Course: Lab Organization, Management & Safety Methods (698)
Semester: Spring, 2021
ASSIGNMENT No. 1

Q.1 How science teachers in Pakistan manage science students for laboratory.

That science education in Pakistan is inadequate is saying the obvious. In fact, it is bad enough to scare students away. There is a long list of problems with science education in the country. Textbooks written for Pakistani textbook boards and colleges are dreary and uninteresting, and only overload students with facts. Badly printed, they are terse in their explanations, and care little for graphic presentations. Teachers are either untrained or poorly trained, and hence uninspiring. Many have poor knowledge of the subject they teach, and hence discourage questions, and kill curiosity.

Examinations demand memorisation, so that students have no reason to understand and internalise the subject matter. Laboratory facilities are not available except in private elite schools or a few well-looked-after public schools. In most public schools, where lab equipment exists, students are not allowed to handle it for fear of causing damage, and the equipment is used by teachers to only demonstrate experiments to the students.

There is no reliable survey data available, but it is safe to say that Pakistani students are in general scared of studying science in schools and colleges. Most students in the higher classes opt for subjects in the arts and commerce. All of this is because of the way science is taught.

Teaching science requires special attention and special training of teachers in teaching methods that invoke reasoning and curiosity. It also requires laboratory equipment to let students explore and verify phenomena and learn methods of scientific inquiry. It requires textbooks that make scientific phenomena understandable through systematic exploration. End-chapter exercises in textbooks must not ask recall questions, but demand thinking, reasoning and analysis. The same is true for examinations.

Sadly none of this is evident in the vast majority of Pakistan's schools, public or private, except in some expensive elite schools. So only a small fraction of the total number of students gets to learn science properly; the rest are left struggling.

The biggest issue in science education in Pakistan, however, is the medium of instruction, an issue on which our policymakers have been vacillating when it comes to teaching in Urdu or English. Not long ago, it was decided by the Punjab chief minister that English would be the language in which science and mathematics would be taught in his province from class I. It transpired that it could not be done because the teachers at that level were unable to employ English as the medium of instruction.

The issue of the medium of instruction in science education is a complex one. Concepts and their explanations can be best conveyed and received in an easily understood language. In this respect, texts written in Urdu or mother tongues should be the best. But the problem arises with terminologies. The latter convey not only concepts behind phenomena but also interconnections between related phenomena through words that are derived from the same root.

The language of science instruction has to have the capacity to allow the formulation of terminologies that possess these two qualities. If a language does not have that capacity, it has no recourse but to borrow words from other languages. In borrowed terminologies, however, that interconnection can be lost, which is not an insignificant loss.

If we are to teach in Urdu and yet desire that the interconnectedness of terms, for example, oxygen, oxide, oxidation, oxidisation, oxidised, of the English language be preserved, the solution would lie in using Arabic and Persian vocabulary and grammar, as was done some decades ago. This for students today would be as unfamiliar as English words. An added problem for students would be to make the transition from Urdu vocabulary to English upon reaching higher classes.

Coupled with this is the seemingly perennial problem of poor teaching of English in public schools. A vast majority of students from public schools can hardly understand English. We observe this even at the university level where we see blank faces when we deliver lectures in English. Students often admit not being able to fully comprehend lessons in foreign textbooks, or even the questions at the end of the chapter.

No one familiar with this problem can agree with the assertion that science and mathematics be taught in English from early schooling. Teaching science and mathematics in English to those students who do not understand the language is tantamount to denying them the means to understand and hence enjoy learning these subjects. It also amounts to forcing them to memorise the text.

But even more painful is reading those science textbooks in Urdu which retain English terminologies transcribed in Urdu. It is not hard to imagine the difficulty faced by a class V student reading terms like ‘endangered species’ or names of complex organic molecules in Urdu, and understand why children get scared of science.

The answer eventually lies in increasing the English language skills of students — of all the students. Teaching of English in schools is a major unresolved problem of our educational system. One wonders why we cannot resolve this problem at the national level once and for all.

Science educators have believed that the laboratory is an important means of instruction in science since late in the 19th century. Laboratory activities were used in high school chemistry in the 1880s (Fay, 1931). In 1886, Harvard University published a list of physics experiments that were to be included in high school physics classes for students who wished to enroll at Harvard (Moyer, 1976). Laboratory instruction was considered essential because it provided training in observation, supplied detailed information, and aroused pupils' interest. These same reasons are still accepted almost 100 years later.

Shulman and Tamir, in the Second Handbook of Research on Teaching (Travers, ed., 1973), listed five groups of objectives that may be achieved through the use of the laboratory in science classes:

1. skills - manipulative, inquiry, investigative, organizational, communicative
2. concepts - for example, hypothesis, theoretical model, taxonomic category
3. cognitive abilities - critical thinking, problem solving, application, analysis, synthesis

4. understanding the nature of science - scientific enterprise, scientists and how they work, existence of a multiplicity of scientific methods, interrelationships between science and technology and among the various disciplines of science
5. attitudes - for example, curiosity, interest, risk taking, objectivity, precision,confidence, perseverance, satisfaction, responsibility, consensus, collaboration, and liking science.

Writing about laboratory teaching at the college level, McKeachie said:

Laboratory teaching assumes that first-hand experience in observation and manipulation of the materials of science is superior to other methods of developing understanding and appreciation. Laboratory training is also frequently used to develop skills necessary for more advanced study or research. From the standpoint of theory, the activity of the student, the sensorimotor nature of the experience, and the individualization of laboratory instruction should contribute positively to learning. Information cannot usually be obtained, however, by direct experience as rapidly as it can from abstractions presented orally or in print... Thus, one would not expect laboratory teaching to have an advantage over other teaching methods in the amount of information retention, in ability to apply learning, or in actual skill in observation or manipulation of materials.

Another writer, identified two misconceptions about the use of the laboratory in college science. One is that laboratories somehow "illustrate" lecture courses - a function that (in Pickering's opinion) is not possible in a simple, one-afternoon exercise. Pickering contended that most scientific theories are based on a large number of very sophisticated experiments. He suggested that, if lecture topics are to be illustrated, this should be done through the use of audio-visual aids or demonstrations. The second misconception is that laboratories exist to teach manipulative skills. Pickering argued that the majority of students in science laboratory classes do not have a career goal of becoming a professional scientist. Further, many of the skills students learn in laboratories are obsolete in science careers. If these skills are worth teaching, it is as tools to be mastered for basic scientific inquiry and not as ends in themselves.

Q.2 Why preservation of science materials is important? Write procedures for maintain stock.

Storage and Preservation are an important part of the storekeeping function. When materials remain idle in the store these materials should be taken care of and looked after properly. Otherwise these materials may get perished due to natural chemical reaction like rusting by moisture, melting by heat etc and also may get affected by insets, rats etc. In order to protect the materials from various adverse effects the following actions should be taken: -

1. Materials should be stocked free from ground. No material should be stocked on the floor as it may be affected by dampness, white ants etc.
2. Materials should be stocked in the appropriate place according to the nature of the materials. **Eg :**
   a. Stationery, Electrical, Civil Engineering, Cleaning and Similar items may be stocked in the steel racks.

b. Medicine items may be stocked in the fridge.

c. Perishable items may be stored in the cold rooms.

d. Explosive, film, fuse items may be stored in the AC room.

e. Attractive items may be stored in shelves under lock and keys.

3. Daily and periodical cleaning should be carried out.
4. Daily and periodical verification of stock should be carried out to ensue correctness of stock.
5. Proper method of handling should be followed to avoid damages to the materials.
6. Preservation materials should be applied to protect the items.
7. Hazardous materials should be segregated and stocked in a separate store house away from other store houses.
8. Safety precautions should be taken and safety appliances should be provided.

Receiving Materials

After, all the pre-purchase actions are completed, like selecting supplier, placing purchase order, follow-up etc., the materials are supplied by the supplier. Which receiving materials, a systematic record of the consignment received, carrier details and descriptions of materials so that inspection can be arranged prior to acceptance. Many organizations have a separate central receiving section for this purpose. As mentioned earlier a copy of the purchase order is sent to the central receiving section for reconciling purposes.

INVOICE CHECKING:

The supplier normally sends the invoice for the materials supplied for payment. It is essential that the invoice is matched against the receipt details, quantity accepted and rejected so that payments can be made within the discount period or provisions be made whic1h will keep in funds planning. Normally invoices are sent to the buyers finance department. A close coordination between the finance and materials management departments is necessary.

OPENING AND CHECKING OF CONSIGNMENT:

The bulk consignment should be opened at the central receiving section in the presence of a properly constituted board of officers comprising a presiding officer and some members from the concerned departments. Number of packages mentioned in the packing notes, If available should be opened and the materials checked against the invoice. The materials should be checked for quantity, quality, specification, condition etc. If the quantity is found less in comparison with the invoice, a discrepancy/shortage report will be raised and sent to the supplier to make good of the quantity found less. If any materials is found of substandard, and found not in confirmation with specification or found in a damaged condition, such materials will be rejected and the supplier should be informed o this matter. The supplier shall collect the rejected materials at his cost and shall provide suitable replacement as per the terms and condition laid down in the purchase order. The materials will be accepted and taken into stores stock and the bill be passed for payment.

RECEIVING MATERIALS SUPPLED AS DOOR DELIVERY:

The materials supplied by the supplier as door delivery, will be checked in comparison with the invoice in the presence of the supplier. If everything is OK the materials will be accepted and one copy of the invoice or the delivery will be signed and returned to the supplier. If any complaint is found, action as mentioned above will be taken.

Store Management

Stores play a vital role in the operations of an organization. It is in direct touch with the user department in its day-to-day activities. The most important purpose served by stores is to provide an uninterrupted service to the various user departments. In the case of a Hospital we can say the Operation Theatre, wards, specialty clinics, units, refraction departments, Registration, Admission departments etc., are the user departments. Further stores often equated directly with money, as materials have money value. The stores function can be details as under:

1. To receive ordered materials such as, components, tools, equipments, and other items and account for them.
2. To provide adequate and proper storage for preservation of various items.
3. The meet the demands of the consuming department by proper issues and account for the issues.
4. To minimize the stock holding through proper codification and handling to avoid the materials becoming surplus, obsolete and scrap.
5. To highlight stock accumulation, discrepancies and abnormal
6. Consumptions and effect suitable control measures.
7. To ensure good house keeping so that material handling, preservation, receipt and issue can be done smoothly.
8. To assist in verification and provide supported information for effective purchase activity.

To carryout the above function the following arrangements are essential:

a. Accommodation
b. Lay of stores
c. Central receiving and dispatching location
d. Cold storage etc
e. Comfortable working condition

Q.3 Write functions and use of the following: chisel, microscope, electric balance, Cork and wax.

1. A **chisel** is a tool with a characteristically shaped cutting edge (such that wood chisels have lent part of their name to a particular grind) of blade on its end, for carving or cutting a hard material such as wood, stone, or metal by hand, struck with a mallet, or mechanical power. The handle and blade of some types of chisel are made of metal or of wood with a sharp edge in it. Chiselling use involves forcing the blade into some material to cut it. The driving force may be applied by pushing by hand, or by using a mallet or hammer. In industrial use, a hydraulic ram or falling weight ('trip hammer') may be used to drive a chisel into the material. A gouge (one type of chisel) serves to carve small pieces from the material, particularly

in woodworking, woodturning and sculpture. Gouges most frequently produce concave surfaces. A gouge typically has a 'U'-shaped cross-section.

Firmer chisel

has a blade with a thick rectangular cross section, making them stronger for use on tougher and heavier work.

Bevel edge chisel

can get into acute angles with its bevelled edges.

Mortise chisel

thick, rigid blade with straight cutting edge and deep, slightly tapered sides to make mortises and similar joints. Common types are registered and sash mortice chisels.

Paring chisel

has a long blade ideal for cleaning grooves and accessing tight spaces.

Skew chisel

has a 60 degree cutting angle and is used for trimming and finishing across the grain.

Dovetail chisel

made specifically for cutting dovetail joints. The difference being the thickness of the body of the chisel, as well as the angle of the edges, permitting easier access to the joint.

Butt chisel

short chisel with beveled sides and straight edge for creating joints.

Carving chisels

used for intricate designs and sculpting; cutting edges are many; such as gouge, skew, parting, straight, paring, and V-groove.

Corner chisel

resembles a punch and has an L-shaped cutting edge. Cleans out square holes, mortises and corners with 90 degree angles.

Flooring chisel

cuts and lifts flooring materials for removal and repair; ideal for tongue-and-groove flooring.

Framing chisel

usually used with mallet; similar to a butt chisel, except it has a longer, slightly flexible blade.

Slick

a very large chisel driven by manual pressure, never struck.

Drawer lock chisel

An all metal chisel with 2 angled blades used for tight spaces, like cutting out the space for fitting a desk drawer lock.

2. There are three structural parts of the microscope i.e. head, base, and arm.

Head – This is also known as the body, it carries the optical parts in the upper part of the microscope.

Base – It acts as microscopes support. It also carriers the microscopic illuminators.

Arms – This is the part connecting the base and to the head and the eyepiece tube to the base of the microscope. It gives support to the head of the microscope and it also used when carrying the microscope. Some high-quality microscopes have an articulated arm with more than one joint allowing more movement of the microscopic head for better viewing.

The optical parts of the microscope are used to view, magnify, and produce an image from a specimen placed on a slide. These parts include:

1. **Eyepiece** – also known as the ocular. this is the part used to look through the microscope. Its found at the top of the microscope. Its standard magnification is 10x with an optional eyepiece having magnifications from 5X – 30X.
2. **Eyepiece tube** – its the eyepiece holder. It carries the eyepiece just above the objective lens. In some microscopes such as the binoculars, the eyepiece tube is flexible and can be rotated for maximum visualization, for variance in distance. For monocular microscopes, they are none flexible.
3. **Objective lenses** – These are the major lenses used for specimen visualization. They have a magnification power of 40x-100X. There are about 1- 4 objective lenses placed on one microscope, in that some are rare facing and others face forward. Each lens has its own magnification power.
4. **Nose piece** – also known as the revolving turret. It holds the objective lenses. It is movable hence it cal revolve the objective lenses depending on the magnification power of the lens.
5. **The Adjustment knobs** – These are knobs that are used to focus the microscope. There are two types of adjustment knobs i.e fine adjustment knobs and the coarse adjustment knobs.
6. **Stage** – This is the section on which the specimen is placed for viewing. They have stage clips hold the specimen slides in place. The most common stage is a mechanical stage, which allows the control of the slides by moving the slides using the mechanical knobs on the stage instead of moving it manually.
7. **Aperture** – This is a hole on the microscope stage, through which the transmitted light from the source reaches the stage.
8. **Microscopic illuminator** – This is the microscopes light source, located at the base. It is used instead of a mirror. it captures light from an external source of a low voltage of about 100v.
9. **Condenser** – These are lenses that are used to collect and focus light from the illuminator into the specimen. They are found under the stage next to the diaphragm of the microscope. They play a major role in ensuring clear sharp images are produced with a high magnification of 400X and above. The higher the magnification of the condenser, the more the image clarity. More sophisticated microscopes come with an Abbe condenser that has a high magnification of about 1000X.
10. **Diaphragm** – its also known as the iris. Its found under the stage of the microscope and its primary role is to control the amount of light that reaches the specimen. Its an adjustable apparatus, hence controlling the light intensity and the size of the beam of light that gets to the specimen. For high-quality microscopes, the

diaphragm comes attached with an Abbe condenser and combined they are able to control the light focus and light intensity that reaches the specimen.

11. **Condenser focus knob** – this is a knob that moves the condenser up or down thus controlling the focus of light on the specimen.
12. **Abbe Condenser** – this is a condenser specially designed on high-quality microscopes, which makes the condenser to be movable and allows very high magnification of above 400X. The high-quality microscopes normally have a high numerical aperture than that of the objective lenses.
13. **The rack stop** – It controls how far the stages should go preventing the objective lens from getting too close to the specimen slide which may damage the specimen. It is responsible for preventing the specimen slide from coming too far up and hit the objective lens.

3. An electromagnet levitates the balance's sample pan above a permanent cylindrical magnet. The amount of light reaching a photodetector indicates the sample pan's position; the amount of light reaching the detector in the absence of a sample defines the balance's null point. Placing an object on the balance displaces the sample pan downward by a force equal to the product of the sample's mass and its acceleration due to gravity. The balance detects this downward movement and generates a counterbalancing force by increasing the current to the electromagnet. The current returning the balance to its null point is proportional to the object's mass.

4. **Cork** is an impermeable buoyant material, the phellem layer of bark tissue that is harvested for commercial use primarily from Quercus suber (the cork oak), which is native to southwest Europe and northwest Africa. Cork is composed of suberin, a hydrophobic substance. Because of its impermeable, buoyant, elastic, and fire retardant properties, it is used in a variety of products, the most common of which is wine stoppers. The montado landscape of Portugal produces approximately half of cork harvested annually worldwide, with Corticeira Amorim being the leading company in the industry. Cork was examined microscopically by Robert Hooke, which led to his discovery and naming of the cell. Cork composition varies depending on geographic origin, climate and soil conditions, genetic origin, tree dimensions, age (virgin or reproduction), and growth conditions. However, in general, cork is made up of suberin (average of about 40%), lignin (22%), polysaccharides (cellulose and hemicellulose) (18%), extractables (15%) and others.

5. **Waxes** are a diverse class of organic compounds that are lipophilic, malleable solids near ambient temperatures. They include higher alkanes and lipids, typically with melting points above about 40 °C (104 °F), melting to give low viscosity liquids. Waxes are insoluble in water but soluble in organic, nonpolar solvents. Natural waxes of different types are produced by plants and animals and occur in petroleum. Waxes are organic compounds that characteristically consist of long aliphatic alkyl chains, although aromatic compounds may also be present. Natural waxes may contain unsaturated bonds and include various functional groups such as fatty acids, primary and secondary alcohols, ketones, aldehydes and fatty acid esters. Synthetic waxes often consist of homologous series of long-chain aliphatic hydrocarbons (alkanes or paraffins) that lack functional groups.

Q.4 Develop evaluative feedback sheet for following practicals:

i. Determination of center of gravity.

The **center of gravity** is a geometric property of any object. The center of gravity is the average location of the weight of an object. We can completely describe the motion of any object through space in terms of the **translation** of the center of gravity of the object from one place to another, and the **rotation** of the object about its center of gravity if it is free to rotate. If the object is confined to rotate about some other point, like a hinge, we can still describe its motion. In flight, both airplanes and rockets rotate about their centers of gravity. A kite, on the other hand, rotates about the bridle point. But the trim of a kite still depends on the location of the center of gravity relative to the bridle point, because for every object the weight always acts through the center of gravity.

Determining the center of gravity is very important for any flying object. How do engineers determine the location of the center of gravity for an aircraft which they are designing?

In general, determining the center of gravity (cg) is a complicated procedure because the mass (and weight) may not be uniformly distributed throughout the object. The general case requires the use of calculus which we will discuss at the bottom of this page. If the mass is uniformly distributed, the problem is greatly simplified. If the object has a line (or plane) of **symmetry**, the cg lies on the line of symmetry. For a solid block of uniform material, the center of gravity is simply at the average location of the physical dimensions. (For a rectangular block, 50 X 20 X 10, the center of gravity is at the point (25,10, 5)). For a triangle of height h, the cg is at h/3, and for a semi-circle of radius r, the cg is at (4*r/(3*pi)) where pi is ratio of the circumference of the circle to the diameter. There are tables of the location of the center of gravity for many simple shapes in math and science books. The tables were generated by using the equation from calculus shown on the slide.

For a general shaped object, there is a simple mechanical way to determine the center of gravity:

1. If we just balance the object using a string or an edge, the point at which the object is balanced is the center of gravity. (Just like balancing a pencil on your finger!)
2. Another, more complicated way, is a two step method shown on the slide. In Step 1, you hang the object from any point and you drop a weighted string from the same point. Draw a line on the object along the string. For Step 2, repeat the procedure from another point on the object You now have two lines drawn on the object which intersect. The center of gravity is the point where the lines intersect. This procedure works well for irregularly shaped objects that are hard to balance.

If the mass of the object is not uniformly distributed, we must use calculus to determine center of gravity. We will use the symbol **S dw** to denote the integration of a continuous function with respect to weight. Then the center of gravity can be determined from:

cg * W = S x dw

where **x** is the distance from a reference line, **dw** is an increment of weight, and **W** is the total weight of the object. To evaluate the right side, we have to determine how the weight varies geometrically. From the weight equation, we know that:

w = m * g

where **m** is the mass of the object, and **g** is the gravitational constant. In turn, the mass **m** of any object is equal to the density, **rho**, of the object times the volume, **V**:

m = rho * V

We can combine the last two equations:

w = g * rho * V

then

dw = g * rho * dV

dw = g * rho(x,y,z) * dx dy dz

If we have a functional form for the mass distribution, we can solve the equation for the center of gravity:

cg * W = g * SSS x * rho(x,y,z) dx dy dz

where **SSS** indicates a triple integral over **dx**. **dy**. and **dz**. If we don't know the functional form of the mass distribution, we can numerically integrate the equation using a spreadsheet. Divide the distance into a number of small volume segments and determining the average value of the weight/volume (density times gravity) over that small segment. Taking the sum of the average value of the weight/volume times the distance times the volume segment divided by the weight will produce the center of gravity.

ii. Preparation of Hydrogen gas in laboratory.

The laboratory preparation of hydrogen gas usually involves the action of dilute sulphuric acid or dilute hydrochloric acid on zinc granules. Granulated zinc is ideal for the preparation of hydrogen gas in chemical laboratories because it usually contains a small amount of copper, which has the ability to act as a catalyst to the associated chemical reaction and, therefore, increase the rate of the chemical reaction without actually participating in it. An experimental procedure for the laboratory preparation of hydrogen gas is provided below.

Procedure for the Laboratory Preparation of Hydrogen Gas

- **Step 1:** Take a few grams of zinc granules and place them in a 500 mL flask.
- **Step 2:** With the help of a thistle funnel, add dilute hydrochloric acid to the zinc granules. If hydrochloric acid isn't available, dilute sulphuric acid can be used as an alternative.
- **Step 3:** Hydrogen gas will be automatically collected with the help of a delivery tube via the downward displacement of water. This can be explained by the fact that hydrogen gas is lighter than water.

The chemical reactions that take place during the preparation of hydrogen gas via this method are listed below.

- **General Format:** Metal + Dilute Acid → Salt of Metal & Acid + Hydrogen
- **With Hydrochloric Acid:** $Zn + 2HCl \rightarrow ZnCl_2 + H_2$
- **With Sulphuric Acid:** $Zn + H_2SO_4 \rightarrow ZnSO_4 + H_2$

Finally, the hydrogen gas can be collected by the downward displacement of water.

Precautions to be Taken While Preparing Hydrogen Gas in the Laboratory

Before collecting the hydrogen gas with the help of the apparatus, precautions must be taken in order to ensure that all the air inside the apparatus has been displaced. This is because hydrogen gas reacts explosively with air.

Characteristics and Uses of Hydrogen Gas

Hydrogen gas is a colourless gas which does not have any distinct odour. This gas is sparingly soluble in water. The solubility of this gas in water is not affected too much by any changes in temperature. Some uses of hydrogen gas are listed below.

- This gas is used to fill many balloons and airships.
- It is also used for the hardening of animal oils and certain vegetable oils.
- Hydrogen gas is widely used as a fuel in oxy-hydrogen blow pipes.

To learn more about the laboratory preparation of hydrogen gas, register with BYJU'S and download the mobile application on your smartphone.

Q.5 What are common characteristics of physics, chemistry and Biology laboratories?

Many high schools teach biology, chemistry and physics as separate classes. Separate classes may suggest that the subjects are unrelated, but this would be an inaccurate assumption. Integrated science classes increasingly linking the subjects of biology, chemistry and physics.

Defining and Integrating Science Disciplines

As Merriam-Webster defines them, biology is the study of life, more specifically "a branch of knowledge that deals with living organisms and vital processes"; chemistry consists of "a science that deals with the composition, structure and properties of substances and with the transformations that they undergo"; and physics means "a science that deals with matter and energy and their interactions."

Integrating Biology and Chemistry

The relationship between chemistry and biology offers many possible connections and science experiments for college students in biology. All life depends on chemical processes. The chemical process of photosynthesis, which uses the sun's energy to convert water and carbon dioxide into glucose (sugar), forms the base of most food chains. Like photosynthesis, chemosynthesis stores energy through chemical processes and underpins the food chains along deep sea vents, suggesting possibilities for Earth's earliest life and life on other planets and moons.

Bioluminescence means living light. Chemical processes in a variety of organisms, ranging from plants to fungi to animals, including dinoflagellates, jellyfish and angler fish, create this living light. Digestion and cellular respiration also depend on chemical reactions within living organisms. Understanding the chemistry of oil production, based on the decomposition of algae under heat and pressure, offers one solution to the global energy crisis by making petroleum from algae, but it potentially creates another environmental crisis through continued use of previously nonrenewable fossil fuels.

Integrating Biology and Physics

The physics of living organisms also offers opportunities for science experiments for college students of biology. Physics includes the studies of mechanics, heat, light, electricity and sound. Studies of the energy used by living organisms, whether from photosynthesis or cellular respiration, blur the line between biology and physics. Studies of bioluminescence examine both the energy and the light generated by organisms, combining physics and biology. The electricity of the nervous system, the mechanisms that trigger hibernation or estivation, and the sensitivity of the retina and eardrum apply the principles of physics to the mechanisms of organisms.

Studies of the forces that break bones provide insights into biomechanical designs for repairing those same bones to their pre-broken strength and suggests methods to correct environmental or genetic defects or deficiencies. Understanding the mechanics and structural requirements of various body joints has already provided the information needed to design replacement knee, hip and shoulder joints.

Integrating Biology, Chemistry and Physics

Organisms, whether living, dead or extinct, function because of their combined biological, chemical and physical elements. Understandings from these disciplines provide insights into the evolutionary and structural characteristics of organisms. For example, trees stand because the cellulose in their cell walls and the water stored in their vacuoles provide the structural strength to hold up the tree's biomass, including the leaves that convert water and carbon dioxide to energy to fuel the chemical processes that allow cells to grow and reproduce to form new cells. Understanding the structural strength of bones and the chemical processes of metabolism helps scientists understand and re-create the biology of extinct organisms like dinosaurs and marine reptiles. Studying the physics and chemistry of Earth-bound biological systems suggests the existence and structures of potential life forms under extra-terrestrial conditions.

Biology, Chemistry or Physics?

Many colleges now offer integrated science programs rather than isolated studies in biology, chemistry or physics. These college programs recognize the interconnectivity of scientific disciplines. The current kindergarten through high school science standards focus on integrated science, with increasing emphasis on interconnected science, technology, engineering and mathematics (STEM or, with the addition of art, STEAM) education. Many colleges, ranging from Princeton's Integrated Science Curriculum to University of Oregon's Department of Chemistry and Biochemistry to the Biology Department at Harvey Mudd College now offer courses and degrees that do not limit themselves to a single traditional scientific discipline.