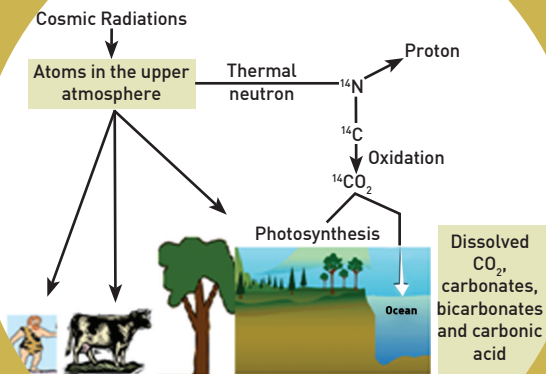


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Production and
distribution of ^{14}C in
the environment

To Our Contributors

School Science is a journal published quarterly by the National Council of Educational Research and Training, New Delhi. It aims at bringing within easy reach of teachers and students the recent developments in science and mathematics and their teaching, and serves as a useful forum for the exchange of readers' views and experiences in science and mathematics education and science projects.

Articles suitable to the objectives mentioned above are invited for publication. An article sent for publication should normally not exceed ten typed pages and it should be exclusive to this journal. A hard copy of the article including illustrations, if any, along with a soft copy should be submitted in CD. Photographs (if not digital) should be at least of postcard size on glossy paper and should be properly packed to avoid damage in transit. The publisher will not take any responsibility or liability for copyright infringement. The contributors, therefore, should provide copyright permission, wherever applicable and submit the same along with the article.

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सशक्त बालिका सशक्त नारी
तभी उन्नत होगी मानवता हमारी

Editorial

In the current issue of December 2014, we have incorporated articles related to physics, chemistry, biology and mathematics.

The first article, “Problem-based Learning in Basic Physics—VI” is a sequel to part V which has been published in the June 2014 issue. The authors pose problems related to the area of quantum physics and nuclear physics and they present the learning objectives in this area thereby achieving the solutions.

“Magic of Vitamin C” is an article in this issue which highlights the importance of Vitamin C in our diet. In the article, “Students’ Understanding of Heredity and Variation”, the author tries to investigate the pedagogical knowledge of students on heredity and variation. The investigation is done through questionnaires distributed to secondary, senior secondary and undergraduate students.

In the article, “Principles behind Carbon Dating and its Various Uses”, the author attempts to bring forth the methods and chemistry behind carbon dating.

The article, “A Study of Scientific Attitude among Learners in Botswana”, describes the analysis of the scientific attitude of varied sample including learners from junior secondary and senior secondary school levels and also a group of prospective science teachers from a college of secondary education in Botswana.

Further, like the other issues, this one also has Science News and Web Watch for our readers. In the Web Watch section, we have included two free websites where you will get to read novels—classic and contemporary, and a website related to science.

Your kind suggestions are always welcome. We wish you a fruitful reading.

*“The future belongs to science and those who make friends
with science.”*

Jawaharlal Nehru

PROBLEM-BASED LEARNING IN BASIC PHYSICS – VI

A.K. Mody

V.E.S. College of Arts, Science and Commerce
Mumbai

H.C. Pradhan

HBCSE, TIFR
Mumbai

In this article, sixth in the series, we present problems for a problem-based learning course from the area of quantum physics and nuclear physics. We present the learning objectives in this area of basic physics and what each problem tries to achieve with its solution.

Introduction

In this article, sixth in the series of 'Problem-based Learning in Basic Physics', we present problems on Quantum Physics and Nuclear Physics. Methodology and philosophy of selecting these problems are already discussed (Pradhan and Mody, 2009; Mody and Pradhan, 2011).

To review methodology in brief, we note here that this PBL (Problem-based Learning) starts after students have been introduced to formal structure of Physics. Ideally, students would attempt only the main problem. If they find it difficult, then depending upon their area of difficulty, right auxiliary problems have to be introduced by the teacher who is expected to be a constructivist facilitator. The teacher may choose as per her/his requirement or may construct questions on the spot to guide students to the right idea and method.

Problems on Quantum Physics

Learning Objectives

1. Exposure to quantum idea.
2. Planck and Einstein equation.

3. Bohr's theory of hydrogen atom and emission of spectral lines.
4. Calculation to get an idea of magnitude of quantities involved.

Problems

1. A beam of light has three wavelengths 4144 \AA , 4972 \AA and 6216 \AA with a total intensity of $3.6 \times 10^{-3} \text{ W/m}^2$ equally distributed amongst the three wavelengths. The beam falls normally on an area of 10 cm^2 of a clean metallic surface of work function 2.3 eV . Assume that there is no loss of light by reflection and that each energetically capable photon ejects one electron. Calculate the number of photoelectrons liberated in two seconds.
 - This problem needs to use photoelectric equation to find which of the wavelengths can induce photoelectric emission. It requires to calculate flux of photon (number of photons incident) of each wavelength to find the number of electrons emitted, by using Planck's quantum hypothesis.

Tasks involved in solving this problem are:

- a. To find which of the wavelength is above threshold to be rejected.

- b. To calculate number of photons incident corresponding to each wavelength using given information and Planck's quantum hypothesis.
 - c. To find number of electrons emitted as per Einstein's photoelectric equation.
2. Consider a potassium surface that is 75 cm away from a 100 W bulb. Suppose that the energy radiated by the bulb is 5% of the input energy. Treating each potassium atom as a circular disc of diameter 1 \AA , determine the time required for each atom to absorb an amount of energy equal to its work function of 2.0 eV, according to the wave interpretation of light.
- This problem involves estimation of time required for photoelectric emission on the basis of classical theory.
 - Since calculation of this problem contradicts observation, it illustrates the need for a new (quantum) theory.

Tasks involved in solving this problem are:

- a. To calculate the amount of energy received by an atom per second from geometrical consideration from given data.
 - b. To calculate the time using given data of energy required for emission of electron.
3. A hydrogen atom is excited from a state with $n=1$ to a state with $n=3$. Calculate (a) the energy absorbed by the atom, and (b) the wavelengths of the spectral lines emitted when the atom returns from $n=3$ to $n=1$ state. Display the lines emitted on an energy level diagram.
- This problem involves simple calculation based on Bohr's theory and understanding of possible paths for de-excitation of electron.

Tasks involved in this problem are:

- a. To calculate energy needed to excite H-atom from ground state to its second excited state.
- b. To recognise all the possible paths available to return to the ground state.
- c. To calculate wavelengths emitted in the process.
- d. To draw and show transitions on energy level diagram.

Problems on Nuclear Physics

Learning Objectives

1. To become familiar with the law of radioactive decay and nuclear energy.
2. Application of radioactivity.
3. Nuclear energy calculation. How important is it?

Problems

1. Assume when the planet earth was formed, U^{238} and U^{235} were present in equal abundance. At present, the ratio of their abundance is 140:1. If their half-lives are 4.5×10^9 years and 7.13×10^8 years respectively, estimate the age of the earth.

Tasks involved in solving this problem are:

- a. To write equation for radioactive decay for each species of uranium.
 - b. To estimate time lapsed assuming both the species were equally abundant initially using their present proportion.
2. A small quantity of solution containing Na^{24} radio nuclide (half-life 15 hours) of activity 1.0μ curie is injected into blood of a person. A sample of the blood of volume

1cc taken after 5 hours shows an activity of 296 disintegrations per minute. Determine the total volume of blood in the body of the person. Assume that the radioactive solution mixes uniformly in the blood of the person. (1 curie = 3.7×10^{10} dps) [JEE¹, 1993]

- This problem also involves simple exponential decay but this time for medical application.

Tasks involved in solving this problem are:

- To understand here that the activity will vary not only with time but also with the sample of blood.
 - To estimate total volume of blood from the sample using exponential decay of activity and volume dependency.
3. In the interior of the Sun, a continuous process of 4 protons fusing into helium nucleus and a pair of positrons is going on. Calculate:
- The release of energy per process.
 - If the Sun radiates an energy of about 4×10^{26} J/s, how much mass gets converted into helium every second?
 - If mass of the Sun is 2×10^{30} kg, estimate the time it will take to convert all the mass into helium.
 - The Sun has been in its present stable state for 5×10^9 yrs, how many more years will it continue to shine in this stable state? Neglect the energy carried away by neutrinos.

Given: $m({}_1\text{H}^1) = 1.007825 \text{ amu}$,

$m({}_2\text{He}^4) = 4.002603 \text{ amu}$,

$m_e = m_\beta = 5.5 \times 10^{-4} \text{ amu}$;

$1 \text{ amu} = 931.5 \text{ MeV}$

- This problem involves simple energy calculation in nuclear processes and estimation (order of magnitude) of life of the Sun.

Tasks involved in solving this problem are:

- To calculate energy released per process.
 - To calculate mass of hydrogen consumed from solar luminosity.
 - To calculate the time required for Sun to burn all its hydrogen and hence estimate its life.
4. It is proposed to use the nuclear fusion reaction ${}_1\text{H}^2 + {}_1\text{H}^2 \rightarrow {}_2\text{He}^4$ in a nuclear reactor of 200 MW rating. If the energy from the above reaction is used with 25% efficiency in the reactor, how many grams of deuterium fuel will be needed per day [The masses of ${}_1\text{H}^2$ and ${}_2\text{He}^4$ are 2.0141 amu and 4.0026 amu respectively].
- This problem is similar to problem 3. Its importance is from the point of view of nuclear power generation.

Tasks involved in solving this problem are similar to those mentioned in problem 3.

Solutions

Quantum Physics

1. Photoelectric Effect

$I = 3.6 \times 10^{-3} \text{ W/m}^2$ distributed equally amongst three wavelengths

\therefore Each will be $1.2 \times 10^{-3} \text{ W/m}^2$ and $W_0 = 2.3 \text{ eV}$

$\lambda_1 = 4144 \text{ \AA}$; corresponding energy $E_1 = hc/\lambda_1 = 2.999 \text{ eV}$

¹JEE — Joint Entrance Examination for admission to IIT.

$$\lambda_2 = 4972 \text{ \AA}; \text{ corresponding energy}$$

$$E_2 = hc/\lambda_2 = 2.500 \text{ eV}$$

$$\lambda_1 = 6216 \text{ \AA}; \text{ corresponding energy}$$

$$E_3 = hc/\lambda_3 = 1.990 \text{ eV}$$

Thus, only the first will be able to knock electrons off.

Thus, in 1 sec (from 10 cm^2) λ_1 will be able to eject

$$N_1 = \frac{1/3}{hc/I_1} A = 2.5 \times 10^{12} \text{ electrons}$$

and λ_2 will be able to eject

$$N_2 = \frac{1/3}{hc/I_2} A = 6.0 \times 10^{12} \text{ electrons}$$

Total number of electrons emitted in 2 sec = $2(N_1 + N_2)$

2. Photoelectric Effect in Classical Domain

Input power: P

Fraction of input power radiated: f

Work function of the metal: W_0

Diameter of the atom: D

Distance of atom from the bulb: d

\therefore time required for emission

$$\ddot{A}t = \frac{W_0}{fP} \frac{4pd^2}{p\left(\frac{D}{2}\right)^2} = 57.6 \text{ sec}$$

3. Bohr Theory

In transition from $n = 3$ to $n = 1$, there are three possible wavelengths that can be emitted:

$$\lambda_{3 \rightarrow 1} = 6577 \text{ \AA}, \lambda_{3 \rightarrow 2} = 1028 \text{ \AA} \text{ and } \lambda_{2 \rightarrow 1} = 1219 \text{ \AA}$$

Nuclear Physics

1. Radioactive Dating

$$N_0 (\text{U}^{238}) = N_0 (\text{U}^{235}) \text{ but } N (\text{U}^{238}) : N (\text{U}^{235}) = 140 : 1$$

$$T_{1/2} (\text{U}^{238}) = 4.5 \times 10^9 \text{ years and } T_{1/2} (\text{U}^{235}) = 7.13 \times 10^8 \text{ years}$$

$$T_{1/2} = 0.693/\lambda$$

$$N = N_0 e^{-\lambda t} \Rightarrow t = \frac{\log_e \left(\frac{N_1}{N_2} \right)}{(I_2 - I_1)} = 6.04 \times 10^9 \text{ years}$$

2. Medical Application of Radioactivity

$$\text{Activity } A = dN/dt, A = A_0 e^{-\lambda t} \text{ and } T_{1/2} = 0.693/\lambda$$

$$A_0 = 3.7 \times 10^4 \text{ dps and } T_{1/2} = 15 \text{ hrs}$$

Let V be the total volume of blood and

$$v = 1 \text{ cc} : \text{ sample}$$

After $t = 5 \text{ hrs}$, $a = 296 \text{ dpm}$ in volume v whereas $A = 2.937 \times 10^3 \text{ dps}$

$$\therefore V = v(A/a) = 5953 \text{ cc} = 5.953 \text{ litre}$$

3. Nuclear Fusion in the Sun

(i) Release of energy per process = mass excess = 25.7066 MeV

(ii) Total energy \div energy per process = no. of processes per sec = $9.725 \times 10^{37} / \text{sec}$

Mass converted into Helium = no. of processes $\times m({}_2^4\text{He}) = 6.5 \times 10^{11} \text{ kg/sec}$

(iii) Time to convert all mass into Helium at this rate = mass of the Sun \div rate of He production = $1.886 \times 10^{11} \text{ years}$

(iv) $1.886 \times 10^{11} \text{ years} - 5 \times 10^9 \text{ years} = 1.836 \times 10^{11} \text{ years}$

4. Nuclear Fission in a Nuclear Reactor

Energy per reaction = mass excess = 23.8464 MeV

200 MW at 25% efficiency means the total energy produced must be 800 MW

This requires $800 \text{ MW} \div 23.8464 \text{ MeV}$
 $= 2.0968 \times 10^{20}$ reaction

Number of deuterium atoms required per second = $2 \times 2.0968 \times 10^{20} = 4.194 \times 10^{20}$

This translates to 1.402×10^{-6} kg per second or 0.1211 kg per day.

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MAGIC OF VITAMIN C

Rajinder Kaur

Assistant Professor, Department of Human Genetics
Punjabi University, Patiala

Gurpreet Kaur

Research Scholar, Department of Human Genetics
Punjabi University, Patiala

Paramvir Singh

Associate Professor, Department of Sport Sciences
Punjabi University, Patiala

Introduction

Vitamin C is an odourless, water-soluble antioxidant vitamin. Humans and some other primates cannot synthesise Vitamin C in their body as they lack enzyme (L-gulonolactone oxidase) which converts glucose into Vitamin C in the liver of certain animals (Burns, 1959). Most plants and animals can synthesise this vitamin. Human body procures this vitamin mainly from fresh fruits and vegetables and also from animal products. There are many health benefits of Vitamin C. It plays a vital role in normal functioning of the body. It helps in the formation of collagen, lowers blood cholesterol, regulates nervous system, formation of neurotransmitters and increases iron absorption in gut. Even a high dose of Vitamin C can help in preventing certain chronic diseases like heart disease, cancer, atherosclerosis, diabetes, cataracts and muscular degeneration. Vitamin C or Ascorbic Acid is a powerful antioxidant because it can form a stable free radical by donating hydrogen atom and protects body from harmful free radical pollutants (e.g., superoxide, nitric oxide and hydroxyl radicals) and other reactive species (e.g., hydrogen peroxide, peroxy nitrite and hypochlorous acid) (Iqbal, Khan and Khan, 2004).

History

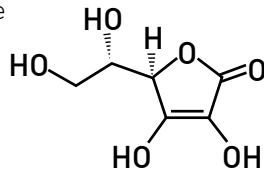
Importance of Vitamin C was noticed during 17th century when the sailors or sea voyagers developed a disease named scurvy when they were in the sea. Some crew members died as the severity of disease increased. It was noticed that fresh fruits and vegetables were lacking in their diet. In the book, *Surgeon's Mate*, written by a ship's surgeon to East India Company, Richard Woodall recommended that citrus juice can be a preventive cure for scurvy. In May 1747, James Lind, a ship's surgeon in British Royal Navy, did a controlled experiment in which he provided citrus or lemon juice to a group of some crew members in addition to normal diet while the other group continued with the normal diet only. Comparing the two groups, he noticed that lemon juice had a positive effect on prevention of the disease.

Chemical Structure of Vitamin C

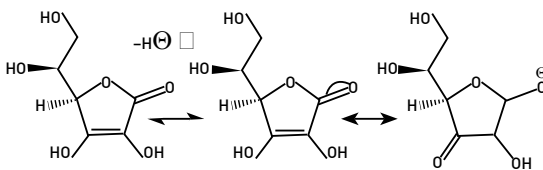
Chemical or molecular formula of Vitamin C is $C_6H_8O_6$ and molecular mass 176.14 grams per mole. Vitamin C naturally exists as L-enantiomer of ascorbate. IUPAC name of Vitamin C is (5R)-[[1S]-1, 2-dihydroxyethyl]-3,

4-dihydrofuran-2(5H)-one. Vitamin C is also known as L-ascorbic acid, 3-oxo-L-gulofurenolactone (enol form) and antisorbutic vitamin because of its anti-scurvy properties (Naidu, 2003).

Ascorbic acid is quite acidic in nature as compared to other hydroxyl groups because it can donate H^+ ion and form two resonating structures which stabilise its deprotonated conjugate base. It reacts with reactive oxygen species quite easily and acts as a powerful reducing agent in certain biochemical reactions.

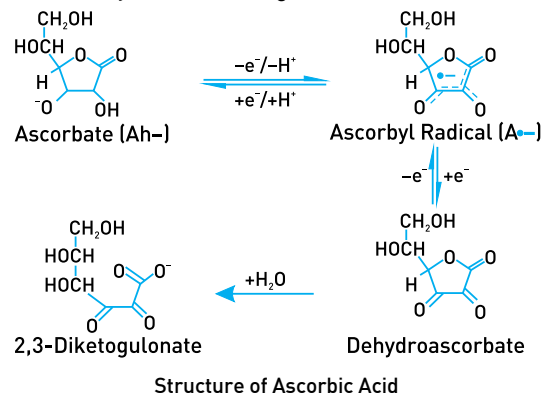


Structure of Vitamin C



Resonance Structures of Ascorbic Acid

The oxidation product of ascorbate is ascorbyl radical and DHA (Dehydro-ascorbic acid), the two electron oxidation products. Both readily reduce back to ascorbic acid but DHA can be hydrolysed irreversibly to 2,3-diketogulonic acid.



Structure of Ascorbic Acid

Discovery

A Polish-American scientist Casimir Funk conducted research in deficiency diseases in early 20th century. In 1912, he formulated the concept of vitamins, those were present in food and were essential to health. From 1928 to 1932, the Hungarian research team of Joseph L. Svirbely and Albert Szent-Györgyi and independently the American Charles Glen King did their research and isolated Vitamin C. In 1937, the Nobel Prize was awarded to Sir Walter Norman Haworth for mass production of Vitamin C artificially (Svirbely and Szent-Györgyi, 1932; King and Waugh, 1932). In 1959, American J.J. Burns showed that mammalian livers produce the active enzyme L-gulonolactone oxidase which synthesises ascorbic acid, due to which mammals are susceptible to scurvy (Burns, 1959).

Sources of Vitamin C

Ascorbic acid or ascorbate is mainly found in fresh citrus fruits like lemon and orange and green vegetables. Some other fruits include mango, cherry, kiwi fruit, strawberry, honeydew, melon, cantaloupe, tangelo, watermelon and papaya. Vegetables which contain Vitamin C are broccoli, brussels, cabbage, peas, red and green peppers, cauliflower, sprouts, potato and tomato. Most animals can synthesise Vitamin C from glucose in liver. Milk and fish also contain some amount of Vitamin C (Platt, Eddy and Pellet, 1963). Additional supplementation of synthetic ascorbic acid which can be taken along with food is available in the form of tablets, chewable tablets, capsules, crystalline powder and also in liquid form. These should be taken under physician's supervision.

Sensitivity of Vitamin C

Vitamin C is sensitive to heat, light, air and water. It may be lost from food during processing/cooking, packaging and storage of food because of its reducing property. This loss of ascorbic acid depends upon the extent of its exposure towards heat, oxygen, water and pH. The amount of Vitamin C can also decrease with age of fruit/vegetable (Platt et al., 1963).

Dietary Reference Intake (DRI) of Vitamin C

Dietary recommendations of Vitamin C for different age-groups based on data given by National Health and Nutrition Examination Survey (NHANES III) are as follows:

RDA (Recommended Daily Allowance) for infants:

0–6 months : 40mg (227 μ mol)/day of Vitamin C
[AI = Adequate Intake]

6–12 months : 50mg (256 μ mol)/day of Vitamin C
[AI = Adequate Intake]

RDA for children:

1–3 years : 15mg (85 μ mol)/day of Vitamin C

4–8 years : 25mg (142 μ mol)/day of Vitamin C

9–13 years : 45mg (256 μ mol)/day of Vitamin C

RDA for adolescents:

Girls 14–18 years: 65mg (370 μ mol)/day of Vitamin C

Boys 14–18 years: 75mg (426 μ mol)/day of Vitamin C

RDA for adults:

Women over 19 years: 75mg (426 μ mol)/day of Vitamin C

Men over 19 years: 90mg (511 μ mol)/day of Vitamin C

RDA for pregnant and lactating women:

Pregnant women over 18 years: 85mg (483 μ mol)/day of Vitamin C

Lactating women over 18 years: 120mg (682 μ mol)/day of Vitamin C

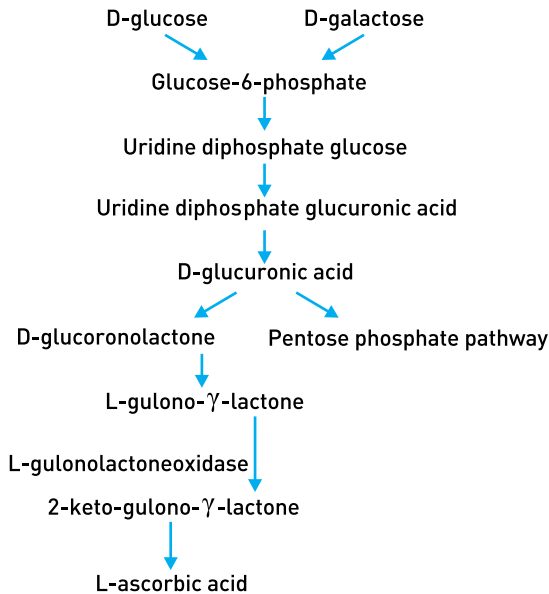
Recommended daily allowance (RDA) is replaced by dietary reference intake (DRI) in 2000 (FAO/WHO, 2000; NRC, 1989).

People who smoke may need an additional amount of 35mg of Vitamin C which is around 50 per cent extra of the regular intake; this is because smoking depletes it more readily. Vitamin C is rapidly used up by body in stressful conditions. In case of alcohol users, during fever, viral illness, exposure to petroleum products and heavy metals, the utilisation of Vitamin C increases. During exercise, Vitamin C is utilised more rapidly than during normal physical tasks (Weber, Bendich and Scralch, 1996).

Metabolism of Vitamin C

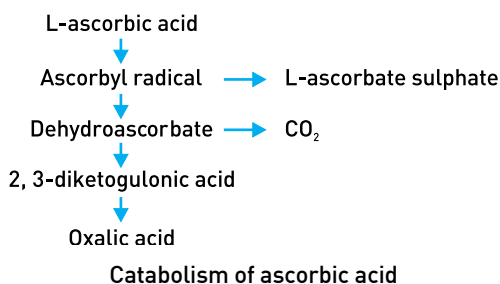
Biosynthesis of Vitamin C occurs in the liver of vertebrates from D-glucose and D-galactose. In the Vitamin C metabolic pathway, semidehydroascorbate is a major product which is reconverted into ascorbate in the cytosol by cytochrome b.

Ascorbic acid is absorbed in buccal mucosa, stomach and small intestine. Gastrointestinal absorption of ascorbic acid occurs through a sodium dependent active transport process that is saturable and dose dependent (Rumsey and Levine, 1998; Stevenson, 1974).



Biosynthesis of L-ascorbic acid in animals

At lower ascorbate concentrations, active transport predominates while at higher concentration, simple diffusion occurs (Gaby and Singh, 1991). When 100mg/day is consumed, its 80–90 per cent is absorbed by the body while the efficiency of absorption declines when the intake is increased up to 500mg/day. The major metabolite of ascorbic acid in humans are DHA, 2,3-ketogulonic acid and oxalic acid. Excess of ascorbic acid is eliminated through urine when consumed in high dose.



Catabolism of ascorbic acid

It is generally non-toxic but in excess dose can cause gastrointestinal disturbances which can be cured by reducing its consumption (Rumsey and Levine, 1998).

Functions of Vitamin C

Vitamin C is truly a wonder nutrient because it helps in regulating normal body functions, and also some serious degenerative diseases can be prevented or reversed by the adequate intake of this nutrient.

Physiological Functioning of Vitamin C

Ascorbic acid is an antioxidant and can reduce oxygen species in a variety of biochemical reactions acting as co-factor in the reactions (Buettner, 1993). Ascorbic acid is electron donor to eight human enzymes which participate in carnitine biosynthesis, amino-acid biosynthesis, collagen hydroxylation, biosynthesis of catecholamines, norepinephrine and epinephrine and amidation of peptide hormones. Carnitine and catecholamines hormones contribute in regulating the nervous system. Ascorbic acid also acts as a co-factor in biosynthesis of neuropeptides (Levine, 1996). It regulates iron absorption, storage and transportation; and also helps the body to absorb the iron component of many allergic reactions. Vitamin C helps in metabolism of tyrosine, folic acid and tryptophan. It helps in cholesterol elimination from body hence reducing blood cholesterol levels (Gaby and Singh, 1991).

Ascorbic acid plays a vital role in influencing collagen gene expression, cellular procollagen secretion and biosynthesis of other connective tissue components, including elastin, fibronectin, proteoglycans, bone matrix and elastin associated fibrillin. It helps in maintenance of

collagen and blood vessel integrity. Ascorbic acid functions as inactivator of substrates such as endogenous hormones or xenobiotics (i.e., other chemical compounds such as drugs, pesticide, or carcinogens that are foreign to humans) (Tsao, 1997). Vitamin C itself acts as an antioxidant and also regenerates other antioxidants. Low levels of Vitamin C in body can cause decreased performance in athletes (Dekkers, Van Doornen and Kemper, 1996). For an exercising individual, 100mg to 500mg is sufficient and should be taken in small quantities and at multiple intervals. If it is taken in adequate amount, it may be beneficial to the performance of athletes (Tsao, 1997).

Vitamin C can have some epigenetic role in control of gene expression. There is some evolutionary significance due to which humans and some primates lost their capability of synthesising Vitamin C (Poliseno et al., 2010) The genetics bases behind the losses in the ability to synthesise Vitamin C is due to mutations in the L-gluono- α -lactone oxidase (GLO) gene which codes for the enzyme responsible for catalysing the last step of Vitamin C biosynthesis (Drouin, Godin and Page, 2011). Mutation in this particular gene is likely due to the fact that losing it only affects Vitamin C production, whereas the GLO gene mutation in fish, anthropoid primates and guinea pigs is irreversible; some of the GLO pseudo genes found in bat species have been shown to be reactivated during evolution. The same phenomenon is thought to have occurred in some Passeriformes bird species. Interestingly, these GLO gene losses and reactivations are unrelated to the diet of the species involved. This suggests that losing the ability to make Vitamin C is a neutral trait (Poliseno et al., 2010).

Clinical Importance

Deficiency of Vitamin C can cause scurvy in which deterioration of elastic tissue occurs as it plays an important role in connective tissue synthesis (Ronchetti, Quagliano and Bergamini, 1996). Several symptoms of ascorbic acid deficiency have been recognised including follicular hyperkeratosis, swollen and inflamed gums, loosening of teeth, dryness of the mouth and eyes, loss of hair and dry itchy skin. Depression and hysteria may also occur as psychological symptoms. It can be prevented by adequate consumption of fresh fruits and vegetables (FAO/WHO, 2002).

In common cold, Vitamin C reduces the risk of getting a cold and also helps reduce the duration of the cold (Dougals, Chalder and Treacy, 2001). Due to its antioxidant activity, risk of high blood pressure may also decrease with the adequate amount of Vitamin C in diet. Overall risk of heart attack can also be reduced and it may slow down the progression of atherosclerosis as it helps in maintaining HDL (high density lipoprotein) and helps the body against LDL (low density lipoprotein); and keeps arteries flexible (Levine, 1996). In Alzheimer's disease, Vitamin C shows positive results as it may dissolve some toxic protein aggregates which are found in the brain of patient. Vitamin C is also associated with the lower rates of cancer and also osteoporosis (Gaby and Singh, 1991). Its antioxidant property is helpful in asthma (Ruskin, 1947). It may protect against rheumatoid arthritis and may stop damage to inflamed joints (Lunec, 1985). It is also helpful in decreasing blood sugar levels, improvement of vision, boosting of immune system, reducing the effect of sun exposure and healing of burns and wounds (Iqbal et al., 2004).

Conclusion

Vitamin C or ascorbic acid is a non-toxic acid which acts as an antioxidant in the human body and helps in regulating and maintaining vital roles in the body. It can not be produced by body and can not be stored in large quantities in the body so it has to be procured from fresh fruits and vegetables. It can be beneficial in certain

diseases such as atherosclerosis, tuberculosis, muscular degeneration, diabetes, cataracts and Alzheimer's disease. It also prevents and lowers the rate of occurrence of heart diseases and cancer. It is helpful in the overall improvement of immunity of body. Vitamin C has some epigenetic role in control of gene expression. There is some evolutionary significance due to which humans and other primates have lost their capability of synthesising Vitamin C.

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STUDENTS' UNDERSTANDING OF HEREDITY AND VARIATION

Prajna Paramita Behera

Regional Institute of Education, Bhubaneswar

The present study examines the pedagogical knowledge of students on heredity and variation. Questionnaires were administered in secondary/senior secondary/undergraduate level students. The comparison of understanding of students of different levels and various classes has been examined. The analysis indicates that the students' understanding of Mendelian inheritance carry a great variation. Interestingly, 2nd year undergraduate students performed better than 4th year undergraduate students. The reason may be attributed to the fact that student-teachers have developed more interest in the curriculum so they perform well in their professional life. The students of school level need better in-depth understanding to develop more interest in the advanced technology of gene and genetics.

Keywords

Gene, heredity, variation, genetics, genetic concepts

Introduction

Genetics is the study of heredity and inheritance. Understanding certain genetic concepts can be difficult if we have no basic knowledge about gene. Genetics helps to explain how traits are passed on from parents to their offspring. Interestingly, variation is also a part of heredity because no two individuals are identical in every respect. Similarity and variation go hand-in-hand as the law of nature constitutes the raw material for a geneticist and breeder to work upon and evolve new strains, breeds, varieties, etc.

Therefore, it is necessary to understand whether the basic concepts of Mendelian inheritance that are transmitted to the students of school level by the teachers before reaching the college level are well understood and whether students utilise that knowledge at the undergraduate level appropriately. It has been found that the students have alternate conception about gene, allele, traits, i.e., about inheritance (Lewis, Leach and Wood-Robinson, 2000a, 2000b; Lewis

and Kattmann, 2004; Chattopadhyay, 2005). According to Banet and Ayuso (2000), the difficulties to teach and to learn genetics remain a problem of students' comprehension.

Literature showed that most students from secondary school after formal teaching do not understand genetic concepts and they cannot describe the relationship between some cellular structures like chromosome DNA and genes (Shaw et al., 2008, Quinn, Pegg and Panizzon, 2009). Saka et al. (2006) have clearly demonstrated that future teachers possess inadequate understanding of some basic genetic concepts.

The questionnaires were administered to the students of both school and undergraduate pre-service teachers to evaluate their pedagogical knowledge on the basic concepts of genetics.

Objectives

The questionnaires filled in by the students were analysed and the results were described based on three objectives.

1. Variation in students' understanding of gene and its role.
2. Comparison of pedagogical knowledge of school students and undergraduate pre-service student-teachers.
3. Performance of pre-service student-teachers of 1st year and final year.

Sample

The students of different schools affiliated to CBSE in Bhubaneswar, Odisha and the students of Regional Institute of Education, Bhubaneswar were selected as sample of study. The sample of students was selected using simple random sampling technique. The study of gene starts from Classes X, XI onwards. Students of Classes X, XI of school level and 1st, 2nd, 3rd and 4th year B.Sc. B.Ed. students of undergraduate level were considered for the study. The sample included both boys and girls.

Tools

The descriptive and statistical analysis of students' answers was based on questionnaires. The questionnaires were administered relating to the basic genetic concepts pertaining to Mendelian inheritance. The topic was chosen from the syllabus of both secondary school level and undergraduate courses. The present paper focuses exclusively on gene and its role in heredity and variation. Questions were developed keeping in view the concept of gene, its role in sex determination and its importance in heredity and variation, etc.

The questionnaires were administered to the students and the purpose of study and method of response were explained to them, 45 minutes'

time was given to the students to answer the questions in the class relating to their previous knowledge.

Results

Variation in students' understanding of gene and its role.

Students' understanding of some basic genetic concepts was verified analysing the answers to the questionnaires (Figure 1).

1. The first question was "What are genes and where are they located in our body?". About gene, only 12 per cent students were unaware of the fact that a gene is molecular unit heredity of a living organism and as a name given to some stretches of DNA and RNA that code for a polypeptide or for RNA chain. But 45 per cent students knew about its position in our body. About 55 per cent students gave confused answer. They were not clear about the term allele, trait, DNA and chromosome, nucleus, etc. The reason may be that in the textbook, the function of gene is highlighted but not much attention has been given to the location of gene.
2. The second question was: "How dominant genes differ from recessive genes?". About 95 per cent of the students expressed the work of both dominant and recessive genes correctly. Only 5 per cent of the students were unaware of the fact that the dominant trait refers to a genetic feature that hides the recessive trait in the phenotype of an individual and this has been clearly explained in the textbook.
3. In the third question, investigation about students' idea on role of male and female in determination of sex was done. The question

was: "How genetic combination of mother plays a significant role in determining the sex of a new born baby?"

Only 45 per cent of the students had clarity that the male has a significant role in determining the sex of a child. The males have sex chromosome XY and females have sex chromosome XX. During fertilisation, either 'X' or 'Y' chromosome may come. Thus, in determination of sex of a newborn baby, father's role is significant in human beings. But only 10 per cent of the students were aware of the fact that different species use different strategies for this. In some animals' environment, i.e., the temperature at which fertilised eggs are kept, determines whether the animals developing in eggs will be male or female. In other animals such as snails, individuals can change the sex thus indicating that sex is not genetically controlled, but in human beings it is largely genetically determined. It has been found that the students who have thoroughly gone through the Class X NCERT textbook were able to answer correctly.

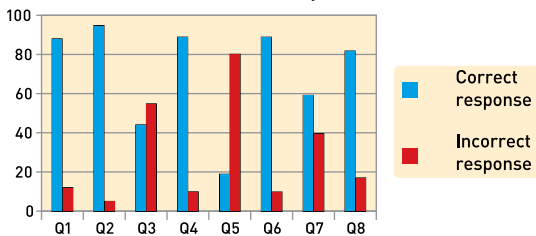


Figure 1. Percentage of students' response to different questions

4&5. The fourth and fifth questions were given to test the students' concept about the role of gene in determining and controlling the characteristics. The questions were: "How are the characteristics transmitted to progeny and how do the genes control

the characteristics?". About 90 per cent of the students of both school level as well as undergraduate level were aware that the characteristics were transmitted to the progeny through gene. Only 10 per cent of students had no clear idea about that. However, about 80 per cent of students were unable to clearly explain how the genes control the characteristics. They were unable to explain the work and role of genes in making proteins in the cell. The fact may be that most of the students do not understand the significance of the concept given in the textbook. Only 20 per cent of the students had clarity that every characteristic of an organism is triggered by hormone. Thus, amount of hormone made will depend on the efficiency of enzyme. This enzyme activity is controlled by a gene. Cellular DNA is the source of information for making proteins in the cell. A section of DNA that provides information for one protein is the gene for that protein.

6. The sixth question was asked, "What do you understand of F1 and F2 generation?". Almost 90 per cent of the students of both school and undergraduate levels were aware of these two terms. The fact may be that the two terms were clearly explained in the textbook. Only 10 per cent of the students had a different concept that F1 and F2 generation is obtained by crossing between the same species only.

7&8. The seventh and eighth questions were related to acquired and inherited traits. The questions were: "How acquired and inherited traits differ from each other and why are the traits acquired during lifetime of an individual not inherited?". About 60 per cent of the students were able

to distinguish between the two terms — acquired and inherited traits. About 40 per cent of the students were confused about these two terms. As 40 per cent of the students were not aware of these terms, they were not able to answer the question as to why are the traits acquired and not inherited. Eighteen per cent of the students had misconceptions. Only 82 per cent of the students had clarity of concept that change in non-reproductive tissues cannot be passed on to the DNA of the germ cells. Therefore, the experiences acquired during lifetime cannot be passed on to its progeny and thus cannot be responsible for variation. The reason may be that the students are unable to link the previous concept to the present concept.

Comparison of Pedagogical Knowledge of School Students and Pre-service Student-teachers

The students' understanding about basic genetic concepts of different classes was compared. The comparison of answers of identical question shows a great variation. This analysis aimed to verify whether the understanding of basic concepts of genetics at school level was modified or not during their undergraduate study. A lot of variation was seen in five questions, i.e., related to sex determination, role of gene in determining the characteristics and knowledge on acquired and inherited traits. The students' knowledge at school level is satisfactory related to role of father in the determination of sex of a newborn baby in animals, including human beings. But surprisingly, the undergraduate students had no knowledge about role of father in determination of sex of a newborn baby in animals except human beings. Both undergraduate and school

students had very less knowledge about the role of gene in determination of a character. They were aware of the role of gene in transmitting the characteristics from parents to progeny but, how it happens, they did not have much idea. Seventy per cent school students were unable to explain it properly, whereas about 37 per cent undergraduate students were also found incapable of giving proper explanation (Figure 2). The school students had clarity of concept about acquired and inherited traits whereas the undergraduate students had misconceptions and were confused about these two terms. The reason for this may be attributed to their ignorance and inadequate knowledge about the concept.

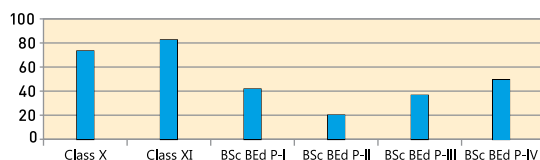


Figure 2. Percentage of incorrect response of students of different classes related to role of gene in controlling the characteristics

Performance of Pre-service Student-teachers of 1st Year and Final Year

The knowledge on basic genetic concepts somewhat modified acquiring more knowledge on Mendelian inheritance in 2nd year undergraduate students as it is included in their curriculum. But, surprisingly, the final year undergraduate trained teachers, i.e., future teachers did not show a better performance in comparison to their juniors though they were studying advanced genetics, i.e., molecular biology, biotechnology, recombinant DNA technology, tissue culture, etc., included in their curriculum. The future teachers showed less interest in answering the questionnaires. All together they were not able to answer more

than 50 per cent of the questions and some students answered only about 35 per cent of the questions correctly.

Discussion

Analytical

The branch of genetics is expanding day-by-day. The knowledge on gene and its characteristics is very important for its utilisation in the application for the betterment of society in the field of biotechnology. The basic genetic concepts should be fundamentally more strong in future teachers to make them professionally successful.

Students opting for study in biology show variation in their understanding of basic genetic concepts. The 1st and 2nd year undergraduate students have clear concepts in comparison to final year students who may have additional professional future building activities. This inadequate understanding might influence the learning of more complex genetic concepts and social implications of genetic modified organisms. This can be explained taking into account the questionnaire related to acquired and inherited traits. In answering these questions, most of the school students had clear concepts about these two terms but most of the undergraduate students did not. This simple example can give us an idea as in how the simple misunderstanding might give rise to distorted understanding of more complex idea related to genetics.

Graphical

Figure 1 shows a lot of variation in students' response to various questions related to gene and its role in heredity and variation.

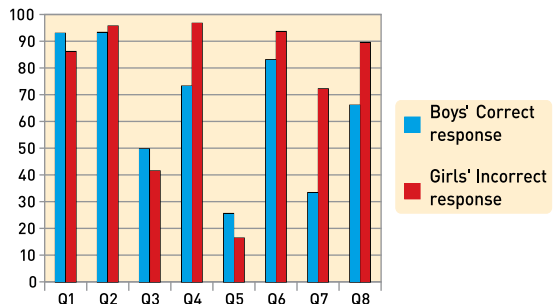


Figure 3. Comparison of correct responses to different questions by boys and girls

Figure 2 represents the incorrect response of students of different classes regarding Q.5, i.e., how gene controls the characteristics? Seventy-four per cent of Class X students were unaware of that, whereas 82 per cent of Class XI students were unable to explain correctly. The undergraduate students responded comparatively better. About 49 per cent Part IV B.Sc. B.Ed. students gave incorrect response, whereas Part II B.Sc. B.Ed. students gave higher number of correct answers.

When the answers of questionnaires were analysed and compared between the responses of boys and girls, Figure 3 indicated that there were negligible differences between boys' and girls' correct responses except for Q 7 and Q 8. Answers to Q 7 and Q 8 show that girls gave more correct responses than the boys. Regarding sex variables, no final conclusion can be drawn because results of studies are consistent with regard to sex variables.

Thus, the result of the present study expects to throw light in the field of science and education and accordingly inspire teachers, educationists and others to build up bright academic accomplishments particularly on the concept of Mendelian inheritance.

Conclusion

The present study involving the students of school level and undergraduate level has clearly shown that many students have less understanding on Mendelian concepts in the field of heredity and variation. The nature of students' misconceptions at different classes and source of alternative conception were analysed. The learning of misconceptions has been understood as a result of the simultaneous exposition to an extensive variety of genetic subjects and the inability to reason on ontologically distinct levels of genetic phenomenon (Duncan and Reiser, 2007; Shaw et al., 2008). Efforts must be made to analyse the contribution of prior knowledge mediated by secondary education to students' performance and professional development (Infante-Malachias et al., 2010). Despite the efforts made in application of alternative strategies to

transmit genetic knowledge, these difficulties to teach and to learn genetics are continuously described and remain a problem of students' comprehension (Banet and Ayuso, 2000; Orcajo and Aznar, 2005).

The concept about Mendelian inheritance and the terms related to that are explained clearly in the NCERT textbook of Class X. The analysis of result showed that the pre-service teachers during their study time were not aware of their future role as a teacher in their professional life. If they carry the alternative conceptions about basic genetic concepts from school to undergraduate level then its application will influence the science and technology and its application for betterment of the society. Therefore, it is necessary to think critically and to develop the method to improve education in genetics. There must be a correlation between curriculum and its implementation in the professional career.

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PRINCIPLES BEHIND CARBON DATING AND ITS VARIOUS USES

Prashant Kumar Patra

Centre for Science Education
North-Eastern Hill University, Shillong

Introduction

Sometimes we are very curious to know the age of ancient objects whose origin and age cannot be determined exactly by normal means, for example, objects dug up by archaeologists. If the object contains radioactive element, an element capable of emitting radiations spontaneously in the form of alpha particle, beta particle or gamma ray, then it is possible to estimate its age using radiometric (also called radioactive) dating method. There are a number of radiometric dating methods such as radiocarbon dating, uranium-lead dating and potassium-argon dating, etc. Among them, carbon dating is the most well-known method used in dating of archaeological specimens. Carbon dating is applicable only to organic materials, that is, the material must once have been a part of living things such as bone, wood, etc. In this method, the age of ancient objects are estimated by measuring their content of carbon-14 (C-14), a radioactive form of carbon with a nucleus containing 6 protons and 8 neutrons, called radiocarbon. This method is known as carbon dating or radiocarbon dating. However, this method cannot be applied to date metal, stone and pottery unless there is some organic material left as a residue. For objects that were never living, other radiometric dating methods are used.

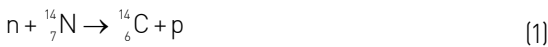
Here, we will be taking only carbon dating and first, we will discuss about different types of carbon atoms, called isotopes that is atoms whose nuclei contain same number of protons but different numbers of neutrons. The known carbon isotopes vary from C-8 to C-22. However, only three isotopes : C-12 , C-13 and C-14 occur naturally on earth. Out of these, C-14 is unstable. In unstable nuclei, the binding energy per nucleon is less than that of the stable nuclei. In order to achieve stability, the unstable nuclei emit radiation. In C-14, the ratio of neutron / proton is 1.33 which is above the band of stability. Hence, it emits beta minus particle which can be counted. Carbon dating is based on measuring the ratio of two types of carbon: (i) the rare radiocarbon C-14; and (ii) the abundant stable C-12 found in the organic material at the time of its death and also at present. Willard. F. Libby and his co-workers at the University of Chicago developed the carbon dating technique in 1949. Libby, Anderson and Arnold in 1949 were the first to measure radiocarbon's rate of decay and found that the half-life ($T_{1/2}$) for C-14 is $5,568 \pm 30$ years. In 1960, Libby received the Nobel Prize in Chemistry "for his method to use carbon-14 for age determination in archaeology, geology, geophysics and other branches of science" (Libby, 1955, 1960).

This article is on the physics and the principles behind carbon dating. First, we will discuss how radiocarbon is produced and how it gets into the different parts of the environment.

Formation of Radiocarbon

Cosmic radiations, from outer space, enter the earth's atmosphere in large numbers every day (Anderson et al., 1947). For example, each of us is hit by about half-a-million cosmic radiations every hour. These radiations consist of charged particles (protons 92 per cent, alpha particles 7 per cent and massive nuclei 1 per cent). When these protons strike ordinary atoms in the upper atmosphere, neutrons are produced.

Some of these thermal neutrons ($E \sim 0.025$ eV) collide with nitrogen gas, the major constituent of the atmosphere, and produce the radioactive isotope C-14 in the upper atmosphere, i.e., in the stratosphere and upper troposphere:



where ${}^{14}_7\text{N}$ represents a Nitrogen-14 atom, n represents a neutron and p represents a proton. The proton takes an electron with it and becomes an atom of hydrogen. We may mention that radiocarbon can be produced through a number of nuclear reactions; however, the most important one for radiocarbon dating is given in Eq. (1).

Basic Principles of Carbon Dating

The observed production of C-14 is usually two to three atoms per sq. cm per second. This variation is due to changes in the cosmic radiations reaching the earth's atmosphere based on the strength of the earth's magnetic field. However, the overall cosmic radiations reaching the earth's atmosphere is expected to remain constant unless there is supernovae contribution which occurs occasionally. The highest rate of C-14 production is observed at altitudes of 9 to 15 km (30,000 to 50,000 ft) and

high geomagnetic latitudes. Since chemically C-14 behaves like ordinary carbons, it combines with oxygen to give carbon dioxide (${}^{14}\text{CO}_2$),



The carbon dioxide diffuses in the atmosphere and is dissolved in the oceans, in the form of carbonates, bicarbonates and carbonic acid. The CO_2 , that is present in the atmosphere, consists almost entirely of stable C-12 (98.89 per cent) with a small admixture of stable C-13 (1.11 per cent) and only one out of every trillion C-12 atoms is C-14.

During photosynthesis, when a plant absorbs CO_2 from the atmosphere and reduces it to sugar and starch with the help of water and sunlight, the entire plant tissue becomes radioactive as the CO_2 in the air. The plants are eaten by animals, therefore their tissues also become radioactive. Even animals eating animals become radioactive as all animals finally depend on plants for food. That means every living organism continuously takes up C-14 along with C-12 in the same ratio that C-14 and C-12 exist in the air. The production and distribution of C-14 is shown schematically in Figure 1. So an organism, or a bone, or a piece of wood, contains

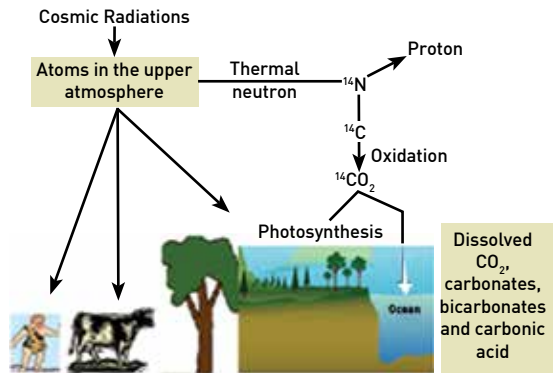


Figure 1. Production and distribution of ${}^{14}\text{C}$

radiocarbon. However, the C-14 atom within a living organism decays continually, but the organism exchanges both types of carbon with its environment keeping the ratio about the same as the atmosphere. At this moment, our body has a certain percentage of C-14 atoms in it, and all living plants and animals have the same percentage.

If we take a sample of air and count how many C-12 atoms there are for every C-14 atom, we will find that

$$\frac{C-14}{C-12} \approx 1.3 \times 10^{-12} \quad (3)$$

At any given time, the above ratio will remain constant as C-14 is well mixed up with C-12. Even if we sample any part of a plant or a part of our body we will find this ratio. Once an organism dies, it ceases to acquire further C-14 atoms. As time passes, the C-14 in its tissues is converted back into nitrogen:



where e^- is the electron (beta minus particle) and $\bar{\nu}_e$ represents the electron antineutrino. In Eq. (4), a neutron present in the unstable C-14 nucleus is converted into a proton with the emission of an electron, to conserve charge, and an electron antineutrino, to conserve energy and angular momentum. The emitted beta minus particles carry maximum energy of 156 keV, while their average energy is 49 keV. So the amount of C-14 in that once-living thing decreases as time goes on, which gives the smaller C-14 / C-12 ratio. This behaves like a "clock" which starts ticking the moment something dies. We can estimate the amount of time that has passed since the death of the organism by comparing the C-14 / C-12 ratio in the current sample and that in the

original living organism. Remember that this works only for things which were once living and cannot be used to date rocks, for example. There is a quantitative relationship between the decay of C-14 and the production of a beta minus particle. The decay is constant but spontaneous. That is, the probability of decay for an atom of C-14 in a discrete sample is constant, thereby requiring the application of statistical methods for the analysis of counting data.

Computation of Ages and Dates

When an organism dies, it stops exchanging carbon with the atmosphere and its C-14 content then starts to decrease at a rate determined by the law of radioactive decay (Krane, 1988).

If N be the number of atoms at any time t in a radioactive sample, the number of atoms dN that will decay during the time t to $t + dt$ must be proportional to N and also proportional to dt . Then

$$dN \propto -N dt \quad (5)$$

The negative sign indicates that number of atoms of the radioactive element decreases with time. The above equation can be expressed by the following differential equation,

$$dN/dt = -\lambda N, \quad (6)$$

where the constant of proportionality λ is called the decay constant, has a different value for each radionuclide. Integrating Eq. (6) we have

$$\int_0^N \frac{dN}{N} = -\lambda \int_0^t dt$$

where N_0 is the number of atoms in the original sample at $t = 0$ and N be the number of atoms at any time t . This gives

$$N = N_0 e^{-\lambda t} \quad (7)$$

We know that in one half-life $T_{1/2}$ half the number of radiocarbon atoms in a given sample decay.

Thus, putting $N = \frac{N_0}{2}$ and $t = T_{1/2}$ in Eq. (7) we have

$$T_{1/2} = \ln_2 / \lambda = 0.693 / \lambda \quad (8)$$

If $T_{1/2}$ of the radioactive element is known, its decay constant can be calculated. There are two $T_{1/2}$ values for radiocarbon available in literature.

- (i) Libby value. $T_{1/2} = 5,568 \pm 30$ years (Anderson and Libby, 1951).
- (ii) Godwin value. $T_{1/2} = 5,730 \pm 40$ years (Godwin, 1962), which is thought to be a more accurate value.

However, researchers are still using Libby value in calculations in order to maintain consistency.

Sometimes we need the value of activity of a radioactive sample to estimate its age. The activity is defined as disintegrations per second (dps) and is denoted by R. This is obtained by differentiating Eq. (7),

$$dN/dt = -\lambda N_0 e^{-\lambda t} \quad (9)$$

When $t=0$, $(dN/dt)_{t=0} = -\lambda N_0$. Hence Eq. (9) gives

$$dN/dt = (dN/dt)_{t=0} e^{-\lambda t} \quad (10)$$

where $R = dN/dt$, and $R_0 = \frac{dN}{dt} \Big|_{t=0}$. The activity of the sample is given by

$$R = \left| \frac{dN}{dt} \right| = \lambda N_0 e^{-\lambda t} = \lambda N \quad (11)$$

Thus, the activity of a sample R is proportional to the product of N, the number of atoms present and the decay constant λ .

The unit of activity is curie, named after Madam Curie, and defined to be equivalent to 3.7×10^{10} dps. Originally, one curie was defined as equal to the number of disintegrations that occur per sec in 1g of radium - 226 by α - emission. There is another unit of activity, called Rutherford, named after Ernest Rutherford, which is equal to 10^6 dps. The SI unit is the becquerel, named after Henri Becquerel, which is equal to 1 dps. From Eq. (11), we obtain

$$t = \frac{1}{\lambda} \cdot 2.303 \cdot \log \frac{R_0}{R}$$

$$= \frac{T_{1/2}}{0.693} \cdot 2.303 \cdot \log \frac{R_0}{R}$$

Or,

$$t = 3.32 \times T_{1/2} \times \log \left(\frac{R_0}{R} \right) \quad (12)$$

where t is the amount of time that has passed since the death of the organism.

Measuring Age with Carbon-14

Using Eq. (12), we can estimate the age of a given sample provided we know (i) how much C-14 the object had at the beginning, and (ii) how much C-14 the object has now. However, in practice, we do not measure the total amount of C-14 in the sample, since that depends on the size of the sample. So, instead we measure the original and current C-14 / C-12 ratio. Thus in Eq. (12), R is the current C-14 / C-12 ratio in the sample and R_0 is the original C-14 / C-12 ratio of the living organism. We can then calculate the amount of time t that has passed since the death of the organism. However, this method breaks down for periods of the order of $t \sim 10 T_{1/2}$, that is, about 50,000 years, because so

little C-14 remains after almost 9 half-lives that it may be hard to detect and obtain an accurate reading, regardless of the size of the sample.

Taking Libby half-life it has been found that 1g of carbon from a living plant decays at a rate of 14 decays per minute (dpm). This means that if the plant dies after 5,568 years, its activity will be dropped to 7 dpm. By measuring the count rate produced by the carbon in archaeological specimens of wood or charcoal, the time which has elapsed since the original plant died can be estimated.

Reliability of Carbon Dating

The carbon dating method has been checked by comparison with wood samples of known age. For example, Libby and Arnold took two wood samples from the tombs of two Egyptian kings and found that the radiocarbon dating gives a fairly reliable result, which launched the "radiocarbon revolution" in archaeology.

The ancient trees can be dated by dendrochronology, a scientific method of dating based on the growth rings of trees. Using this method one can date the time at which tree rings were formed, in many types of wood, to the exact calendar year. Radiocarbon dating may be compared with dendrochronology. From the dating of ancient bristlecone pine trees from the western U.S., a correction curve for the carbon dating over the range back to 5000 BC has been developed. Trees dated at 4000 BC show the maximum deviation of between 600 and 700 years, too young by carbon dating. A tree-ring calibration now allows for correction of radiocarbon dates; however, older radiocarbon dates cannot be corrected. For this reason, older radiocarbon dates are not regarded as true year dates; such dates are reported as radiocarbon years.

Techniques Used to Measure Radiocarbon

Libby measured the C-14 fraction of a sample by using the radioactivity of these unstable nuclei. By rubbing carbon sample on the inner wall of a Geiger counter, he was able to count each emitted beta particle from C-14 decays and hence he estimated the current C-14 content in the sample. This is known as solid counting system. However, this method is very slow because in one year only 0.01 per cent of the C-14 atoms in a sample decays. Again, it is found that most Geiger counter are not able to detect the presence of C-14 in amounts less than 10^5 dpm. Hence, this method is not efficient. Nowadays there are three principal techniques used to measure C-14 content of any given sample. They are gas proportional counting (GPC), liquid scintillation counting (LSC) and accelerator mass spectrometry (AMS).

(i) Gas Proportional Counting

In this method, the sample is converted to carbon dioxide gas. Then this gas is filled in a proportional counter. The radioactive C-14 content of the gas emits beta particles within the counter and this electrical discharge is counted electronically. Sometimes, the sample is also converted to methane gas which is used in place of carbon dioxide in carbon dating counters.

(ii) Liquid Scintillation Counting

In this case the sample is in liquid form, i.e., it is converted to a carbon-rich aromatic liquid (benzene). A scintillator is added to it and placed in a clear container. Whenever a beta particle, emitted by a given sample, strikes the scintillator it produces a flash of light. Sensitive photo multiplier tubes are placed near the container and count the flash of light. The performance of

such system is superior to GPC because if the age of a sample is greater than 35,000 yr BP, the uncertainty of ages determined by the GPC method increases as net count rate declines towards the limit of detection. This technique was popular in the 1960s.

Both GPC and LSC methods count beta particle emitted from the sample. But the decay of a radioactive atom is a random event. So, the measurement needs to be performed over a period of 2–7 days depending on the age of sample. Moreover, a large amount of sample is required in both the techniques. A modern radiocarbon dating method, known as AMS, was developed in 1970.

(iii) Accelerator Mass Spectrometry

In AMS, the radiocarbon concentration in a sample is determined by counting the C-14 atoms in an ion-beam produced from the sample, using an accelerator mass spectrometer (Tuniz et al., 1998). We shall discuss the principle of this method in detail.

We can extract carbon from the material to be dated using a variety of chemical techniques. But, the chemical properties of any element are governed by the number of protons present in the element. Hence, C-14 has the same chemical property as the other carbon isotopes. So, it cannot be easily isolated by chemical means. Further, the number of neutrons does affect the physical properties of an element. Therefore, we have to rely on the physical properties of this isotope, i.e., its larger mass and its radioactivity.

We can sort relatively heavy carbon ions from a small sample of material using mass spectrometry, which uses electric and magnetic fields. In this method, the individual atoms are first released from the sample and then

ionised by adding or removing electrons from each atom. As these atoms have a net charge, they are attracted towards metal plates with an opposite charge and move faster and faster as they approach the metal plates. These atoms are allowed to pass through a hole of the plates and then enter an electromagnet. Atoms with different masses follow different path through the magnetic fields. The C-14 atoms can then be isolated and counted separately.

For extremely small sample, we can use an accelerator mass spectrometry (AMS). In this case, multiple stages of acceleration and ionisation are used. The ionised atoms pass through several electromagnets. Consequently, the C-14 atoms are clearly separated. The main advantage of AMS is that it does not count beta particle but rather all C-14 atoms in a sample. AMS analysis of samples takes only a few hours whereas conventional methods take one to two days. Further, this method needs only a sample size as small as one milligram whereas conventional methods need at least 10 grams.

Factors which Affect the C-14 / C-12 Ratio

For steady cosmic radiations reaching the earth's atmosphere the C-14 / C-12 ratio in living organisms remains constant, and is the same as that in air. But, there are factors such as astronomical and human activities which affect the amount of C-14 produced in the atmosphere.

(a) Astronomical Effect

The strength of the earth's magnetic field affects the amount of cosmic radiations entering earth's atmosphere. These fluctuations affect the C-14 / C-12 ratio and hence the dating system. However, one can correct these errors using other techniques for calibration such as

tree-ring data and foraminifera, a phylum or class of amoeboid protists and corals.

(b) Human Effects

Burning of fossil fuels like coal and oil adds a large amount of C-12 to the atmosphere which makes the C-14 / C-12 ratio smaller, whereas nuclear bomb testing (since 1940) makes its value large. However, these errors do not affect anything on dating over 150 years old because of the formation of fossil fuels from the remains of organisms that died millions of years ago. By this time, all the original C-14 organisms must have already been absorbed from the atmosphere.

Further, all organisms do not absorb C-14 directly from atmospheric reservoir, so in those cases we cannot use the same C-14 / C-12 ratio. This is known as reservoir effects. For example, (i) Trees absorb carbon dioxide directly from the atmosphere (one reservoir), so this does not require reservoir corrections, (ii) Seals breathe air from the atmosphere, whereas their main food supply is sea food that draws its carbon from underwater sources (a second reservoir) which is not in direct contact with the atmosphere. It takes some time for atmospheric carbon to mix deeper into the ocean, furthering the C-14 decay. This leads to a smaller C-14 / C-12 ratio than in land animals, consequently gives older radiocarbon dates unless corrected. (iii) Shell-fish living in a lake surrounded by limestone show a different (third) reservoir effect. Limestone forms from the remains of long-dead organisms that are severely depleted of C-14. Weathering of the limestone into the lake (where shell-fish will incorporate the carbon into shells) changes the C-14 / C-12 ratio. This gives older radiocarbon dates unless corrected.

Thus, researchers must carefully study each sample to know its general history and environment before measuring its age with carbon dating.

Limitations of C-14 Dating

There are a number of limitations of C-14 dating which are discussed next:

- (i) The archaeological sample should be collected and packed air tight very carefully in chemically neutral materials in order to avoid contamination by new C-14. The contaminated carbons from the sample are usually removed by using purification and distillation methods. For this reason, the size of the sample should be larger. But, accelerator dating helps in working with very small samples. However, this is expensive.
- (ii) In Eq. (12), the decay rate is logarithmic. This gives significant upper and lower limits. So, it is not very accurate for fairly recent deposits, where the error factor (the standard deviation) may be larger than the date obtained. The practical upper limit is about 50,000 years, because so little C-14 remains after almost 9 half-lives that it may be hard to detect and obtain an accurate reading, regardless of the size of the sample.
- (iii) The C-14 / C-12 ratio is not constant in the atmosphere. It was found that this ratio has varied significantly during the history of the earth. In order to compensate this variation, the dates obtained from radiocarbon should be corrected by using standard calibration tables developed by scientists.
- (iv) Finally, the dates obtained from radiocarbon dating are not infallible, that is, in general, single dates should not be trusted. Thus,

if possible, multiple samples should be collected and dated.

Uses of Carbon Dating

1. Radiocarbon dating method is used for estimating the age of old organic matters which were once living. For example, ancient manuscripts, historical artifacts made from wood or leather, bones, etc., can be dated. Traditional radiocarbon dating can be applied to organic remains between 500 and 50,000 years old. However, using accelerator techniques the upper limit can be extended to one million years.
2. This is used for dating the culture history or estimating the age of geological formation.
3. Using carbon dating, forensic scientists determine age and year of death in cases involving unidentified human remains.
4. Archaeology and other human sciences use radiocarbon dating to prove or disprove theories. C-14 provides a radioactive clock for anthropologists just as uranium provides a radioactive clock for geologists. The C-14 half-life is suitable for the dating of cultural history, just as the half-life of uranium is suitable for the dating of history of the earth. Using radiocarbon dating, archaeologists have been able to obtain a much needed global perspective on the timing of major prehistoric events such as the development of agriculture in various parts of the world.
5. Over the years, Carbon-14 dating has found applications in archaeology, anthropology, geology, hydrology, geophysics, atmospheric science, oceanography, paleoclimatology and even biomedicine.
6. Carbon dating has received the most publicity after it is used in dating popular artifacts, such as the Shroud of Turin.

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A STUDY OF SCIENTIFIC ATTITUDE AMONG LEARNERS IN BOTSWANA

Vijay P. Singh*

S.C.E.R.T., New Delhi
Ex-faculty with Department of Sciences,
Molepolole College of Education

This paper describes the analysis of the scientific attitude of varied sample, including learners from Junior Secondary and Senior Secondary school levels and also a group of prospective science teachers from a college of secondary education in Botswana. The tool used for the study was a Likert type five-point Scientific Attitude Scale (SAS) developed and standardised by the investigator. The tool contained items on six of essential component behaviours of the scientific attitude like open mindedness; belief in truth/facts; appreciation of nature of Science; free from superstitions; curiosity to learn/explore new facts and phenomena; and objectivity. The analysis of the scores indicated that the level of scientific attitude of some of the learners was very low, whereas a good proportion of sample showed an average level. No significant difference was noticed in the attitude of male and female respondents. A need of serious, sound and sustainable planning of the school Science curriculum and its dissemination was reflected by the study. As way forward, the investigator has proposed strategies for enhancing the opportunities for the effective development of scientific attitude by creating an enabling environment of Science learning in the educational institutions in Botswana.

**Now working as Professor in Science Education at RIE (NCERT) Ajmer*

Introduction

Botswana is a fast developing country of South African region with highest per capita income of the Africa. The government has created excellent schooling facilities in all habitations with the desired infrastructural, material and human resources. There was a shortage of local manpower for teaching of Science, Maths and Design and Technology at all levels of school education. The government even declared Science, Maths and Design and Technology as areas of 'Scarce Skills' and incentives such as one scale-up was given to teachers of these subject areas to attract more talent towards these categories.

For teaching-learning of Science, almost similar set of equipments, apparatus and material is available in all the Community Junior Secondary Schools (CJSS). The same is also true about Senior Secondary schools and Department of Science in colleges of secondary education. The country has envisioned development of a scientific society in Botswana and resources have been created for teaching-learning of Science and concerted efforts are being made to achieve this vision goal.

As we all know that Science is the process as well as product of the process, however, process is more important than the product. Any curriculum on Science is aimed at the

development of scientific attitude through processes of its transaction. The first and foremost aim of Science education is to inculcate scientific attitude among the learners. The scientific attitude is characterised by a number of component behaviours such as: openness in day-to-day life; belief in truth; appreciation of nature of Science; free from superstitions and myths; objectivity in taking decisions; curiosity to learn more; aesthetic sensibility and the like. In other words, scientific attitude is reflected through positive attitudes in all actions in day-to-day life of an individual. The efforts done by the Ministry of Education in Botswana has emphasised on 'Science by Investigation' at the school level and in training of teachers. A context-specific and child-centred Science curriculum for school education is being implemented in the country.

Literature Review

With the advent of new ways of communication and information technology, the teaching-learning of Science has become more interesting. Hence, greater responsibility has to be shouldered by the Science teachers and curriculum developers to plan and organise scientific processes by using multimedia approaches to enhance pupils' learning. Swift (1992, p. 7) has advocated for indigenous knowledge by saying that, greater the indigenous knowledge and less the imported knowledge, the more likely it is that the latter will be assimilated and used. On the other hand, for teaching diverse student populations, a multicultural coursework is recommended by Wiggins and Follo (1999). They felt strongly that "multicultural coursework must move beyond knowledge about other culture, whether that knowledge is from a pedagogical perspective or a historical perspective".

Science educationists have defined scientific attitudes as having the characteristics of "critical mindedness, respect for evidence, objectivity, open-mindedness and questioning attitude" (Mayer and Richmond, 1982, p. 56). Johnston (1997) in his paper has argued about the construction of tools and analyses traditional tools used to measure scientific attitudes in secondary school children and considers their use with younger children and adults. Fraser (1978, p. 510) also discussed types of items in the scientific attitude scale. Further, authors like Weaver (1998) while commenting on the role of teachers and facilitation of learning stated that "teachers may need professional development in order to effectively act as facilitators of learning". Thomas (2012) in his essay on changing landscape of inquiry for a new science of education, also argues that 'scientific' percepts do not characterise scientific endeavour, which is fluid and plural: Science flexes to any angle to answer the questions that are posed in any field.

For the inculcation of scientific attitude and improving achievement of students in Science, studies have been conducted as quoted by Johnston (1997). In the context of Botswana, Miller and Osborne (1998), Solomon (2002), Sutton (1992), Kesamang and Taiwo (2002) have reported the correlates of the socio-cultural background of Botswana Junior Secondary School students with their attitude towards and achievements in Science.

Rationale of the Study

Since a lot of focus had been given for improving the teaching-learning of Science at various levels of schooling in Botswana, during the last two decades, it was thought proper to study the impact of these efforts in developing the

scientific attitude among the learners at all levels and prospective Science teachers. The findings of such a study will reflect upon the effectiveness of these efforts and pedagogical practices in school Science education. The study may have implications in deciding the future course of action about the pedagogical practices of Science education so that country's vision to develop a Scientific Society in Botswana is realised in due course.

Objectives of the Study

The following objectives were kept in mind while carrying out the study:

1. To see the impact of Science learning in developing the scientific attitude among the learners at different levels.
2. To compare the scientific attitude of male and female subjects at each level.
3. To compare the difference in the attitudes of different categories of sample.
4. To suggest measures to improve the level of scientific attitude of subjects.

Methodology

The Tool

A scientific attitude scale developed by the author was used which contained 36 items, including six on each of the six component behaviours of the scientific attitude like open mindedness; belief in truth/facts; appreciation of nature of Science; free from superstitions; curiosity to learn/explore new facts and phenomena; and objectivity. The tool used for the study was a Likert type five-point Scientific Attitude Scale (SAS) developed for the purpose. The scale was subjected to peer review and tried out before its administration to

the sample. The reliability of Scientific Attitude Scale (SAS) was found 0.56 as calculated by using Spearman-Brown formula.

The Sample

The sample included students from Community Junior Secondary School (34 consisting of 18 males and 16 females) and Senior Secondary School (49 consisting of 24 females and 25 males) and also a group of prospective Science teachers (44) from Molepolole College of Education — a college of secondary education in Botswana.

Result and Discussion

The data collected on SAS were subjected to statistical analysis and a comparison of the performance of various groups was done. A comparison of the scientific attitude of the teacher trainees and students studying at senior secondary level of schooling is given in Table 1.

Table 1. Performance of Trainees vs Senior Secondary Students on SAS

Group	No. of students	Mean	SD	SE of SD	't'
Trainees	44	97.57	10.68	6	1.01*
Sr. Sec. Students	49	95.57	8.05		
	N=93 df = 91	Mean Diff. = 2			

**Insignificant at 0.05 and 0.01 level*

The results indicate that there was no significant difference in the performance of the groups with regard to their scientific attitude measured by a newly developed Scientific Attitude Scale. The 't' value computed for the groups is insignificant at 0.05 and 0.01 level. This insignificant difference

in the scientific attitude of the two groups may be due to very less difference in their age, qualification and mental maturity. It is worth mentioning here that the teacher trainees' entry qualification was senior secondary (12th Standard).

On comparing scientific attitude of teacher trainees with the students studying at junior secondary school level of education, it was found that the mean score of the teacher trainees is much higher than those of junior secondary students. The analysis of the score and further statistical treatment indicate that there is a significant difference in the scientific attitude of the two groups and prospective teachers have better scientific attitude than the junior secondary students. This difference in the attitude could be attributed to the large difference in the age, level of education and mental maturity of the subjects forming two groups. The statistical data of the groups are given in Table 2.

Table 2. Performance of Trainees vs Community Junior Senior Secondary School (CJSS) Students on SAS

Group	No. of Students	Mean	SD	SE of SD	't'
Teacher Trainees	44	97.57	10.68	6.36	2.89*
CJSS Students	34	91.21	8.71		
	N=78 df = 76	Mean Diff. = 6.36			

*Significant at 0.05 level

Similarly, a comparison of the scientific attitude of senior secondary and junior secondary students was done and a significant difference was noticed in the mean score of the groups

at 0.05 level. However, the difference was insignificant at the 0.01 level. Here also the difference in the attitude may be due to the gap in the level of education, age and mental maturity or exposure to learning of the students in the groups. As we know, senior secondary level is a higher level of education in comparison to that of junior secondary level. Accordingly, the scientific attitude of senior level students is better than the junior level students. The statistical data are given in Table 3.

Table 3. Performance of Senior Secondary Students vs CJSS Students

Group	No. of Students	Mean	SD	SE of SD	't'
Sr. Sec. Students	49	95.57	8.05	1.88	2.31*
CJSS Students	34	91.21	8.71		
	N=83 df = 81	Mean Diff. = 4.36			

*Significant at 0.05 and insignificant at 0.01 level

A comparison of the scientific attitude of the male and female teacher trainees of all the groups was carried out. The analysis of the scores of male and female Science teacher trainees of Molepolole College of Education, indicates that the female trainees have better mean score (100.33) in comparison to their male counterparts (97.71). However, the difference in the mean scores is significant at 0.05 and insignificant at 0.01 level. Thus, the statistical analysis of the scores does not indicate any difference in the scientific attitude on the basis of gender. Thus, it can be inferred that there is no significant difference in the scientific attitude of the female and male teacher trainees as their level of education, age group and mental

maturity level is almost the same and they have acquired same level of education and exposure before entry to the pre-service teacher training. The statistical data are given in Table 4.

Table 4. Performance of Female vs Male Teacher Trainees on SAS

Group	No. of Students	Mean	SD	SE of SD	't'
Female Trainees	9	100.33	8.20	4.01	0.65*
Male Trainees	14	97.71	11.00		
	N=23 df = 21	Mean Diff. = 2.62			

*Insignificant at 0.05 and 0.01 level

In case of female and male students of senior secondary level, it was noticed that the male students have a little higher mean score (97.12) than the girl students (93.96) of the same level. Here also, the mean difference was found insignificant at 0.05 and 0.01 level attributable to the same of level of education, age and exposure to learning. The data showing the comparison are given in Table 5.

Table 5. Performance of Female vs Male Senior Secondary Students on SAS

Group	No. of Students	Mean	SD	SE of SD	't'
Female Students	24	93.96	9.15	2.27	1.39*
Male Students	25	97.12	6.41		
	N = 49 df = 47	Mean Diff. = 3.16			

*Insignificant at 0.05 and 0.01 level

Similarly, no significant difference was found in the attitude of boys and girls studying at junior secondary level, as indicated by the data given in Table 6.

Table 6. Performance of Female vs Male Community Junior Secondary Students on SAS

Group	No. of Students	Mean	SD	SE of SD	't'
Female Students	16	91.56	8.49	2.98	0.22*
Male Students	18	90.89	8.91		
	N = 34 df = 32	Mean Diff. = 0.67			

*Insignificant at 0.05 and 0.01 level

Conclusion

On the basis of the above study, the data collected and analysis — it is revealed that the level of scientific attitude is not very good among all categories of students constituting the sample. The learners at lower levels of schooling need much attention in order to develop a better scientific attitude. The scores of subjects under each category were also compared component behaviour wise and it was found that they have lowest score for appreciating the nature of Science. Hence, there is a need of serious and concerted efforts for planning and implementing school Science curriculum in the country.

As way forward, it is proposed to emphasise on creative hands-on activities during teaching–learning of Science at all levels. Every effort should be made to develop the competencies of Science learning and learners should be exposed to innovative practices of Science teaching and

learning. They should be taught and trained to have a scientific bent of mind while dealing with problems in their day-to-day life. They should be given maximum exposure to understand the very nature and various forms of scientific knowledge as seen in the surroundings. Science curriculum should be developed and disseminated in such a way that it becomes useful for teachers and learners, environment-oriented and local need based.

For making all these efforts, the onus is on the educational institutions and other stakeholders concerned with the development of the child as an empowered future citizen of scientific temperament. There is a need to draw a comprehensive plan and make meticulous efforts for equipping all teachers with desired pedagogical content knowledge through pre-service as well as in-service training in Botswana.

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SCIENCE NEWS



Human Influence on Climate Clear, IPCC Report Says

Human influence on the climate system is clear. This is evident in most regions of the globe, a new assessment by the Intergovernmental Panel on Climate Change (IPCC) concludes.

It is extremely likely that human influence has been the dominant cause of the observed warming since the mid-20th century. The evidence for this has grown thanks to more and better observations, an improved understanding of the climate system response and improved climate models.

Warming in the climate system is unequivocal and since 1950 many changes have been observed throughout the climate system that are unprecedented over decades to millennia. Each of the last three decades has been successively warmer at Earth's surface than any preceding decade since 1850, reports the Summary for Policymakers of the IPCC Working Group I assessment report, *Climate Change 2013: The Physical Science Basis*, approved by



A new assessment by the IPCC finds that warming in Earth's climate system is unequivocal and since 1950 many changes have been observed throughout the climate system that are unprecedented over decades to millennia. Each of the last three decades has been successively warmer at Earth's surface than any preceding decade since 1850. (Credit: © Meryll / Fotolia)

member-governments of the IPCC in Stockholm, Sweden.

"Observations of changes in the climate system are based on multiple lines of independent evidence. Our assessment of the Science finds that the atmosphere and ocean have warmed, the amount of snow and ice has diminished, the global mean sea level has risen and the

concentrations of greenhouse gases have increased," said Qin Dahe, Co-Chair of IPCC Working Group I.

Thomas Stocker, the other Co-Chair of Working Group I said: "Continued emissions of greenhouse gases will cause further warming and changes in all components of the climate system. Limiting climate change will require substantial and sustained reductions of greenhouse gas emissions."

"Global surface temperature change for the end of the 21st century is projected to be likely to exceed 1.5°C relative to 1850 to 1900 in all but the lowest scenario considered, and likely to exceed 2°C for the two high scenarios," said Co-Chair Thomas Stocker. "Heat waves are very likely to occur more frequently and last longer. As Earth warms, we expect to see currently wet regions receiving more rainfall, and dry regions receiving less, although there will be exceptions," he added.

Projections of climate change are based on a new set of four scenarios of future greenhouse gas concentrations and aerosols, spanning a wide range of possible futures. The Working Group I report assessed global and regional-scale climate change for the early, mid- and late 21st century.

"As the ocean warms, and glaciers and ice sheets reduce, global mean sea level will continue to rise, but at a faster rate than we have experienced over the past 40 years," said Co-Chair Qin Dahe. The report finds with high confidence that ocean warming dominates the increase in energy stored in the climate system, accounting for more than 90 per cent of the energy accumulated between 1971 and 2010.

Co-Chair Thomas Stocker concluded: "As a result of our past, present and expected future

emissions of CO₂, we are committed to climate change, and effects will persist for many centuries even if emissions of CO₂ stop."

Rajendra Pachauri, Chair of the IPCC, said: "This Working Group I Summary for Policymakers provides important insights into the scientific basis of climate change. It provides a firm foundation for considerations of the impacts of climate change on human and natural systems and ways to meet the challenge of climate change." These are among the aspects assessed in the contributions of Working Group II and Working Group III to be released in March and April 2014. The IPCC Fifth Assessment Report cycle concludes with the publication of its Synthesis Report in October 2014.

"I would like to thank the Co-Chairs of Working Group I and the hundreds of scientists and experts who served as authors and review editors for producing a comprehensive and scientifically robust summary. I also express my thanks to the more than one thousand expert reviewers worldwide for contributing their expertise in preparation of this assessment," said IPCC Chair Pachauri.

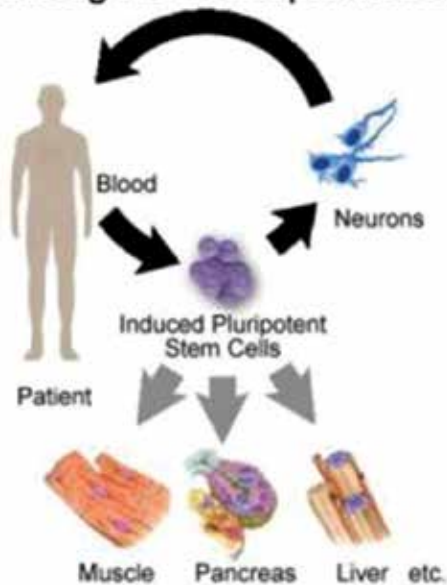
Patient's Own Cells Might be Used as Treatment for Parkinson's Disease

Induced pluripotent stem cells (iPSCs) taken from a patient hold great therapeutic potential for many diseases. However, studies in rodents have suggested that the body may mount an immune response and destroy cells derived from iPSCs. New research in monkeys refutes these findings, suggesting that in primates like us, such cells will not be rejected by the immune system. In the paper published in *Stem Cell Reports*, iPSCs from non-human primates successfully developed into the neurons

depleted by Parkinson's disease while eliciting only a minimal immune response. The cells therefore could hold promise for successful transplantation in humans.

iPSCs are cells that have been genetically reprogrammed to an embryonic stem-cell-like state, meaning that they can differentiate into virtually any of the body's different cell types. iPSCs directed to differentiate into specific cell types offer the possibility of a renewable source of replacement cells and tissues to treat ailments, including Parkinson's disease, spinal cord injury, heart disease, diabetes and arthritis.

Autologous Transplantation



This illustration shows the image of autotransplantation. The paper shows evidence only for neural cells and the brain, not for other organs. Immunogenicity in other organs needs to be explored. (Credit: *Stem Cell Reports*, Morizane et al.)

Studies in rodents have suggested that iPSC-derived cells used for transplantation may be rejected by the body's immune system. To test this in an animal that is more closely related to humans, investigators in Japan directed iPSCs taken from a monkey to develop into certain neurons that are depleted in Parkinson's disease patients. When they were injected into the same monkey's brain (called an autologous transplantation), the neurons elicited only a minimal immune response. In contrast, injections of the cells into immunologically unmatched recipients (called an allogeneic transplantation) caused the body to mount a stronger immune response.

"These findings give a rationale to start autologous transplantation — at least of neural cells — in clinical situations," says senior author Dr Jun Takahashi, of the Kyoto University's Center for iPS Cell Research and Application. The team's work also suggests that transplantation of such neurons into immunologically matched recipients may be possible with minimal use of immunosuppressive drugs.

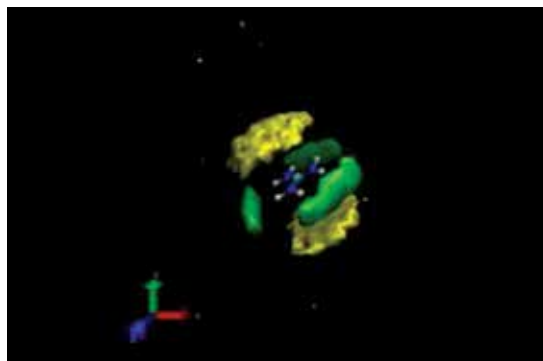
In Water as in Love, Likes Can Attract

At some point in elementary school, you were shown that opposite charges attract and like charges repel. This is a universal scientific truth — except when it isn't. A research team led by Berkeley Lab chemist Richard Saykally and theorist David Prendergast, working at the Advanced Light Source (ALS), has shown that, when hydrated in water, positively charged ions (cations) can actually pair up with one another.

"Through a combination of X-ray spectroscopy, liquid microjets and first principles" theory,

we have observed and characterised contact pairing between guanidinium cations in aqueous solution," Saykally says. "Theorists have predicted this cation-to-cation pairing but it has never been definitively observed before. If guanidinium cations can pair this way, then other similar cation systems probably can too."

Guanidinium is an ionic compound of hydrogen, nitrogen and carbon atoms whose salt — guanidinium chloride — is widely used by scientists to denature proteins for protein-folding studies. This practice dates back to the late 19th century when the Czech scientist Franz Hofmeister observed that cations such as guanidinium can pair with anions (negatively charged ions) in proteins to cause them to precipitate. The Hofmeister effect, which ranks ions on their ability to 'salt-out' proteins, became a staple of protein research even though its mechanism has never been fully understood.



This model of the guanidinium chloride salt (blue and silver) in solution shows carbon (yellow) and water (green) surrounding the cations and demonstrates cation-cation pairing. (Credit: Image courtesy of DOE/Lawrence Berkeley National Laboratory)

In 2006, Kim Collins of the University of Maryland proposed a 'Law of Matching Water Affinities' to help explain 'Hofmeister effects.' Collins' proposal holds that the tendency of

a cation and anion to form a contact pair is governed by how closely their hydration energies match, meaning how strongly the ions hold onto molecules of water. Saykally, who is a faculty scientist in Berkeley Lab's Chemical Sciences Division and a professor of Chemistry at the University of California Berkeley, devised a means of studying both the Law of Matching Water Affinities and Hofmeister effects. In 2000, he and his group incorporated liquid microjet technology into the high-vacuum experimental environment of ALS beamlines and used the combination to perform the first X-ray absorption spectroscopy measurements on liquid samples. This technique has since become a widely used research practice.

"The XAS spectrum is generally sensitive to the changes in the local solvation environment around each atom, including potential effects of ion-pairing," Saykally says. "However, the chemical information that one can extract from such experimental data alone is limited, so we interpret our spectra with a combination of molecular dynamics simulations and a first principles theory method."

Development of this first principles theory method was led by Prendergast, a staff scientist in the Theory of Nanostructures Facility at Berkeley Lab's Molecular Foundry. Computational resources were provided by the National Energy Research Scientific Computing Center (NERSC). The Molecular Foundry and NERSC, as well as the ALS, are all U.S. Department of Energy national user facilities hosted at Berkeley Lab.

With the liquid microjet technology, a sample rapidly flows through a fused silica capillary shaped to a finely tipped nozzle with an opening only a few micrometers in diameter. The resulting liquid beam travels a few centimetres in a vacuum chamber and is intersected by an X-ray beam then collected and condensed out. In analysing their current results, which

were obtained at ALS Beamline 8.0.1, the Berkeley Lab researchers concluded that the counterintuitive cation–cation pairing observed is driven by water-binding energy, as predicted by theory.

Orion Shih, a recent graduate of Saykally's research group, is the lead author of a paper describing this study in the *Journal of Chemical Physics*. The paper is titled 'Cation–cation contact pairing in water: Guanidinium'. Saykally is the corresponding author. Other co-authors are Alice England, Gregory Dallinger, Jacob Smith, Kaitlin Duffey, Ronald Cohen and Prendergast.

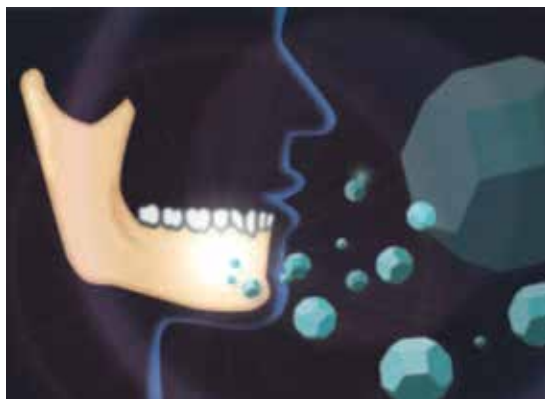
"We found that the guanidinium ions form strong donor hydrogen bonds in the plane of the molecule, but weak acceptor hydrogen bonds with the pi electrons orthogonal to the plane," Shih says. "When fluctuations bring the solvated ions near each other, the van der Waals attraction between the pi electron clouds squeezes out the weakly held water molecules, which move into the bulk solution and form much stronger hydrogen bonds with other water molecules. This release of the weakly interacting water molecules results in contact pairing between the guanidinium cations. We believe our observations may set a general precedent in which like charges attract becomes a new paradigm for aqueous solutions."

Are Nanodiamond-Encrusted Teeth the Future of Dental Implants?

UCLA researchers have discovered that diamonds on a much, much smaller scale than those used in jewellery could be used to promote bone growth and the durability of dental implants.

Nanodiamonds, which are created as byproducts of conventional mining and refining operations,

are approximately four to five nanometers in diameter and are shaped like tiny soccer balls. Scientists from the UCLA School of Dentistry, the UCLA Department of Bioengineering and Northwestern University, along with collaborators at the NanoCarbon Research Institute in Japan, may have found a way to use them to improve bone growth and combat osteonecrosis, a potentially debilitating disease in which bones break down due to reduced blood flow.



Nanodiamonds. (Credit: Courtesy of UCLA School of Dentistry)

When osteonecrosis affects the jaw, it can prevent people from eating and speaking; when it occurs near joints, it can restrict or preclude movement. Bone loss also occurs next to implants such as prosthetic joints or teeth, which leads to the implants becoming loose or failing.

The implant failures necessitate additional procedures, which can be painful and expensive, and can jeopardize the function the patient had gained with an implant. These challenges are exacerbated when the disease occurs in the mouth, where there is a limited supply of local bone that can be used to secure the prosthetic tooth, a key consideration for both functional and aesthetic reasons.

The study, led by Dr Dean Ho, professor of oral biology and medicine and co-director of the Jane and Jerry Weintraub Center for Reconstructive Biotechnology at the UCLA School of Dentistry, appears online in the peer-reviewed *Journal of Dental Research*.

During bone repair operations, which are typically costly and time-consuming, doctors insert a sponge through invasive surgery to locally administer proteins that promote bone growth, such as bone morphogenetic protein.

Ho's team discovered that using nanodiamonds to deliver these proteins has the potential to be more effective than the conventional approaches. The study found that nanodiamonds, which are invisible to the human eye, bind rapidly to both bone morphogenetic protein and fibroblast growth factor, demonstrating that the proteins can be simultaneously delivered using one vehicle. The unique surface of the diamonds allows the proteins to be delivered more slowly, which may allow the affected area to be treated for a longer period of time. Furthermore, the nanodiamonds can be administered non-invasively, such as by an injection or an oral rinse.

"We've conducted several comprehensive studies, in both cells and animal models, looking at the safety of the nanodiamond particles," said Laura Moore, the first author of the study and an M.D., Ph.D. student at Northwestern University under the mentorship of Dr Ho. "Initial studies indicate that they are well tolerated, which further increases their potential in dental and bone repair applications."

"Nanodiamonds are versatile platforms," said Ho, who is also professor of bioengineering and a member of the Jonsson Comprehensive Cancer Center and the California NanoSystems

Institute. "Because they are useful for delivering such a broad range of therapies, nanodiamonds have the potential to impact several other facets of oral, maxillofacial and orthopedic surgery, as well as regenerative medicine."

Ho's team previously showed that nanodiamonds in preclinical models were effective at treating multiple forms of cancer. Because osteonecrosis can be a side effect of chemotherapy, the group decided to examine whether nanodiamonds might help treat the bone loss as well. Results from the new study could open the door for this versatile material to be used to address multiple challenges in drug delivery, regenerative medicine and other fields.

"This discovery serves as a foundation for the future of nanotechnology in dentistry, orthopedics and other domains in medicine," said Dr No-Hee Park, dean of the School of Dentistry. "Dr Ho and his team have demonstrated the enormous potential of the nanodiamonds toward improving patient care. He is a pioneer in his field."

Other authors of the study were Professor Eiji Osawa of the NanoCarbon Research Institute in Japan, and Ho-Joong Kim, a postdoctoral research scholar who was previously in Dr Ho's laboratory and is currently an assistant professor of chemistry at Chosun University in South Korea.

Harnessing the Sun's Energy with Tiny Particles

Engineers at Sandia National Laboratories, along with partner-institutions Georgia Tech, Bucknell University, King Saud University and the German Aerospace Center (DLR), are using a falling particle receiver to more efficiently convert the Sun's energy into electricity in large-scale, concentrating solar power plants.



Joshua Mark Christian working with the falling particle receiver, which more efficiently converts the Sun's energy into electricity in large-scale, concentrating solar power plants. (Credit: Randy Montoya)

Falling particle receiver technology is attractive because it can cost-effectively capture and store heat at higher temperatures without breaking down, which is an issue for conventional molten salts. The falling particle receiver developed at Sandia drops sand-like ceramic particles through a beam of concentrated sunlight, and captures and stores the heated particles in an insulated container below. The technique enables operating temperatures of nearly 1,000 degrees Celsius. Such high temperatures translate into greater availability of energy and cheaper storage costs because at higher temperatures, less heat-transfer material is needed.

Central receiver systems use mirrors to concentrate sunlight on a target, typically a fluid, to generate heat, which powers a turbine and generator to produce electricity. Currently, such systems offer about 40 per cent thermal-to-electric efficiency. The falling particle receiver enables higher temperatures and can work with higher-temperature power cycles that can achieve efficiencies of 50 per cent or more.

"Our goal is to develop a prototype falling particle receiver to demonstrate the potential for greater than 90 per cent thermal efficiency, achieve particle temperatures of at least 700 degrees Celsius, and be cost competitive," said the project's principal investigator, Sandia engineer Cliff Ho. "The combination of these factors would dramatically improve the system performance and lower the cost of energy storage for large-scale electricity production."

The project is funded up to \$4 million by the Department of Energy's SunShot Initiative, which aims to drive down solar energy production costs and pave the way to widespread use of concentrating solar power and photovoltaics.

Falling particle receiver technology was originally studied in the 1980s, and Sandia researchers are working to address challenges that hindered greater acceptance of the concept. Among the issues are mitigating particle loss, maintaining the stability of falling particles, increasing the residence time of the particles in the concentrated beam and reducing heat losses within the receiver cavity.

Ho and his colleagues at Sandia have been working to address these issues by studying the effect of an added air curtain, created by a series of blower nozzles, to help particles fall in a stable pattern and reduce convective losses. Adjusting the particle size and how sand is dropped has also helped, ensuring more of the sand gets heated in a pass and makes it to the collection bin at the bottom. Researchers are also investigating the benefits of using an elevator to recirculate particles through the aperture a second time to increase their temperature.

"Given our unique facilities at the National Solar Thermal Test Facility, we have the capability

of developing prototype hardware and testing the concepts we've simulated, which include innovations such as air recirculation and particle recirculation. Advanced computing lets us do complex simulations of the falling particle receiver to understand the critical processes and behaviour," Ho said. "We're very encouraged by our progress and look forward to further developing this enabling technology."

Falling particle receiver technology is expected to lead to power-tower systems capable of generating up to 100 megawatts of electricity.

Snake Robot on Mars?

The ESA wants its operations on other planets to have greater mobility and manoeuvrability. SINTEF researchers are looking into whether snake robots could be the answer.

So far, NASA has landed four rovers on Mars. These are solar-powered robots with six wheels and robotic arms that can take soil samples and operate cameras. Sojourner landed in 1997, Spirit and Opportunity in 2003, while the more advanced Curiosity was landed in 2012. "Manoeuvrability is a challenge. The Spirit rover was lost after it became stuck in the sand on Mars. The vehicles just cannot get to many of the places from which samples have to be taken," say Pål Liljebäck and Aksel Transeth at SINTEF ICT.

The researchers are busy working on a feasibility study assigned to them by the ESA. The ESA and the researchers believe that by combining a rover that can navigate over large distances with a snake robot that can crawl along the ground and can get into inaccessible places, so many more possibilities could be opened up.

At the moment, soil samples from Mars are analysed on board the rover itself, and the results are communicated back to Earth.



The researchers envisage using the rover to navigate over large distances, after which the snake robot can detach itself and crawl into tight, inaccessible areas. (Credit: Image courtesy of SINTEF)

However, the ESA also wants to examine options that could allow samples to be returned to Earth. Snake robots could assist with collecting such samples, since they enable access to tight spots that the rovers cannot reach.

An Arm becomes a Snake Robot

"We are looking at several alternatives to enable a rover and a robot to work together. Since the rover has a powerful energy source, it can provide the snake robot with power through a cable extending between the rover and the robot. If the robot had to use its own batteries, it would run out of power and we would lose it," explains Aksel Transeth.

"One option is to make the robot into one of the vehicle's arms, with the ability to disconnect and reconnect itself, so that it can be lowered to the Paraground, where it can crawl about independently."

The researchers envisage using the rover to navigate over large distances, after which the snake robot can detach itself and crawl into tight, inaccessible areas. A cable will connect the robot to the vehicle. The cable will supply

power and tractive power, i.e., it can be winched back to the rover. Communication between the pair will be facilitated via signals transmitted down the cable.

"The connection between the robot and the rover also means that the snake robot will be able to assist the vehicle if the latter gets stuck," says Liljebäck. "In such a situation, the robot could lower itself to the ground and coil itself around a rock enabling the rover pull itself loose by means of the cable winch, which the rover would normally use to pull the snake robot towards the rover."

Report to the ESA "At the Department of Applied Cybernetics, we have been working closely with the Norwegian University of Science and Technology's (NTNU's) Department of Engineering Cybernetics on snake robots for many years, and our teams have had some ideas about this for a long time," say Transeth and Liljebäck. "It is only now that we are starting to see some actual applications, and it is wonderful to be given this opportunity to provide the ESA with information about future technologies in this field. What we hope is that our ideas will trigger the ESA into initiating a targeted development process around this kind of system."

Videos: <http://robotnor.no/research/serpentine-robots-for-planetary-exploration-serpex/>

So far, NASA has landed four rovers on Mars: Sojourner in 1997, Spirit and Opportunity in 2004, and Curiosity in 2012. The latter is highly advanced and comes with a built-in laboratory. The ESA has new missions planned for 2016 and 2028.

After the Storms, a Different Opinion on Climate Change

Extreme weather may lead people to think more seriously about climate change, according to a new research. In the wake of Hurricanes Irene and Sandy, New Jersey residents were more likely to show support for a politician running on a 'green' platform, and expressed a greater belief that climate change is caused by human activity.

This research, published in *Psychological Science*, a journal of the Association for Psychological Science, suggests that traumatic weather events may have the power to shift people's automatic attitudes — their first instincts — in favour of environmentally sustainable policies.

Though scientists are in near-unilateral agreement that human activity contributes to climate change, the relationship is not as clear to many politicians and citizens. This translates into lackluster support for environmental policies, especially when the short-term consequences amount to higher taxes.

"Americans tend to vote more from a self-interested perspective rather than demand that their government affect change," says lead researcher Laurie Rudman of Rutgers University.

In 2010, Rudman and her colleagues Meghan McLean and Martin Bunzl surveyed over 250 Rutgers undergraduate students, measuring their attitudes towards two politicians, one who favoured and another who opposed environmental policies that involve tax increases. The researchers asked the students whether they believed that humans are causing climate change, and they also had the students complete



Hurricane Sandy destruction. In the wake of Hurricanes Irene and Sandy, New Jersey residents were more likely to show support for a politician running on a 'green' platform, and expressed a greater belief that climate change is caused by human activity. (Credit: © Leonard Zhukovsky / Fotolia)

a test intended to reveal their automatic, instinctual preferences towards the politicians.

Though most students said they preferred the green politician, their automatic preferences suggested otherwise. The automatic-attitudes test indicated that the students tended to prefer the politician who did not want to raise taxes to fund environment-friendly policy initiatives.

After Hurricanes Irene and Sandy devastated many areas on the Eastern Seaboard in 2012, Rudman and her colleagues wondered whether they would see any differences in students' attitudes towards environmental policies.

"It seemed likely that what was needed was a change of 'heart,'" Rudman explains. "Direct, emotional experiences are effective for that."

In contrast with the first group, students tested in 2012 showed a clear preference for the green politician, even on the automatic attitudes test. And those students who were particularly affected by Hurricane Sandy — experiencing power outages, school disruptions, even

damaged or destroyed homes — showed the strongest preference for the green politician.

"Not only was extreme weather persuasive at the automatic level, people were more likely to base their decisions on their gut-feelings in the aftermath of Sandy, compared to before the storm," Rudman explains.

While they don't know whether the first group of students would have shown a shift in attitudes after the storms, the researchers believe their findings provide evidence that personal experience is one factor that can influence instinctive attitudes towards environmental policy. If storms do become more prevalent and violent as the climate changes, they argue, more people may demand substantive policy changes.

Waiting for severe storms to shift the public's opinions on policy changes might be a sobering reality, but Rudman and her colleagues are more optimistic.

"Our hope is that researchers will design persuasion strategies that effectively change people's implicit attitudes without them having to suffer through a disaster," Rudman concludes.

Four New Species of 'Legless Lizards' Discovered Living on the Edge

California biologists have discovered four new species of reclusive legless lizards living in some of the most marginal habitat in the state. "This shows that there is a lot of undocumented biodiversity within California," said Theodore Papenfuss, a reptile and amphibian expert, or herpetologist, with UC Berkeley's Museum of Vertebrate Zoology, who discovered and identified the new species with James Parham of California State University, Fullerton. The

discoveries raise the number of California legless lizard species from one to five.

The herpetologists named the new snake-like lizards after four legendary UC Berkeley scientists: museum founder Joseph Grinnell, paleontologist Charles Camp, philanthropist and amateur scientist Annie Alexander and herpetologist Robert C. Stebbins, at 98 the only one of the group still alive.



One of four newly discovered species of legless lizard is from Bakersfield and has a purple belly and yellow sides. UC Berkeley and Cal State-Fullerton biologists named it *Anniella grinnelli* after Joseph Grinnell, founder of UC Berkeley's Museum of Vertebrate Zoology. This species today ranges from downtown Bakersfield in the southern San Joaquin Valley to the Carrizo Plain National Monument 30 miles to the west. (Credit: Alex Krohn)

"These are animals that have existed in the San Joaquin Valley, separate from any other species, for millions of years, completely unknown," said Parham, who obtained his doctorate from Berkeley and is now curator of paleontology at the John D. Cooper Archaeology and Paleontology Center. "If you want to preserve biodiversity, it is the really distinct species like these that you want to preserve."

Papenfuss and Parham reported their discovery this month in the journal *Breviora*, a publication of the Museum of Comparative Zoology at Harvard University.

"Legless lizards, represented by more than 200 species worldwide, are well-adapted to life in loose soil", Papenfuss said. Millions of years ago, lizards on five continents independently lost

their limbs in order to burrow more quickly into sand or soil, wriggling like snakes. Some still have vestigial legs. Though up to eight inches in length, the creatures are seldom seen because they live mostly underground, eating insects and larvae, and may spend their lives within an area the size of a dining table. Most are discovered in moist areas when people overturn logs or rocks.

Herping the Central Valley

For the past 15 years, Papenfuss and Parham have scoured the state for new species, suspecting that the fairly common California legless lizard (*Anniella pulchra*), the only legless lizard in the U.S. West, had at least some relatives. They discovered one new species — yellow-bellied like its common cousin — under leaf litter in protected dunes west of Los Angeles International Airport. They named that species *A. stebbinsi*, because Stebbins grew up and developed an early interest in natural history in the nearby Santa Monica Mountains.

Because many sandy, loamy areas, including dunes and desert areas, offer little cover for lizards if they emerge, Papenfuss distributed thousands of pieces of cardboard throughout the state in areas likely to host the lizard. He returned year-after-year to see if lizards were using the moist, cool areas under the cardboard as resting or hunting grounds.

This led to the discovery of a silver-bellied species near Fellows in the oil fields around Taft, which they named *A. alexandrae* after Annie Alexander, who endowed the UC Berkeley museum in 1908 and added 20,000 specimens to its collections. The herpetologists found another species in three isolated, arid canyons on the edge of the Mojave Desert just below and east of Walker Pass in the Sierra Nevada and named it *A. campi* after Charles Camp,

because of his early-career discovery of the Mt. Lyell salamander in the Sierra. The purple-bellied fourth was found in three vacant lots in downtown Bakersfield, though only one of those lots remains: the others have been bulldozed and developed. The biologists named that species *A. grinnelli* after Joseph Grinnell, who in 1912 first noted habitat destruction around Bakersfield from agriculture and oil drilling.

Interestingly, all these species had been collected before and were in collections around California, but when preserved in alcohol, the lizards lose their distinctive colour and look identical. Papenfuss and Parham identified the species through genetic profiling, but they subsequently found ways to distinguish them from one another via belly colour, number and arrangement of scales, and number of vertebrae. However, two species — the previously known common legless lizard of Northern California and the newly named southern species found at LAX and apparently broadly distributed south of the Tehachapi Mountains—remain indistinguishable except by genetic tests or, now, the location where they are found.

Species of Special Concern

Papenfuss and Parham are working with the California Department of Fish and Wildlife (CDFW) to determine whether the lizards need protected status. Currently, the common legless lizard is listed by the state as a species of special concern.

"These species definitely warrant attention, but we need to do a lot more surveys in California before we can know whether they need higher listing," Parham said.

Papenfuss noted that two of the species are within the range of the blunt-nosed leopard

lizard, which is listed as an endangered species by both the federal and state governments.

"On one hand, there are fewer legless lizards than leopard lizards, so maybe these two new species should be given special protection," he said. "On the other hand, there may be ways to protect their habitat without establishing legal status. They don't need a lot of habitat, so as long as we have some protected sites, they are probably OK."

Papenfuss says they are not yet in danger of going extinct, since he has found some of the lizards in protected reserves operated by the CDFW, the U.S. Bureau of Land Management and a private water reserve outside Bakersfield, in addition to the El Segundo Dunes near LAX.

Barriers to HIV Vaccine Response Explored by Researchers at The Scripps Research Institute (TSRI)

Barriers to HIV vaccine response explored by the researchers at The Scripps Research Institute (TSRI) discovered that an antibody that binds and neutralises HIV likely also targets the body's own 'self' proteins. This finding could complicate the development of HIV vaccines designed to elicit this protective antibody, called 4E10, and others like it, as doing so might be dangerous or inefficient.

"We developed two new mouse models that allow us to visualise the fate of the rare B cells that can see HIV and we thought could be stimulated by vaccines to produce neutralising antibodies — the type of antibodies we seek to produce in response to a vaccine," said David Nemazee, Ph.D. professor in the Department of Immunology and Microbial Science at TSRI and senior author of the study. "We were able to

study vaccine responses of B12, an antibody that sees the CD4 binding site of HIV, but, surprisingly to us, not 4E10, an antibody that sees the stem of the HIV envelope protein."

Nemazee and his team went on to discover that cells with the potential to produce 4E10 antibodies trigger several natural safeguards that shut down the production of any antibody that might recognise and destroy the body's own tissues. They concluded that 4E10 cross-reacts with host tissues in this way, prompting its removal before it can do any harm or good. The study was recently published in *The Journal of Immunology*.

HIV Vaccine Development

4E10 antibodies were originally isolated from a human HIV patient. The antibodies specifically recognise and bind an HIV surface protein called gp41. The virus uses gp41 like a long spike to poke holes in its host's immune cells. But when 4E10 antibodies clog up gp41, the virus is neutralised and host cells are protected.

4E10 especially interests HIV researchers because the antibody recognises and binds to gp41 on the surface of many different strains of the virus, not just the one strain with which the patient was most recently infected. If a vaccine could be made to specifically and safely stimulate 4E10-like production, recipients would likely be protected against multiple HIV strains.

In humans, HIV slowly destroys the immune system, leading to Acquired Immune Deficiency Syndrome (AIDS). According to the Center for Disease Control and Prevention, more than 1.1 million people in the U.S. are living with HIV infection. While treatments developed in the past decade can keep the virus in check for many years, there is no vaccine and there is no cure.

Proceeding with Caution

In several ongoing studies, the TSRI team and others are working out how to make a vaccine that stimulates the production of 4E10, b12 and other broadly neutralising anti-HIV antibodies. However, this latest study indicates that this approach might be complicated by unwanted self-reactivity. Antibodies that cross-react with host tissue — like 4E10 has now been shown to do — are associated with auto-immune diseases such as multiple sclerosis and lupus.

The TSRI study also raises the question of how 4E10 was generated in the first place. According to Nemazee, 4E10 may be a fluke, cropping up in an HIV patient who was also prone to autoimmune diseases. Alternatively, the autoreactive antibody could have arisen in the patient as a consequence of the disease perhaps the body's normal mechanism for weeding out such antibodies failed, allowing the serendipitous production of an anti-HIV antibody.

Despite this new concern, there is still hope for 4E10's role in HIV vaccine development. A companion paper published in the same issue of *The Journal of Immunology* (<http://www.jimmunol.org/content/191/6/3179.long>) found that another potent, broadly neutralising anti-HIV antibody, b12, was not self-reactive and could respond to a candidate vaccine preparation provided by Richard Wyatt, TSRI Professor of Immunology and Director of Viral Immunology at the International AIDS Vaccine Initiative Neutralizing Antibody Center.

"It's still possible that we could safely elicit the 4E10-like antibody in order to protect against HIV," Nemazee said. "We just have to think about how to generate the best antibodies without causing other problems. We have a lot of questions. And now we have a good model to help us answer them."

Blood Pressure Cuff may Save Lives in Patients with Acute Heart Attack

In patients with an acute heart attack, remote ischemic conditioning — intermittent inflation of a blood pressure cuff to cut off blood flow to the arm during transportation to hospital for acute balloon dilatation — reduces subsequent cardiac symptoms and mortality after acute heart attack. The results are presented by researchers from Aarhus University Hospital and Aarhus University in *European Heart Journal* on-line 12 September 2013.

Activating the Body's Defense Mechanism

Lack of oxygen for short periods of time in a distant organ by intermittently stopping blood flow to a limb, can protect another organ (i.e., the heart), during a prolonged period of lack of oxygen as it is the case during a heart attack. Professor Hans Erik Bøtker and his research team have previously demonstrated that remote ischemic conditioning reduces cardiac tissue damage on average 30 per cent in patients undergoing acute balloon treatment for a heart attack. In patients treated with conditioning, a blood pressure cuff was placed around the upper arm and inflated to 200 mmHg for 5 minutes to cut off blood flow, and then released. The arm then rested for 5 minutes, and then the blood pressure cuff was re-applied. This procedure was repeated 4 times.

The rate of complications is halved

The researchers have now followed 251 patients assigned to receive conditioning or no conditioning in addition to usual care during transportation to the heart centre for up to 4 years. During the follow-up period the initial salvage of heart tissue by conditioning was translated into a clinical benefit for the patients.

The occurrence of new heart symptoms was reduced by 51 per cent in the conditioning group compared to the control group. The total number of deaths was low and the deaths caused by heart disease was reduced by 61 per cent.

The underlying mechanisms are thought to involve activation of endogenous protective systems that induce resistance towards tissue damage in the heart during a heart attack and in particular when re-opening the occluded heart vessel by balloon dilatation. Ph.D. student Astrid Drivsholm Sloth, who conducted the present study, characterises the treatment as promising and predicts that it will have widespread potential in the treatment of heart attacks. However, larger studies are required to confirm the clinical implications of this smaller pilot trial such that it can be clarified whether the new intervention can reduce mortality and the development of heart failure after a heart attack.

How Lethal Bird Flu Viruses Evolved

Deadly H7N9 avian flu viruses infected many people, but little is known about how they evolved to become harmful to humans. In a study published in *Cell Host & Microbe*, an in-depth evolutionary analysis of whole-genome sequences of different types of avian flu viruses has revealed that new H7N9 viruses emerged from distinct H9N2 viruses in a two-step process, first occurring in wild birds and then continuing in domestic birds.

"A deep understanding of how the novel H7N9 viruses were generated is of critical importance for formulating proper measures for surveillance and control of these viruses and other potential emerging influenza viruses," says senior study author Taijiao Jiang of the Chinese Academy of Sciences.

First detected in people in late March, H7N9 viruses have resulted in more than 130 human infections and at least 44 deaths. Most of these infections occurred after exposure to infected poultry or contaminated environments rather than person-to-person contact, but these viruses could evolve to become more readily transmissible among humans. This possible threat highlights the importance of understanding the evolutionary history of H7N9 viruses for developing appropriate strategies to monitor and control outbreaks.

To address this problem, Jiang teamed up with Daxin Peng of Yangzhou University and their collaborators to analyse whole-genome sequences of avian flu viruses from humans, poultry and wild birds from China. They discovered that H7N9 viruses are genetically diverse, suggesting that complex genetic events were involved in their evolution.

Their analysis revealed that the new H7N9 viruses emerged through a two-step process involving the exchange of genetic material between distinct viruses. In the first step, which took place in wild birds, genetic material from H9N2 viruses and unspecified H7 and N9 viruses was mixed to create precursor H7N9 viruses. The second step, which occurred in domestic birds in eastern China early last year, involved the exchange of genetic material between the precursor H7N9 viruses and other H9N2 viruses to create new, genetically diverse H7N9 viruses.

"Our work not only re-enforces the important role of wild birds in the emergence of novel influenza viruses but also highlights the necessity of integrating data from infections in humans, poultry, and wild birds for effective influenza surveillance," Jiang says.

'Jekyll-and-Hyde' Protein Offers a New Route to Cancer Drugs

The researchers in Britain, with collaborators in Singapore and the USA, carried out a comprehensive biological study of the protein E2F, which is abnormal in the vast majority of cancers. They were able to explain the dual nature it can take up in cells in the body, and indicate how it could be a potent target for developing new cancer drugs.

The Oxford University scientists have since carried out a drug-discovery screen, and shown that compounds which block the protein's change into 'Mr Hyde' result in the death of cancer cells.

"This mechanism for switching a key protein is very novel. Nothing else I've come across behaves like it," says Professor Nick La Thangue of the Department of Oncology at Oxford University, who led the work. Subtle changes in terms of the chemistry of the protein have dramatic and polar opposite effects on the tumour cell, either allowing them to continuously grow or switching them to cell death mode.

"We are excited by this new discovery, which provides a new and very important approach to developing new types of cancer drugs. We have much work to do," says Professor La Thangue.

The researchers from the University of Oxford, the Genome Institute of Singapore and the University of Texas' MD Anderson Cancer Centre in the USA report their findings in the journal *Molecular Cell*. The study was part-funded by the UK Medical Research Council and Cancer Research UK.

Cells in the body go through cycles of growth and division, pauses and death in a highly regulated

way. Cancer involves the breakdown of these controls leading to unlimited expansion of the cells in a growing tumour.

The protein E2F is inextricably linked to cancer. It is normally tightly controlled in the cell cycle, but in most if not all cancer cells the processes E2F oversees go awry so that it keeps cells growing.

Puzzlingly, while it can be a factor driving cancer, on other occasions E2F is protective and removes damaged cells. When normal cells experience damage, E2F is involved in switching the cell towards cell death in a process called apoptosis. This helps prevent the build up of DNA errors and the development of cancer.

It's this dual Jekyll-and-Hyde nature of E2F that the researchers have been able to explain for the first time.

The researchers show that two enzymes compete to attach a molecular label, or flag, on different parts of the E2F protein. The flag in one position sees E2F act to cause cell death and the same flag in another position sees E2F boost cell growth and proliferation.

Professor La Thangue says: "It's like there's an angel and a devil competing to get on each shoulder of the protein. Which one gets the upper hand is able to whisper in the ear of the protein and tell it what it should do. With the molecular flag on one shoulder, E2F goes into cell kill mode. With the flag on the other, it goes into cell growth mode. The challenge is to mimic this process with drugs, and reinstate the death pathway in tumour cells."

In cancer cells, E2F gets stuck with the flag boosting growth and division, helping drive the tumour's growth. The researchers identified another protein in the cell which looks for the presence of this flag.

"Blocking this protein means the devil's whispers never get heard and E2F doesn't transform into Mr Hyde," says Professor La Thangue. Instead, E2F switches over to cell-death mode and the cancer cells die out.

"We've identified compounds — drug candidates — that do exactly that," he explains.

Dr Shunsheng Zheng, first author of the study and a graduate student on the joint A*STAR-University of Oxford D.Phil. scholarship programme, said: "E2F is a tricky protein to work with. Normal cells use it for growth, cancer cells need it for hypergrowth, but too much of it seems to drive cancer cells into suicidal mode."

Dr Kat Arney, science information manager at Cancer Research UK, which part-funded the work, said: "Cancer is a complex biological problem, and getting to grips with the molecules that drive it is essential if we're to find new cures. Although there's a lot more work to be done before this new discovery could become a treatment for patients, this research is an important step forward in understanding E2F's 'split personality' in both driving and destroying cancer cells."

New Teaching Method Improves Maths Skills, Closes Gender Gap in Young Students

When early elementary maths teachers ask students to explain their problem-solving strategies and then tailor instruction to address specific gaps in their understanding, students learn significantly more than those taught using a more traditional approach. This was the conclusion of a year-long study of nearly 5,000 kindergarten and first-grade students conducted by researchers at Florida State University.

The researchers found that 'formative assessment,' or the use of ongoing evaluation of student understanding to inform targeted instruction, increased students' mastery of foundational maths concepts that are known to be essential for later achievement in mathematics and science.

Their results corroborated those of two earlier pilot projects indicating that implementation of the Mathematics Formative Assessment System (MFAS) can markedly improve academic performance in mathematics. The findings further suggested that MFAS may help close the gender gap that often develops by third grade.

"The results of the most recent study conducted in schools across Florida are exciting," said Laura Lang, principal investigator who directed development and testing of MFAS. "The randomised field trial showed that students in K-3 classes where teachers used MFAS were well ahead of other students taught by teachers using more traditional approaches. As one of the elementary principals of a participating school put it, MFAS is a real 'game changer' in terms of student engagement and success in maths."

MFAS was created through the efforts of researchers at the Florida Center for Research in Science, Technology, Engineering and Mathematics (FCR-STEM) who received \$2.9 million in competitively awarded grant funds from the Florida Department of Education's Race to the Top programme to pursue the project. MFAS is fully aligned with the Common Core State Standards adopted in Florida and many other states.

The randomised field trial was conducted in partnership with 31 schools and 301 teachers in three Florida districts across the state — one urban, one sub-urban and one rural. Schools were randomly assigned to either the MFAS

treatment group or to a group that used a more typical approach to maths instruction.

Comparing average annual gains in maths on nationally normed tests to the results, learning was accelerated when teachers integrated MFAS in their day-to-day instruction.

"In kindergarten, we can infer that students learned at a rate equivalent to an extra six weeks of instruction," Lang said. "In first grade, the gains were even greater — two months of extra instruction. It was as if we extended the school year without actually adding any more days to it."

In constructing MFAS, Lang and her team drew upon research demonstrating that the learning of mathematics is facilitated when teachers gain deeper insights into what their students already know and are able to do as well as what students do not know and are unable to do. Teachers gather these insights through careful observation and by engaging students in discussions of their mathematical thinking.

"Formative assessment is a process, not a test," Lang said, "and feedback is a key element".

The approach enables teachers to address each child's instructional needs. Teachers can avoid holding back those who are ready to advance, while efficiently helping those who are struggling. This contrasts sharply with current practice in many elementary classrooms.

"Based on our classroom observations over the past four years, teachers typically rely heavily on a maths textbook to guide the planning of day-to-day instruction and often provide students feedback only on whether their answers are correct," Lang said. "Teachers integrating formative assessment in instruction not only ask students to do maths tasks but also to explain their reasoning and to justify their solutions. As

a result, teachers are better equipped to identify misconceptions, determine gaps in understanding and adjust their instruction accordingly.”

Students play a key role in the formative assessment process. MFAS actively engages students, encouraging them to monitor and regulate their own learning. Students also evaluate each other’s work and provide productive feedback, working as a team.

“MFAS also has potential long-term effects on closing the gender gap in mathematics”, Lang said. Studies show that even though both boys and girls enter school with a fundamental number sense, by the third grade, boys tend to do better in mathematics.

The results of a pilot study conducted in second- and third-grade classrooms suggest that, in

classrooms where MFAS was used, by third grade, the girls showed no statistically significant difference in mathematics achievement from boys, according to Mark LaVenia, methodologist on the MFAS team. However, in classrooms with more conventional instruction, girls continued to lag behind boys in maths achievement.

Source : Science Daily

Compiled and edited by

Sunita Farkya

DESM, NCERT, New Delhi

Somesh Banerjee

JPF, DESM, NCERT, New Delhi

WEB WATCH

In this section, we present websites and a brief introduction about them. Inclusion of a site does not imply that *School Science* endorses the content of the site. Sites have been suggested on the basis of their possible utility to school systems.



- **www.treehugger.com**

This website is dedicated to a greener environment. It gives green news, solutions and product information. The website also publishes up-to-date minute blogs, weekly and daily newsletter and radio interviews too. One will get information and news related to greener sustainable resources.

- **www.bestfree-book.com**

This website is for avid fiction readers. The website contains novels belonging to different genres — Vampires, horror, thriller, fantastic fiction, science fiction, mystery or suspense, romance and classics. One will get to read fiction for free in this website.

- **www.pagebypagebooks.com**

This website is dedicated to classic literature. It contains hundreds of classic literature which one can read online and for free. The website is an ideal way to expand your horizons when it comes to classic literature.

Compiled and edited by

Sunita Farkya

DESM, NCERT, New Delhi

Somesh Banerjee

JPF, DESM, NCERT, New Delhi

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For further enquiries, please write to:

Chief Business Manager, Publication Division

National Council of Educational Research and Training

Sri Aurobindo Marg, New Delhi 110 016

E-mail : gg_cbm@rediffmail.com, Phone : 011-26562708, Fax : 011-26851070

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