substances at concentrations well below the danger level. Analytical chemists seek to develop increasingly accurate and sensitive techniques and instruments.

Sophisticated analytic instruments, often coupled with computers, have improved the accuracy with which chemists can identify substances and have lowered detection limits. An analytic technique in general use is gas chromatography, which separates the different components of a gaseous mixture by passing the mixture through a long, narrow column

of absorbent but porous material. The different gases interact differently with this absorbent material and pass through the column at different rates. As the separate gases flow out of the column, they can be passed into another analytic instrument called a mass spectrometer, which separates substances according to the mass of their constituent ions. A combined gas chromatograph–mass spectrometer can rapidly identify the individual components of a chemical mixture whose concentrations may be no greater than a few parts per billion. Similar or even greater sensitivities can be obtained under favourable conditions using techniques such as atomic absorption, polarography, and neutron activation. The rate of instrumental innovation is such that analytic instruments often become obsolete within 10 years of their introduction. Newer instruments are more accurate and faster and are employed widely in the areas of environmental and medicinal chemistry.[22]

### *Inorganic chemistry*

Modern chemistry, which dates more or less from the acceptance of the law of conservation of mass in the late 18th century, focused initially on those substances that were not associated with living organisms. Study of such substances, which normally have little or no carbon, constitutes the discipline of inorganic chemistry. Early work sought to identify the simple substances—namely, the elements—that are the constituents of all more complex substances. Some elements, such as gold and carbon, have been known since antiquity, and many others were discovered and studied throughout the 19th and early 20th centuries. Today, more than 100 are known. The study of such simple inorganic compounds as sodium chloride (common salt) has led to some of the fundamental concepts of modern chemistry, the law of definite proportions providing one notable example. This law states that for most pure chemical substances the constituent elements are always present in fixed proportions by mass (e.g., every 100 grams of salt contains 39.3 grams of sodium and 60.7 grams of chlorine). The crystalline form of salt, known as halite, consists of intermingled sodium and chlorine atoms, one sodium atom for each one of chlorine. Such a compound, formed solely by the combination of two elements, is known as a binary compound. Binary compounds are very common in inorganic chemistry, and they exhibit little structural variety. For this reason, the number of inorganic compounds is limited in spite of the large number of elements that may react with each other. If three or more elements are combined in a substance, the structural possibilities become greater.

After a period of quiescence in the early part of the 20th century, inorganic chemistry has again become an exciting area of research. Compounds of boron and hydrogen, known as boranes, have unique structural features that forced a change in thinking about the architecture of inorganic molecules. Some inorganic substances have structural features long believed to occur only in carbon compounds, and a few inorganic polymers have even been produced. Ceramics are materials composed of inorganic elements combined with oxygen. For centuries ceramic objects have been made by strongly heating a vessel formed from a paste of powdered minerals. Although ceramics are quite hard and stable at very high temperatures, they are usually brittle. Currently, new ceramics strong enough to be used as turbine blades in jet engines are being manufactured. There is hope that ceramics will one day replace steel in components of internal-combustion engines.[23] In 1987 a ceramic containing yttrium, barium, copper, and oxygen, with the approximate formula  $\text{YBa}_2\text{Cu}_3\text{O}_7$ , was found to be a superconductor at a temperature of about 100 K. A superconductor offers no resistance to the passage of an electrical current, and this new type of ceramic could very well find wide use in electrical and magnetic applications. A superconducting ceramic is so simple to make that it can be prepared in a high school laboratory. Its discovery illustrates the unpredictability of chemistry, for fundamental discoveries can still be made with simple equipment and inexpensive materials.

Many of the most interesting developments in inorganic chemistry bridge the gap with other disciplines. Organometallic chemistry investigates compounds that contain inorganic elements combined with carbon-rich units. Many organometallic compounds play an important role in industrial chemistry as catalysts, which are substances that are able to accelerate the rate of a reaction even when present in only very small amounts. Some success has been achieved in the use of such catalysts for converting natural gas to related but more useful chemical substances. Chemists also have created large inorganic molecules that contain a core of metal atoms, such as platinum, surrounded by a shell of different chemical units. Some of these compounds, referred to as metal clusters, have characteristics of metals, while others react in ways similar to biologic systems. Trace amounts of metals in biologic systems are essential for processes such as respiration, nerve function, and cell metabolism. Processes of this kind form the object of study of bioinorganic chemistry. Although organic molecules were once thought to be the distinguishing chemical feature of living creatures, it is now known that inorganic chemistry plays a vital role as well.





### Organic chemistry

Organic compounds are based on the chemistry of carbon. Carbon is unique in the variety and extent of structures that can result from the three-dimensional connections of its atoms. The process of photosynthesis converts carbon dioxide and water to oxygen and compounds known as carbohydrates. Both cellulose, the substance that gives structural rigidity to plants, and starch, the energy storage product of plants, are polymeric carbohydrates. Simple carbohydrates produced by photosynthesis form the raw material for the myriad organic compounds found in the plant and animal kingdoms. When combined with variable amounts of hydrogen, oxygen, nitrogen, sulfur, phosphorus, and other elements, the structural possibilities of carbon compounds become limitless, and their number far exceeds the total of all nonorganic compounds. A major focus of organic chemistry is the isolation, purification, and structural study of these naturally occurring substances. Many natural products are simple molecules. Examples include formic acid ( $\text{HCO}_2\text{H}$ ) in ants, ethyl alcohol ( $\text{C}_2\text{H}_5\text{OH}$ ) in fermenting fruit, and oxalic acid ( $\text{C}_2\text{H}_2\text{O}_4$ ) in rhubarb leaves. Other natural products, such as penicillin, vitamin  $\text{B}_{12}$ , proteins, and nucleic acids, are exceedingly complex. The isolation of pure natural products from their host organism is made difficult by the low concentrations in which they may be present. Once they are isolated in pure form, however, modern instrumental techniques can reveal structural details for amounts weighing as little as one-millionth of a gram. The correlation of the physical and chemical properties of compounds with their structural features is the domain of physical organic chemistry. Once the properties endowed upon a substance by specific structural units termed functional groups are known, it becomes possible to design novel molecules that may exhibit desired properties. The preparation, under controlled laboratory conditions, of specific compounds is known as synthetic chemistry. Some products are easier to synthesize than to collect and purify from their natural sources. Tons of vitamin C, for example, are synthesized annually. Many synthetic substances have novel properties that make them especially useful. Plastics are a prime example, as are many drugs and agricultural chemicals. A continuing challenge for synthetic chemists is the structural complexity of most organic substances. To synthesize a desired substance, the atoms must be pieced together in the correct order and with the proper three-dimensional relationships. [24] Just as a given pile of lumber and bricks can be assembled in many ways to build houses of several different designs, so too can a fixed number of atoms be connected together in various ways to give different molecules. Only one structural arrangement out of the many possibilities will be identical with a naturally occurring molecule. The antibiotic erythromycin, for example, contains 37 carbon, 67 hydrogen, and 13 oxygen atoms, along with one nitrogen atom. Even when joined together in the proper order, these 118 atoms can give rise to 262,144 different structures, only one of which has the characteristics of natural erythromycin. The great abundance of organic compounds, their fundamental role in the chemistry of life, and their structural diversity have made their study especially challenging and exciting. Organic chemistry is the largest area of specialization among the various fields of chemistry.

### IV. CONCLUSIONS

**Physical science**, the systematic study of the inorganic world, as distinct from the study of the organic world, which is the province of biological science. Physical science is ordinarily thought of as consisting of four broad areas: astronomy, physics, chemistry, and the Earth sciences. Each of these is in turn divided into fields and subfields. This article discusses the historical development—with due attention to the scope, principal concerns, and methods—of the first three of these areas. Physics, in its modern sense, was founded in the mid-19th century as a synthesis of several older sciences—namely, those of mechanics, optics, acoustics, electricity, magnetism, heat, and the physical properties of matter. The synthesis was based in large part on the recognition that the different forces of nature are related and are, in fact, interconvertible because they are forms of energy. The boundary between physics and chemistry is somewhat arbitrary. As it developed in the 20th century, physics is concerned with the structure and behaviour of individual atoms and their components, while chemistry deals with the properties and reactions of molecules. These latter depend on energy, especially heat, as well as on atoms; hence, there is a strong link between physics and chemistry. Chemists tend to be more interested in the specific properties of different elements and compounds, whereas physicists are concerned with general properties shared by all matter. Astronomy is the science of the entire universe beyond Earth; it includes Earth's gross physical properties, such as its mass and rotation, insofar as they interact with other bodies in the solar system. Until the 18th century, astronomers were concerned primarily with the Sun, Moon, planets, and comets. During the following centuries, however, the study of stars, galaxies, nebulae, and the interstellar medium became increasingly important. Celestial mechanics, the science of the motion of planets and other solid objects within the solar system, was the first testing ground for Newton's laws of motion and thereby helped to establish the fundamental principles of classical (that is, pre-20th-century) physics. Astrophysics, the study of the physical properties of celestial bodies, arose during the 19th century and is closely connected with the determination of

the chemical composition of those bodies. In the 20th century physics and astronomy became more intimately linked through cosmological theories, especially those based on the theory of relativity [23,24]

The physical sciences ultimately derive from the rationalistic materialism that emerged in classical Greece, itself an outgrowth of magical and mythical views of the world. The Greek philosophers of the 6th and 5th centuries BCE abandoned the animism of the poets and explained the world in terms of ordinarily observable natural processes. These early philosophers posed the broad questions that still underlie science: How did the world order emerge from chaos? What is the origin of multitude and variety in the world? How can motion and change be accounted for? What is the underlying relation between form and matter? Greek philosophy answered these questions in terms that provided the framework for science for approximately 2,000 years.

Western astronomy had its origins in Egypt and Mesopotamia. Egyptian astronomy, which was neither a very well-developed nor an influential study, was largely concerned with time reckoning. Its main lasting contribution was the civil calendar of 365 days, consisting of 12 months of 30 days each and five additional festival days at the end of each year. This calendar played an important role in the history of astronomy, allowing astronomers to calculate the number of days between any two sets of observations. Babylonian astronomy, dating back to about 1800 BCE, constitutes one of the earliest systematic, scientific treatments of the physical world. In contrast to the Egyptians, the Babylonians were interested in the accurate prediction of astronomical phenomena, especially the first appearance of the new Moon. Using the zodiac as a reference, by the 4th century BCE, they developed a complex system of arithmetic progressions and methods of approximation by which they were able to predict first appearances. The mass of observations they collected and their mathematical methods were important contributions to the later flowering of astronomy among the Greeks. The Pythagoreans (5th century BCE) were responsible for one of the first Greek astronomical theories. Believing that the order of the cosmos is fundamentally mathematical, they held that it is possible to discover the harmonies of the universe by contemplating the regular motions of the heavens. Postulating a central fire about which all the heavenly bodies including Earth and the Sun revolve, they constructed the first physical model of the solar system. Subsequent Greek astronomy derived its character from a comment ascribed to Plato, in the 4th century BCE, who is reported to have instructed the astronomers to “save the phenomena” in terms of uniform circular motion. That is to say, he urged them to develop predictively accurate theories using only combinations of uniform circular motion. As a result, Greek astronomers never regarded their geometric models as true or as being physical descriptions of the machinery of the heavens. They regarded them simply as tools for predicting planetary positions. Eudoxus of Cnidus (4th century BCE) was the first of the Greek astronomers to rise to Plato’s challenge. He developed a theory of homocentric spheres, a model that represented the universe by sets of nesting concentric spheres the motions of which combined to produce the planetary and other celestial motions. Using only uniform circular motions, Eudoxus was able to “save” the rather complex planetary motions with some success. His theory required four homocentric spheres for each planet and three each for the Sun and Moon. The system was modified by Callippus, a student of Eudoxus, who added spheres to improve the theory, especially for Mercury and Venus. Aristotle, in formulating his cosmology, adopted Eudoxus’s homocentric spheres as the actual machinery of the heavens. The Aristotelian cosmos was like an onion consisting of a series of some 55 spheres nested about Earth, which was fixed at the centre. In order to unify the system, Aristotle added spheres in order to “unroll” the motions of a given planet so that they would not be transmitted to the next inner planet.[25]

The theory of homocentric spheres failed to account for two sets of observations: (1) brightness changes suggesting that planets are not always the same distance from Earth, and (2) bounded elongations (i.e., Venus is never observed to be more than about  $48^\circ$  and Mercury never more than about  $24^\circ$  from the Sun). Heracleides of Pontus (4th century BCE) attempted to solve these problems by having Venus and Mercury revolve about the Sun, rather than Earth, and having the Sun and other planets revolve in turn about Earth, which he placed at the centre. In addition, to account for the daily motions of the heavens, he held that Earth rotates on its axis. Heracleides’ theory had little impact in antiquity except perhaps on Aristarchus of Samos (3rd century BCE), who apparently put forth a heliocentric hypothesis similar to the one Copernicus was to propound in the 16th century.

Hipparchus (flourished 130 BCE) made extensive contributions to both theoretical and observational astronomy. Basing his theories on an impressive mass of observations, he was able to work out theories of the Sun and Moon that were more successful than those of any of his predecessors. His primary conceptual tool was the eccentric circle, a circle in which Earth is at some point eccentric to the geometric centre. He used this device to account for various irregularities and inequalities observed in the motions of the Sun and Moon. He also proved that the eccentric circle is

mathematically equivalent to a geometric figure called an epicycle-deferent system, a proof probably first made by Apollonius of Perga a century earlier.

Among Hipparchus's observations, one of the most significant was that of the precession of the equinoxes—i.e., a gradual apparent increase in longitude between any fixed star and the equinoctial point (either of two points on the celestial sphere where the celestial equator crosses the ecliptic). Thus, the north celestial pole, the point on the celestial sphere defined as the apparent centre of rotation of the stars, moves relative to the stars in its vicinity. In the heliocentric theory, this effect is ascribed to a change in Earth's rotational axis, which traces out a conical path around the axis of the orbital plane.[23]

Ptolemy (flourished 140 CE) applied the theory of epicycles to compile a systematic account of Greek astronomy. He elaborated theories for each of the planets, as well as for the Sun and Moon. His theory generally fitted the data available to him with a good degree of accuracy, and his book, the *Almagest*, became the vehicle by which Greek astronomy was transmitted to astronomers of the Middle Ages and Renaissance. It essentially molded astronomy for the next millennium and a half.

Several kinds of physical theories emerged in ancient Greece, including both generalized hypotheses about the ultimate structure of nature and more specific theories that considered the problem of motion from both metaphysical and mathematical points of view. Attempting to reconcile the antithesis between the underlying unity and apparent multitude and diversity of nature, the Greek atomists Leucippus (mid-5th century BCE), Democritus (late 5th century BCE), and Epicurus (late 4th and early 3rd century BCE) asserted that nature consists of immutable atoms moving in empty space. According to this theory, the various motions and configurations of atoms and clusters of atoms are the causes of all the phenomena of nature.

In contrast to the particulate universe of the atomists, the Stoics (principally Zeno of Citium, bridging 4th and 3rd centuries BCE, Chrysippus [3rd century BCE], and Poseidonius of Apamea [flourished c. 100 BCE]) insisted on the continuity of nature, conceiving of both space and matter as continuous and as infused with an active, airlike spirit—*pneuma*—which serves to unify the frame of nature. The inspiration for the Stoic emphasis on pneumatic processes probably arose from earlier experiences with the “spring” (i.e., compressibility and pressure) of the air. Neither the atomic theory nor Stoic physics survived the criticism of Aristotle and his theory.

In his physics, Aristotle was primarily concerned with the philosophical question of the nature of motion as one variety of change. He assumed that a constant motion requires a constant cause; that is to say, as long as a body remains in motion, a force must be acting on that body. He considered the motion of a body through a resisting medium as proportional to the force producing the motion and inversely proportional to the resistance of the medium. Aristotle used this relationship to argue against the possibility of the existence of a void, for in a void resistance is zero, and the relationship loses meaning. He considered the cosmos to be divided into two qualitatively different realms, governed by two different kinds of laws. In the terrestrial realm, within the sphere of the Moon, rectilinear up-and-down motion is characteristic. Heavy bodies, by their nature, seek the centre and tend to move downward in a natural motion. It is unnatural for a heavy body to move up, and such unnatural or violent motion requires an external cause. Light bodies, in direct contrast, move naturally upward. In the celestial realm, uniform circular motion is natural, thus producing the motions of the heavenly bodies. Archimedes (3rd century BCE) fundamentally applied mathematics to the solution of physical problems and brilliantly employed physical assumptions and insights leading to mathematical demonstrations, particularly in problems of statics and hydrostatics. He was thus able to derive the law of the lever rigorously and to deal with problems of the equilibrium of floating bodies.[25]

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