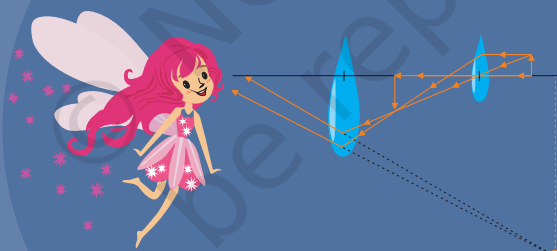


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# School Science

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Combination of lenses increases the magnification and makes the object look larger in size

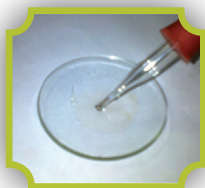
## To Our Contributors

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.

Manuscripts with illustrations, charts, graphs, etc., along with legends, neatly typed in double space on uniform-sized paper, should be sent to the Executive Editor, School Science, Department of Education in Science and Mathematics, NCERT, Sri Aurobindo Marg, New Delhi 110 016 or email at [school.science@yahoo.com](mailto:school.science@yahoo.com).

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## EDITORIAL

In this issue of December 2016, we have incorporated articles and research papers from various domains of Science Education.

The article 'Qualitative Analysis of Manganese (II) ions: Sensitive, Selective and Time Effective Method' by Ruchi Verma, discusses selective test for identification of manganese (II) ion in a salt mixture without following the standard sequence of reactions. It is found that the colour of the mixture may interfere to identify given substance. Taking this into consideration as a limitation, the test can be used as a sensitive, selective and time effective qualitative analysis of Mn(II) ions. Moreover, it can be used for demonstrating the concept of stability of complexes in different oxidation states, such as, Manganese in both oxidation states as Mn(II) and Mn(IV).

The paper on 'Problem Based Learning in Basic Physics - XI' by A.K. Mody and H.C. Pradhan is a sequel to Part X which includes several problems in the area of geometrical optics and presents the learning objectives in this area of basic physics thereby achieving solutions.

'Back-of-the-Envelope Estimation: An Excellent Pedagogical Tool' by B.K. Parida and J.K. Mohapatra describes how the back of the envelope estimation can be used as a pedagogical tool. Authors have pointed out some of its merits with examples from the history of science and some examples from school level science. This approach to estimating things can be useful in a classroom and makes teaching-learning more engaging, interesting and effective.

The research paper on 'Effectiveness of Structured and Unstructured Field Trip: An Experimental Study' by Meena Sehrawat and M.M. Roy indicates that structured field trip significantly enhances learning of concepts.

The article, 'Tales Building Concepts: A Constructivist Approach to Teaching-learning Science' is intended to use pedagogy of storytelling as a strategy of teaching and learning of science concepts beyond classroom and textbooks.

We sincerely hope that our readers would find the articles, features and news interesting and informative. Your valuable suggestions, observations and comments are always welcome to bring further improvement in the quality of the journal.

Form IV (See Rule 8)

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I, Anup Kumar Rajput, hereby declare that the particulars given above are true to the best of my knowledge and belief.

**Publisher**

# QUALITATIVE ANALYSIS OF MANGANESE (II) IONS: SENSITIVE, SELECTIVE AND TIME EFFECTIVE METHOD

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This article discusses about a novel method for identification of Manganese (II) ion in a given substance through a selective test without following the sequence of reactions which is done in the traditional method of qualitative analysis. This can be considered as sensitive, selective and time effective method for qualitative analysis of Mn(II) ions.

**KEY WORDS:** Qualitative analysis, Manganese (II) ion, Cations, Anions, Reagent, Oxidation state

## Introduction

Qualitative analysis is one of the important laboratory works. This is a technique used to determine the identities of chemical substances present in a sample. This is done through a series of chemical tests conducted on a chemical substance to identify or determine the cations and anions present in it. The chemical properties of an unknown substance are determined by the reaction between the unknown substance and a suitable reagent. This provides an opportunity for students to think about the properties and reactions of a great variety of individual compounds and ions through first hand experience. In addition to this, it provides practical illustrations of important chemical concepts, particularly those concerned with ionic equilibrium, solubility product, oxidation-reduction reactions and the formation and stability of complexes.

This article discusses the selective test for identification of Manganese (II) ion in a salt. This can also be used as a demonstration to discuss the chemistry of different oxidation

states of manganese metal and the stability of its salts.

## Method in Practice for Qualitative Analysis of Manganese(II) Ion

Generally, identification of Manganese (II) ions is done by the following the standard scheme of qualitative analysis. According to this scheme, cations are divided into groups. A specific reagent is used for their separation from the solution. This separation and identification is done in a particular sequence because some ions of prior groups can also react with the reagent of later groups. In this way Manganese ion is placed in group III with cations which include Cr(III), Al(III), Fe(III), Co(II), Zn(II) and Ni(II) (Vogel's Qualitative Inorganic Analysis).

## Alternative Method

### Materials

Test tubes, test tube holder, spatula, watch glass, dropper, mortar and pestle, weighing machine.



Fig 1:  $MnSO_4$  in a test tube

### Chemicals

Salt of manganese (manganese sulphate, manganese chloride)

Concentrated Hydrochloric Acid (HCl),  
Concentrated Nitric Acid ( $HNO_3$ )

### Experimentation

Take small amount of manganese salt in a dry test tube. Add 2-3 drops of 1:1 mixture of hydrochloric acid (HCl) and nitric acid ( $HNO_3$ ) in it.

Yellowish brown colouration with precipitate appears within a few seconds which turns darker on standing. Add small quantity of water into it. Brown colour disappears gradually and a transparent solution is obtained. This confirms the presence of manganese(II) ion in the salt.



Fig 2 : After addition of 1:1 mixture of (HCl +  $HNO_3$ )



Fig 3: After addition of water

Care needs to be taken that the test should be done in a dry test tube.

### Sensitivity of the Test

The test can be done at micro level. About 0.002g of a salt is sensitive to give observable results for the test.

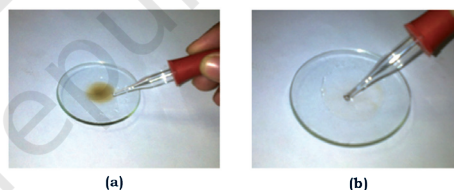


Fig 4: Sensitivity of the test

### Selectivity and Time Effectiveness of the Test

This test identifies Mn(II) ion without following the sequence of reactions. This test is reproducible with pure manganese salt as well as mixture of salts with the condition that mixture is colourless. In case of coloured mixtures, the colour of mixture may interfere to identify the colour of resulting solution and may change the colour of precipitate. Taking this into consideration as a limitation, the test



can be considered as a selective and time effective test for Mn(II) ion.

Generally, for qualitative analysis simple, quick and easily doable tests are preferred. This test also possesses all these properties.

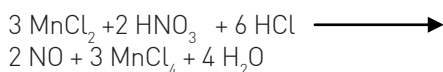
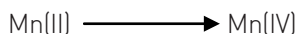
### A Classroom Demonstration

This test can also be used for demonstrating the concept of stability of complexes in different oxidation states. Chemistry of Mn(II) and Mn(IV) oxidation states and their relative stabilities can be easily viewed and appreciated with the help of this test.

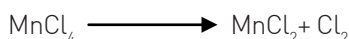
### Discussion

Manganese salt contains Mn(II) ions. The mixture of concentrated HNO<sub>3</sub> and HCl

behaves as an oxidising agent and oxidises Mn(II) ions into Mn(IV) ions. The appearance of dark brown precipitate indicates this change.



In acidic medium when water is added Mn(IV) ion reduces into Mn(II) ion.



Due to the presence of large amount of water, hexa aquo complex of Mn(II) is formed resulting into appearance of transparent solution.



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# PROBLEM BASED LEARNING IN BASIC PHYSICS - XI

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[In this article, eleventh in the series of articles, we present problems for a problem-based learning course from the area of geometrical optics. We present the learning objectives in this area of basic physics and what each problem tries to achieve with its solution.]

## Abstract

In this article, eleventh in the series of Problem-based Learning in Basic Physics, we present problems on geometrical optics. Methodology and philosophy of selecting these problems are already discussed. In this article we present problems from which students apart from solving actual problems can carry out an activity of geometrically constructing ray diagrams to locate where the image is formed. This activity, as we found, gives students good insight into not only the process of image formation but also how the rules for image tracing are arrived at.

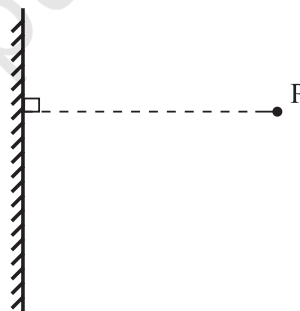
## Learning Objectives

1. To understand how the rules for image tracing are arrived at.
2. To be able to trace the rays to see where the image is formed.
3. To be able to use sign conventions in problems of geometrical optics for locating image and its nature.

## Problems

### 1. Ray Tracing for Finding Image due to a Point Object in Front of a Plane Mirror.

Consider a point object in front of a mirror. We need to find the position of image formed by the mirror. We will use the laws of reflection in constructing ray diagram.



**1 A.** Additional Activity: Once students have succeeded in the preceding activity, they should be able to draw the diagram for the following problem: If two mirrors have an angle  $\theta$  (in degree) between them, they form number ( $n$ ) of images given by  $n = \frac{180}{\theta} - 1$ . Thus, if we take two mirrors at an angle of  $90^\circ$  between them, they should form three images. Make students construct a ray diagram to discover formation of two images. Even  $120^\circ$  makes a good activity.

## 2. Consider the Problem of Finding Image Due to a Curved Mirror

- (i) A convex mirror and
- (ii) A concave mirror. In both the cases we consider point objects off the principal axis.

### Further Activity for Convex Mirror

Take an extended object PQ in front of the convex mirror. Construct a ray diagram to locate images of points P and Q. Now guess how the image of an extended object PQ would appear.

### Calculation

**2 A:** A 4.5 cm needle is placed 12 cm away from a convex mirror of focal length 15 cm. Give the location of the image and the magnification. Describe what happens as the needle is moved farther from the mirror<sup>4</sup>.

**2 B:** A small candle, 2.5 cm in size is placed at a distance of 27 cm in front of a concave mirror of radius of curvature 36 cm. At what distance from the mirror should a screen be placed in order to obtain a sharp image? Describe the nature and size of the image. If the candle is moved closer to the mirror, how should the screen be moved?

### Further Activities for Concave Mirror

- (i) For a concave mirror, we take  $f = R/2$ , i.e. the focal point is midway between mirror and centre of curvature. You may take two rays parallel to the principal axis. At the point of incidence, draw a normal to the mirror (radius vector). Construct reflected rays and see where they meet or appear to meet. This point will be in the focal plane. If this point is on the principal axis then it is the focal point. Can you establish  $f = R/2$  using your ray diagram or otherwise? Do you find any difference

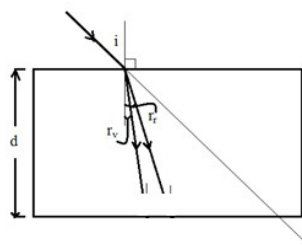
between your observation and the accepted result?

- (ii) You may construct the image of an extended object (say a pin) placed perpendicular to the principal axis at different positions. Say,

- (a)  $u = \infty$  (b)  $u > 2f$  (c)  $u = 2f$  (d)  $f < u < 2f$
- (e)  $u = f$  (f)  $u < f$

## 3. Refraction at a Plane Surface

Take a slab of thickness  $d = 4$  cm and of material having refractive index 1.7 for violet and 1.5 for red. (These numbers are hypothetical and taken for drawing purpose. In practice,  $\mu$  for violet is only slightly greater than that for red.) Draw a ray of white light (consisting of all colours from violet to red) incident at an angle of incidence  $53^\circ$  on the slab as shown. Calculate the angle of reflection for violet and red and draw these rays travelling in the glass slab. They all emerge at an angle  $53^\circ$  in air but separated. Measure separation between them. Check your answer with that obtained from  $\Delta S = (\mu_V - \mu_R)d \tan(r_{\text{mean}})$ .



- 3 A: Further Activity** After you have successfully completed the above mentioned activity, repeat a similar ray diagram construction for an equilateral prism of side 4 cm. Find  $\delta_{\text{Violet}}$  and  $\delta_{\text{Red}}$  from your diagram. You may take  $\mu_{\text{Yellow}} = 1.6$  and

find  $\delta_{\text{Yellow}}$ . Calculate,  $\frac{\mu_v - \mu_R}{\mu_v - 1}$ . How does this value compare with your  $\frac{\delta_v - \delta_R}{\delta_y}$  based on measured values of  $\delta$ ? Discuss if you find any discrepancy.

#### 4. Refraction at Spherical Surface

To understand image formation due to a spherical surface separating two media, consider a glass sphere ( $\mu = 1.5$ ) of radius 5 cm and having a tiny air bubble at a distance 2 cm from the centre.

We want to construct a ray diagram to know the position of the image when viewed along the diameter passing through the bubble. As seen from two different ends of the diameter, rays which reach the surface as they emerge out in the air, bend away from the normal (radial direction, except the rays travelling along the diameter, which will be travelling undeviated) and will appear to have started from  $I_1$  and  $I_2$  respectively.

Use formula  $\frac{\mu_2}{v} - \frac{\mu_1}{u} = \frac{\mu_2 - \mu_1}{R}$  ( $\mu_1 = 1.5$  and

$\mu_2 = 1$  in this case). We need to calculate positions of the images  $I_1$  and  $I_2$ . Check if your calculated positions match with schematic diagram positions.

**[Sign Convention:** For first surface (on left), ray from the bubble travels from right to left which becomes positive direction. Distances measured  $v$  and  $R$  are to the right of the surface and hence are to be substituted with negative sign and value of  $v$  is to be interpreted accordingly for position of the image. Second surface is left as homework.]

#### Further Activity

Imagine a spherical fish tank. A fish is looking at an insect which is outside the tank. Take

suitable parameters and construct your ray diagram to locate insect position as seen by the fish. Check your obtained position by calculating image position from your equation.

#### 5. Image Formation Due to a Lens

For a thin lens, we consider these points of importance. Two focal points are such that if light is incident parallel to principal axis, then after refraction it will pass through the focal point on the other side or will appear to come from the focal point.

##### Rules

- Optic centre is the centre of the lens through which light ray passes undeviated.
- If a ray of light passes through the focal point or is directed towards it, then it emerges parallel to the principal axis of the lens.

All these happen in an approximation in which we assume rays to be paraxial (i.e. they make small angles with the principal axis) and lens is thin (i.e., thickness of the lens is negligible in comparison with distance we deal with for studying formation of image).

**5 A:** Carry out a similar ray tracing for concave lens for different positions of objects.

**5 B:** Repeat similar diagram for a convex lens for object at distances, say

(a)  $u = \infty$  (b)  $u > 2f$  (c)  $u = 2f$  (d)  $f < u < 2f$

(e)  $u = f$  (f)  $u < f$

#### 6. Prism

Consider an equilateral prism made of material having refractive index 1.63. Let a monochromatic ray of light be incident on the first surface at an angle of incidence  $37^\circ$ .

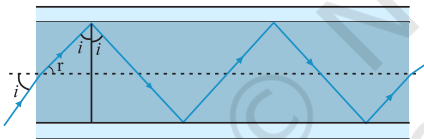
Trace the path of the ray and find angle of deviation.

### 7. Combination of Lens and Mirror

A convex lens of focal length 10 cm is placed in front of a convex mirror. Both are coaxial and the lens is 10 cm from the apex of the mirror. When an object is placed on the axis at a distance of 12 cm from the lens, it is found that the image coincides with the object. Calculate the focal length of the convex mirror.

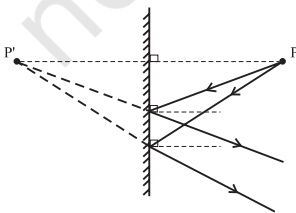
### 8. Total Internal Reflection<sup>4</sup>

The figure below shows a cross-section of a 'light pipe' made of a glass fiber of refractive index 1.68. The outer covering of the pipe is made of a material of refractive index 1.44. What is the range of angles of the incident rays with the axis of the pipe for which total internal reflection inside the pipe takes place, as shown in the figure. What is the answer if there is no outer covering of the pipe?



### Solutions

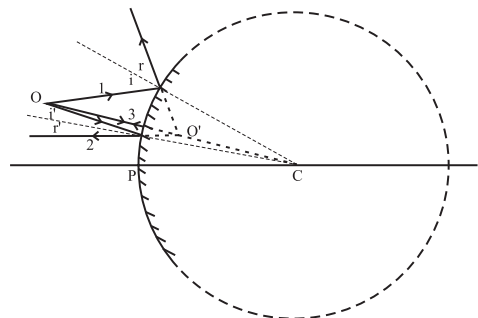
1. Take any two rays originating from P directed towards the mirror. Due to the mirror the rays are reflected as per law of reflection, that is  $i = r$ . For an observer, as shown in the figure, they appear to come from P'. P as seen in mirrors appears to be at P. This is the image of P.



You may ask students to repeat this exercise with any number of more rays. [Hint: Take one ray along normal from P to mirror. Take two rays on different sides of the normal]. Convince yourself (if your drawing is accurate and each ray obeys  $i = r$ ) that all the rays appear to originate from P' due to reflection.

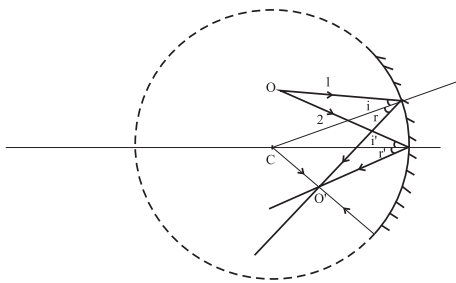
### 2. Reflection from a Spherical Surface

**Convex Surface:** Consider a convex surface. (You may take a circle of appropriate radius. Part of the circle can be treated as a convex mirror as shown.) This surface can be thought of a sphere of same radius with centre at C. Since C is centre, any line joining C to any point on the mirror will be normal to the spherical surface. Take a ray (no.1) starting from point object O to be incident on the convex mirror and draw a reflected ray as per law  $i = r$ . Take another ray directed to the pole and reflected similarly. Both these rays appear to come from O'. You may take more rays and convince yourself that after reflection they will appear to come from O'. For example, take a ray directed towards C, the centre of curvature. This ray is incident normally and will retrace its path backward after reflection and will still appear to be coming from O'. Thus O' is the image of point object O due to convex mirror.



### Concave Mirror

Repeat reflection at the surface (Hypothetical drawn with dotted line) again supposed to be passing through activity now for a concave mirror as described for a convex mirror. A direct ray passing through C after same point O'. Any number of rays directed towards mirror thus pass through O' which is now the image of O due to the mirror.

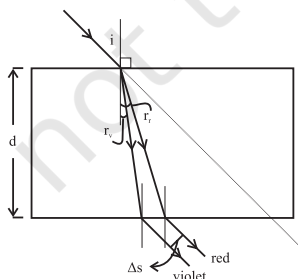


You may change the position of O for each of the mirrors placed – plane, convex and concave and redraw these ray diagrams to understand image formation due to mirrors.

**2 A. Calculation:**  $v = 6.7\text{cm}$ . Magnification =  $5/9$ , i.e., the size of the image is  $2.5\text{ cm}$ . As  $u \rightarrow \infty$ ;  $v \rightarrow f$  (but never beyond).

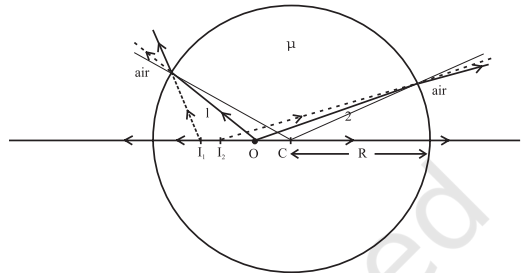
**2 B.**  $v = -54\text{ cm}$ . The image is real, inverted and magnified. The size of the image is  $5.0\text{ cm}$ . As  $u \rightarrow f$ ,  $v \rightarrow \infty$ ; for  $u < f$ , image is virtual.

3.



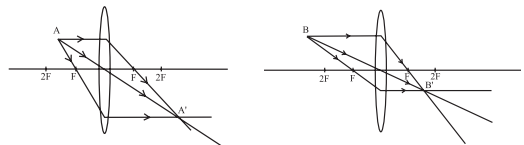
Can you explain why in real life when we see objects through glass windows, we do not see separated colours?

4.

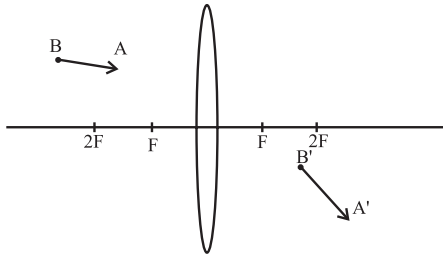


5. Consider two different off axis points A and B as shown in below. To find the images of these points due to a lens we draw three rays in the following manners.

- (i) Draw a ray parallel to principal axis starting from A which after refraction passes through focal point F on the other side.
- (ii) A ray passing through the optic centre, that passes undeviated.
- (iii) A ray passing through the focal point before passing through the lens emerges parallel to the principal axis.



- (iv) The point where these three rays converge will be the image position A' and/or B'. If we have an extended object AB, the corresponding image formed will be A' B'.



Note: We can have infinite rays starting from A and converging to A'. The rules for ray tracing for all the rays except the three mentioned above are not so obvious. However three rays are sufficient to trace the position of the image. If by some reasons part of the lens is covered, we still have full image (only lesser in intensity). As in reality infinite number of rays starting from A and pass through the lens to form image at A'. Blocking of the lens only means blocking some of these infinite rays.

6. For equilateral prism  $A = 60^\circ$

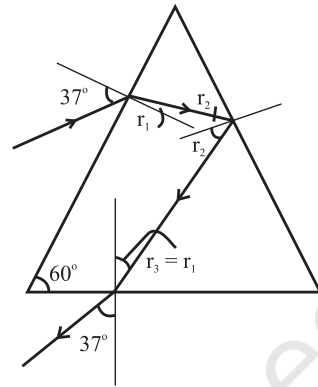
Angle of refraction at the first surface  $r_1 = \sin^{-1}(\sin i / \mu) = 21.6670^\circ$

This makes angle of incidence on the second surface  $r_2 = A - r_1 = 38.3329^\circ$

Thus angle of emergence from the second surface  $e = \sin^{-1}(\mu \sin r_2) = \sin^{-1}(1.0109) \rightarrow$  is indeterminate.

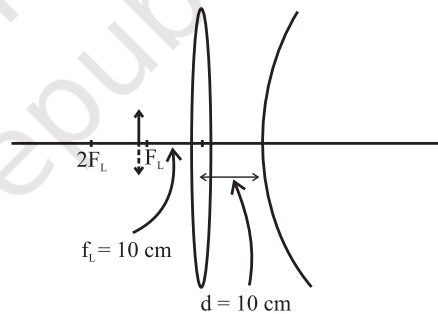
Critical angle  $C = \sin^{-1}(1/\mu) = 37.8427^\circ$

Clearly  $r_2 = 38.3329^\circ > C$  which means total internal reflection occurs at the second surface. In this case there will be no emergent ray and the internally reflected ray will be incident on the third surface at an angle of  $r_3 = A - r_2 = 21.6670^\circ$  to emerge from the 3rd surface at an angle of emergence  $e' = 37^\circ$ . Clearly at the second surface  $\delta_2 = 180 - 2(38.3329) = 108.333^\circ$  and  $\delta_3 = \delta_1 = 15.333^\circ$



Thus the deviation suffered by the ray will be (referring to the figure)  $\delta = 15.333 + 108.333 + 15.333 = 139^\circ$ .

7.



For lens  $f = 10$  cm and  $u = 12$  cm. With appropriate sign convention, we get  $v = 60$  cm to the right of the lens. This image acts as an object for the mirror and we take object distance  $u_m = 50$  cm (since distance between lens and mirror is 10 cm).

The image formed by the mirror acts as an object for the lens which forms its final image.

Since final image for the lens is to its left at 12 cm, appropriate sign convention gives object distance as 60 cm to the right. Which means it was at 50 cm to the right of the mirror.

Thus, for mirror, object and image are at the same location. This means for mirror,  $2f = 50$  cm and its focal length is 25 cm.

**8:**  $\sin i_c = \frac{1.44}{1.68}$  which gives  $i_c = 59^\circ$ . Total internal

reflection takes place when  $i > 59^\circ$  or when  $r < r_{\max} = 31^\circ$ .

Now  $\frac{\sin i_{\max}}{\sin r_{\max}} = 1.68$  which gives  $i_{\max} = 60^\circ$ .

Thus all incident rays of angles in the range  $0 < i < 60^\circ$  will suffer total internal reflection

in the pipe. (If the length of the pipe is finite, which it is in practice, there will be a lower limit on  $i$ , determined by the ratio of the diameter to the length of the pipe.)

If there is no outer coating ,

$i_c = \sin^{-1}\left(\frac{1}{1.68}\right) = 36.5^\circ$ . Now,  $i = 90^\circ$  will satisfy

$r = 36.5^\circ$  and  $i' = 53.5^\circ$  which is greater than  $i_c$ . Thus all incident rays (in the range  $53.5^\circ < i < 90^\circ$ ) will suffer total internal reflection.

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# 'BACK-OF-THE-ENVELOPE' ESTIMATION: AN EXCELLENT PEDAGOGICAL TOOL

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### Abstract

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In this article we point out the merits of back-of-the-envelope estimation as a pedagogical tool, with a few wonderful examples from the history of science and some simple worked out examples from school level science. The same may be utilised by teachers and students to make teaching-learning more engaging, interesting and effective.

### What is 'back-of-the-envelope' estimation?

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'Back-of-the-envelope' estimation is often used as a tool to gain an insight to a problem or situation, or even to make a prediction through a quick calculation. It literally means a calculation that can be worked out in the small space available on the backside of a conventional postal envelope. In a general sense, it means a calculation that can be written down on any scrap of paper, or even worked out mentally. It usually involves reasonable guesses, plausible approximations or rounding ups and is quite

useful for order-of-magnitude estimation. Hence it is also called 'guesstimation' (guess and estimation) or 'order-of-magnitude' estimation. For example, though students are advised to take  $9.8\text{m/s}^2$  as the standard value of the acceleration due to gravity ( $g$ ) for 'exact' calculations, the amount  $10\text{ m/s}^2$  is a good enough order-of-magnitude value of  $g$  and is used often. While estimating, one should know how to retain what is important and throw away what is not.

### Pedagogical significance of back-of-the-envelope estimation

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Back-of-the-envelope estimation ought to be an essential component of teaching-learning process as it has great pedagogical virtues. It enables the practitioner. For example,

- to enhance numerical ability and thinking skill,
- to judge the relative importance of the quantities involved,
- to make plausible guesses and approximations,

- to decide when and how to round up numbers,
- to link concepts and principles from different areas of study,
- to broaden perspective,
- to make and verify predictions,
- to make classroom processes exciting and rewarding,
- to use it as a guide for more elaborate or more exact calculation,
- to use it as a study guide,
- to use it as an assessment tool, etc.

Superficially, one may deem back-of-the-envelope estimation as important for students aspiring to become scientists, engineers, accountants, actuaries, business planners, etc. who are supposed to deal with numbers. However, the fact is that almost all of us use rough or approximate calculations even in our everyday life. In view of this, the National Curriculum Framework 2005 (NCF 2005) underlines the importance of approximation and estimation as an essential mathematical skill and advocates its teaching-learning right from primary stage of schooling in the subject domains of mathematics (NCF 2005, p. 43) and science (NCF 2005, p. 48). Needless to say, scientists use it routinely in their own work as well as in teaching their students and research scholars.

## The Plan

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In this article we shall reproduce or workout a few simple examples of back-of-the-envelope estimation based on school level science and point out their pedagogical features. Before that, as a motivating factor, it may be worthwhile

to recount a few famous instances from the history of science ([https://en.wikipedia.org/wiki/Back-of-the-envelope\\_calculation](https://en.wikipedia.org/wiki/Back-of-the-envelope_calculation) and references therein) to highlight the power of the practice much valued by scientists.

## Examples from the History of Science

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In 1945, while witnessing the first atomic bomb explosion, Enrico Fermi (who played a very significant role in the science of nuclear fission, one outcome of which was the atomic bomb) dropped a few bits of paper, measured how far they were blown away by the blast wave and then quickly estimated the energy yield of the bomb to be equivalent to 10 kilotons of TNT. This came out to be close to the measured yield of 18.6 kilotons, obtained later.

Though the credit for invention of RADAR (1935) goes to R. A. Watson-Watt, the idea was actually born out of a back-of-the-envelope calculation made by one of his associates, A. F. Wilkins on the use of radio waves in warfare.

C. H. Townes apparently made a few quick calculations on the back of an envelope pulled from his pocket while relaxing in a park and the calculations led to the concepts of MASER and LASER for which he was honoured with the 1964 Nobel Prize in Physics along with two Russian scientists.

In 1989, during a lunch break, a couple of engineers, deeply disturbed by the exploding size of the internet on which they were working, scribbled a new internet protocol on the back of three ketchup-stained napkins; the protocol became famous as the Border Gateway Protocol or the 'three-napkin protocol' and

has proved to be highly successful in the management of worldwide internet service.

There are highly successful scientist-teachers who encourage their students to practise back-of-the-envelope calculation by posing interesting questions and themselves working out some of them using this technique (e.g. Weisskoff, 1970; Wikipedia.html - Fermi problem; Wikipedia.html - Fermi questions). An Indian scientist and popular science writer, G. Venkataraman (Venkataraman, 2013) has collected some examples of such simple calculations in his exciting book titled *Why are Things the Way they Are?* We work out below a few examples of plausible guesstimation mostly following the references cited above, for the benefit of students and teachers.

## Some Worked out Examples

### 1. The Fermi Poser

Enrico Fermi, referred to above, is credited with popularisation of back-of-the-envelope calculation in natural sciences to make quick order-of-magnitude estimations. He himself made use of such estimations on several occasions as has been illustrated above. He was also regarded as one of the most popular teachers of his time who used back-of-the-envelope calculation to teach his students. Fermi won the 1938 Physics Nobel Prize for his contribution in nuclear science. As narrated by Venkataraman in his book referred to above, Fermi apparently once asked his students to estimate the number of pianos in the city of Chicago. This is an excellent example of guesstimation which may be carried out in the following manner.

- Let the number of pianos in Chicago be  $N$ . The estimation of  $N$  may follow the

below-mentioned steps, as quoted in Venkataraman, 2013.

- $N$  cannot certainly be greater than the population of the city. Assuming that every person may have one piano at the most and the population of Chicago is one million ( $10^6$ ) we have  $N \leq 10^6$ .
- But actually, it is way too much to say that every person in the city has one piano. It is more reasonable to suppose that every family may have one piano each. So, if there are 5 members in each family on the average, then  $N \leq (10^6/5 =) 200,000$ .
- Even this is too big a number. All families certainly cannot afford to have piano, a class of costly musical instruments. Let us say only the very affluent can afford it and this is only 20% or 1/5th of the families. Then,  $N \approx (200,000/5 =) 40,000$ .
- But now every rich family may not prefer a piano; may be only 30 per cent or 3 out of 10 choose to do so. This then leads to the figure  $N \approx (40,000 \times 3/10 =) 12,000$ , which could be taken as a fairly accurate estimate of the number of pianos in Chicago.

One may not agree to some of the percentages assumed here. But this example illustrates how one makes arguments, guesses, puts upper limits, lower limits, etc. However, to do all these, one needs conceptual clarity and depth.

Many more of such back-of-the-envelope estimates, popularly known as 'Fermi questions' (Wikipedia.html - Fermi questions), are ascribed to Fermi, which

include finding the number of piano tuners in a city, number of jelly beans that fill a one-litre bottle, etc.

Recognising that the above examples do not refer to problems in science, let us now see, with the help of a few examples, how back-of-the-envelope calculations can be made to answer some tricky scientific questions without much sweat. For this, we shall use Venkataraman's book referred to above and references therein.

## 2. How many Types of Atoms one there in Nature?

The conception of atom as the building block of matter, enunciated by Indian philosophers during 800 BC and by the Greek philosopher Democritus in 400 BC, was definitely the manifestation of genius of the highest order. Then, after a long gap, came Dalton's atomic theory in the first decade of 19th century. Subsequently, scientists discovered that there were just 92 naturally occurring elements. Of course, new elements are being made in the laboratory and added to the periodic table off and on, the latest number of elements being 118. Most of these elements are short lived and do not occur naturally.

Why only 92 elements occur naturally, or why the atomic number  $Z$  is restricted to 92 in case of naturally occurring elements is a worthwhile question to ponder.

As quoted by Venkataraman in his book, S. Chandrasekhar (Physics Nobel Laureate of 1983) tried to give an answer using a back-of-the-envelope calculation. It uses the well-known Bohr model of hydrogen-like atoms. Let us consider an atom or ion

with atomic number  $Z$  or nuclear charge  $+Ze$  with just one electron (charge =  $-e$ , mass =  $m$ ) revolving around the nucleus in permissible circular orbits. As students calculate in higher secondary physics, in the ground state of the atom the electron moves in an orbit of radius

$$r_1 = 0.53 / Z \text{ angstrom} \quad \dots \quad (1)$$

$$\text{with a speed, } v_1 = Z c \alpha \quad \dots \quad (2)$$

$$\text{where, } \alpha = e^2 / (4\pi \epsilon_0 \hbar c) \approx 1 / 137 \quad \dots \quad (3)$$

is called the fine structure constant. In Equation (3),  $\epsilon_0$  is the permittivity of free space,  $\hbar (= h / 2\pi)$  is the reduced Planck's constant, and  $c$  is the speed of light in vacuum.

What is interesting is the dependence of orbit radius and electron speed on the atomic number  $Z$ . The former decreases and the latter increases with increasing  $Z$ . Einstein's celebrated theory of relativity stipulates that the velocity of the electron cannot be more than  $c$ . Then, taking  $(v_1)_{\max} = c$  in Equation (2), we get an upper limit of  $Z$  namely

$$Z_{\max} = 1/\alpha \approx 137 \quad \dots \quad (4)$$

Equation (4) may be interpreted by saying that one cannot have stable atomic structure with a nuclear charge in excess of  $137e$ .

Now, from Equations (4) and (1) we get the ground state radius of the corresponding atom or ion

$$\begin{aligned} r_{1 \min} &= 0.53 / Z_{\max} \\ &= 0.004 \text{ angstrom} = 400 \text{ fermi} \dots \end{aligned} \quad (5)$$

Note that  $1 \text{ angstrom} = 10^{-10} \text{ m}$  and  $1 \text{ fermi} = 10^{-15} \text{ m}$ . Atomic size is usually measured in angstrom unit whereas nuclear

size is measured in fermi unit.

Both Equations (4) and (5) may justify why we cannot have arbitrarily many naturally occurring elements and there may be an upper limit to the number.

It may also be noted that the value of  $\alpha$  as determined in Equation (3) is more or less an exact value obtained by substituting the known values of  $e$  ( $= 1.6 \times 10^{-19} \text{ C}$ ),  $1/4\pi\epsilon_0$  ( $= 9 \times 10^9 \text{ N m}^2 \text{ C}^{-2}$ ),  $\hbar$  ( $= 1 \times 10^{-34} \text{ J s}$ ),  $c$  ( $= 3 \times 10^8 \text{ m s}^{-1}$ ). A rough mental calculation may be very quickly done by taking the order of magnitude of the above quantities:  $e$  ( $= 10^{-19} \text{ C}$ ),  $1/4\pi\epsilon_0$  ( $= 10^{10} \text{ N m}^2 \text{ C}^{-2}$ ),  $\hbar$  ( $= 10^{-34} \text{ J s}$ ),  $c$  ( $= 10^8 \text{ m s}^{-1}$ ) and this yields the value of  $\alpha \approx 10^{-2}$ , which is often used as an order-of-magnitude estimate of the fine structure constant.

### 3. Size of the Universe

Apparently, based on the work of a previous astronomer called Aristarchus, Archimedes guessed a formula (Venkataraman, 2013, p. 107) according to which the ratio of the size of the universe and the size of the solar system is equal to the ratio of the size of the solar system and the size of the earth. Assuming them all to be spherical in shape we get,

$$\text{diameter of the universe} = \frac{(\text{diameter of the solar system})^2}{\text{diameter of the earth}} \quad \dots(6)$$

Now, using the present value of the diameter of the solar system as 287.46 billion kilometres (<https://www.universetoday.com/15585/diameter-of-the-solar-system/>) rounded up to  $3 \times 10^{14} \text{ km}$  and the average diameter of the earth as

12, 742 kilometres rounded up to  $1.3 \times 10^4 \text{ km}$ , we get from Equation (6), diameter of the universe  $= 7 \times 10^{24} \text{ km}$  which appears to be just about 8 times the current value of the diameter of the observable universe,  $8.8 \times 10^{23} \text{ km}$  ([https://en.wikipedia.org/wiki/Observable\\_universe](https://en.wikipedia.org/wiki/Observable_universe)). Thus, the simple looking Archimedes formula not only gives a plausible estimate of the size of the universe thereby illustrating the utility of back-of-the-envelope estimate but also sheds light on the structure of the universe.

### 4. Planetary Distances from the Sun

In 1772, a German astronomer Johann Elert Bode gave a simple rule (a thumb rule, sometimes loosely called a law) (*The New Book of Popular Science*, Vol. 1, pp. 84-85; <https://www.britannica.com/science/Bode's-law>) to calculate planetary distances from the sun. The rule may be described in a few simple steps:

- (i) Start with the numbers 0 and 3.
- (ii) Continue the series by doubling the last number to get the series 0, 3, 6, 12, 24, 48, 96, 192, 384....
- (iii) Add 4 to each number in the series.
- (iv) Divide the resulting numbers by 10 to get the planetary distances from the sun in a.u. where a.u. or astronomical unit is the distance of the earth from the sun, nearly 1.5.

Table 1: Bode’s values of planetary distances in comparison with their measured values, for the solar system

Planet/ Member of solar system	Distance from Sun in a.u. (Bode’s law)	Distance from Sun in a.u. (measured)
Mercury	0.4	0.38
Venus	0.7	0.72
Earth	1.0	1.0
Mars	1.6	1.5
Ceres	2.8	2.76
Jupiter	5.2	5.2
Saturn	10.0	9.5
Uranus	19.6	19.2
Neptune	38.8	30.1

In Bode’s time only the first 6 planets were known: Mercury, Venus, Earth, Mars, Jupiter, and Saturn. Though there was no theoretical justification of Bode’s rule, it was taken seriously by the astronomers. Its results for the first four planets matched the measured values exceedingly well as the table above indicates. The fifth planet Jupiter’s distance (5.2 a.u.) is identical to the sixth number in the Bode sequence and not the fifth number (2.8 a.u.) as it should have. But the astronomers were so convinced by the predictive power of Bode’s law that they thought there must be a planet at 2.8 a.u. and started looking for it. Actually, in 1801 the first and the largest asteroid Ceres was discovered between Mars and Jupiter at 2.76 a.u. thereby strengthening the power of Bode’s law. Another success story came in the form of Uranus which was discovered in 1781 (see Table 1). However, the last planet in the revised planetary list for the solar

system namely Neptune, discovered in 1846, shows appreciable departure from Bode’s prediction.

Bode’s rule beautifully exhibits the power of back-of-the-envelope calculation even if it does not enjoy theoretical support.

### 5. How many Molecules are there in 1 Gram of Water?

There is a straight forward back-of-the-envelope answer to this question. Molecular weight of water ( $H_2O$ ) is  $(2 \times 1 + 16) = 18$ . Then in accordance with Avogadro’s law, 18 gram of water contains  $6.022 \times 10^{23}$  molecules (the Avogadro’s number) under STP (standard temperature and pressure i.e.  $0^\circ C$  or  $273 K$  and 1 atmosphere). Hence, if  $n$  be the number of molecules in 1 gram of water under these conditions, then

$$n = 6.022 \times 10^{23} / 18 \approx 0.3 \times 10^{23} \dots \quad (7)$$

We may also calculate the same number in another simple way. Let us illustrate it.

According to the law of equipartition of energy, each degree of freedom of a molecule has  $0.5 kT$  energy at temperature  $TK$ , where  $k$  is the Boltzmann's constant ( $= 1.38 \times 10^{-23} \text{ J/K}$ ). A molecule of water (a tri-atomic molecule) has 6 degrees of freedom. Hence the thermal energy possessed by 1 gram of water at  $TK$  is equal to  $3 n kT$ . Let us equate this energy with the latent heat of fusion of water to calculate  $n$ .

We know that at STP, 1 gram of water needs to give up  $334 \text{ J}$  of heat energy (the latent heat of fusion of water,  $L_f$ ) to convert into 1 gram of ice. We therefore have the equation

$$3 \times n \times 1.38 \times 10^{-23} \text{ J/K} \times 273 \text{ K} = 334 \text{ J}$$

which gives,  $n \approx 0.3 \times 10^{23}$  ... (8)

almost the same value as in Eq. (7). Equality between these two calculations is expected as both correspond to STP.

## 6. How many Atoms are there in a Human Body?

Though a large variety of atoms occur in nature, only a few of them are found in our body. According to an estimation, as percentage of body mass, they are 65 per cent oxygen (O), 18 per cent carbon (C), 10 per cent hydrogen (H), 3 per cent nitrogen (N), 1.4 per cent calcium (Ca), 1.1 per cent phosphorus (P) the rest being trace elements of very low abundance. The first four elements alone add up to 96 per cent of body mass and only these may be considered for our back-of-the-envelope calculation. Let us consider a 40 kg child. Then in the child's body, masses of O, C, H, and N are  $m_o = 26 \text{ kg}$ ,  $m_c = 7.2 \text{ kg}$ ,  $m_H = 4 \text{ kg}$ , and  $m_N = 1.2 \text{ kg}$  respectively. Now noting that their atomic weights are  $A_o = 16$ ,  $A_c = 12$ ,  $A_H = 1$ , and  $A_N = 14$  respectively and using the Avogadro's law with the Avogadro's number as  $N_A = 6.022 \times 10^{23}$  for 1 gram-atom or

$6.022 \times 10^{26}$  for 1 kilogram-atom, we get

$$n_o = \text{the number of O atoms} = N_A \times 26 / 16 \approx 1.0 \times 10^{27}$$

$$n_c = \text{the number of C atoms} = N_A \times 7.2 / 12 \approx 0.4 \times 10^{27}$$

$$n_H = \text{the number of H atoms} = N_A \times 4 / 1 \approx 2.4 \times 10^{27}$$

$$n_N = \text{the number of N atoms} = N_A \times 1.2 / 14 \approx 0.5 \times 10^{26}$$

Adding up these numbers we get the total number of atoms in the body of the 40 kg child as about  $4 \times 10^{27}$ . Note that in the final count the contribution of N is almost negligible compared to the other three. Hence we might have omitted N from the estimation altogether.

## 7. How many Protons, Neutrons and Electrons are there in a Human Body?

Out of hundreds of (elementary) particle types discovered and catalogued, only three, namely, protons, neutrons, and electrons constitute atoms. Of these protons and neutrons constitute the nucleus of atom and electrons are found outside the nucleus revolving around it. It is therefore worthwhile to find how many of these particles might be present in a human body. To get an answer let us again consider the case of a 40 kilogram child with the four dominant elements O, C, H and N as in the previous example. The numbers of the respective atoms in the body of the child  $n_o$ ,  $n_c$ ,  $n_H$ , and  $n_N$  as calculated there shall be used here. Now, in view of the facts that (i) atomic weight of an element is equal to the total number of protons and neutrons in its nucleus, (ii) number of electrons is equal to that of protons because of charge neutrality of atom, and (iii) the number of protons is equal to that of neutrons in the lighter elements considered here except H which has only one proton and no neutron, it is enough to calculate the number of protons in each case. Accordingly, the number of protons in  $O = n_o \times (A_o / 2) \approx 8.0 \times 10^{27}$

the number of protons in  $C = n_C \times (A_C / 2) \approx 2.4 \times 10^{27}$

the number of protons in  $H = n_H \times (A_H) \approx 2.4 \times 10^{27}$

the number of protons in  $N = n_N \times (A_N / 2) \approx 0.3 \times 10^{27}$

Adding these numbers we get the total number of protons in the body of the 40kg child as nearly  $1.3 \times 10^{28}$ , which is also equal to the number of electrons in the body, whereas the number of neutrons is nearly  $1 \times 10^{28}$  as there are no neutrons in H.

This back-of-the-envelope calculation gives an idea about the number of elementary particles like proton, neutron, and electron in a human body.

## Concluding Observations

In view of the utility of back-of-the-envelope calculations to arrive at quick answers, make plausible predictions, develop scientific thinking and broaden perspectives, we have discussed a few examples keeping them simple. More examples, at a higher level, may be found in the literature, a glimpse of which is available in the references. The basic process involves some reasonable guesses or assumptions, approximations, rounding

up, etc., which are considered to be part of the skill set of a person doing science. Hence teachers may like to train the students in the process with suitably designed exercises. An interesting question may initiate the process and guidance may be provided by the teacher as and when needed. A simple example of guesstimating the perimeter and area of the school premises or even the classroom may be a good starting point at an early stage.

It may also be noted that in many of the cases discussed here, the numbers involved are usually large. It could mean that large numbers are more amenable to approximations than small numbers. This is similar to the fact that the same error is more tolerable in the measurement of a large quantity than in the measurement of a small quantity. For example, you may not notice an error of 1 mm in the length of your shirt but a similar error in the size of a ring may pose problem. Moreover, such calculations are likely to challenge the mental faculty of the children and make them wiser. Such practices are often followed by professionals in all fields and, therefore, those who are on their way to join them ought to be educated in the same.

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# EFFECTIVENESS OF STRUCTURED AND UNSTRUCTURED FIELD TRIP: AN EXPERIMENTAL STUDY

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Field trips are an opportunity for an enriching, educational, entertaining, and hands-on experience for children in the 'real world.' Field trips provide an opportunity for students to learn key skills which are tough to impart in a school environment. It provides first hand experiences with meaningful transfer of learning. Schools organise field trips. Schools should ensure maximum learning of students by the field trips. But question arises how? Will it be possible if the students are let free to visit the places? In this respect the present study was an attempt by the investigators to study the effectiveness of structured and unstructured field trips to explore the displays in the fun with science gallery of National Science Centre, Delhi. Effectiveness of structured and unstructured field trip was seen in terms of mean gain scores of students. Study indicates that structured field trip significantly enhanced mean gain scores of students who were in the experimental group.

## Introduction

The limitless resources of the community give ample opportunities for introspection and study. Educational field trips fulfil such purpose of content enrichment. It also provides opportunities for breaking monotony of classroom setting, and also designed to provide complete sensory experience with things and phenomena which cannot be brought into the classroom. It involves taking students to places where the subject matter may be studied in a natural setting. NCF (2005) proposes that (i) knowledge should be connected to life outside school, (ii) learning should be shifted away from rote methods, and (iii) curriculum should be enriched so that it goes beyond textbooks. NCF (2005) further recommends that teaching should aim at enhancing children's natural

desire and strategies to learn. Field trips expand children's learning through active hands-on experience with the rich resources of the local community. Field trips increase student's knowledge and understanding of a subject and add realism to the topic of study. Teachers use field trips as part of their pedagogy because they feel that their students need hands-on, real life experiences or to examine applications of science which augment their classroom studies (Michie Michael 1998). Well-planned field trips provide participants with first-hand experience related to the topic or concept being discussed in the programme. They provide unique opportunities for learning that are not available within the four walls of a classroom. (Brian Myers and Linda Jones 2004). Educational field trips help to give a practical approach

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for the curriculum and it is helpful to develop more interest in learning among students (Shakil Fatima, Anila; *et.al* 2011). Sorrentino and Bell (1970) reviewed texts and research articles by science educators, summarising their reasons for taking field trips into five attributed values: providing first-hand experience, stimulating interest and motivation in science, giving meaning to learning and interrelationships, observation and perception skills, and personal (social) development. Quantitative studies of the attitudes of teachers towards field trips were undertaken by Falk and Balling (1979), Fido and Gayford (1982) and Muse, Chiarelott and Davidman (1982). The researchers found that, in the opinion of teachers, the positive benefits derived from field trips were:

- Hands-on, real world experiences.
- Quality of education, positive attitudes to science and motivation towards the subject.
- Improvement of the socialisation between students, which would impinge on the classroom, and development of rapport between teachers and students enabling teachers to utilise other learning strategies such as cooperative learning.

## Rationale of the Study

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An educational well-planned field trip can be a valuable tool and should be an integral part of the instructional programme. Quality field trips must run smoothly in terms of planning and logistics (Storksdieck, M., Robbins, D., Kreisman, S.2007). Good field trips provide

participants with first-hand experience related to the topic or concept being discussed in the programme. A good field trip should also have the effect of stimulating further study. The students not only observe the situation while they are there, but are encouraged to think further about what they have seen. Many teachers work hard to develop “post-classroom carry over.” The field trip has this ingredient built into it from the start. There is also an element of personal involvement in the field trip, particularly if the teacher has been wise enough to allow the students to participate actively in the planning of the trip. Good planning must precede field trips. Careful attention should be given to trip selection, pre visit preparation, the trip itself, appropriate follow up, and evaluation. Children need both preparation and follow up to get most out of a field visit (Brooke, *et.al.*, 1996).

In India lot of researches have been conducted on evaluation and effectiveness of museums, i.e., visitors' response towards exhibits in museums (Nair 1993), creation of scientific temper among school children (Singh, D.P. 1985). Khatter (1988) developed museum by collecting specimens through survey. Gujarati (1994) evaluated the potential of museum as institution that could complement and supplement school education. There are very few studies in India which have experimentally studied the contribution of National Science Centre and Museum at secondary and lower primary levels. Javelekar, V.D. (1988) found that participatory museum displays helped in conveying scientific concepts more effectively than the other method at secondary level and Sangeeta (1999) found

that pupils taught through museum based teaching strategy have higher achievement level at lower primary stage.

In Delhi schools under Directorate of Education organise local and outside field trips to various places. Guidelines are also issued to the schools by the authorities regarding the scheme under which tour is to be organised, list of agencies, site for local tour, standard menu for breakfast and lunch, type of transport, etc. Schools should ensure that the experience gained by the students during the field trips must give relevance and meaning to their knowledge but a question arises how to ensure maximum learning from this? Whether it is to be carried out by structuring the visit or it should be unstructured to ensure maximum learning. This study was the experimental investigation of contribution of structured and unstructured field trips to National Science Centre, Delhi in terms of academic achievement of students at upper primary level. So, keeping in view, the above rationale, the present study was conducted by the investigators to study the effectiveness of structured and unstructured field trips through experimental design.

The following title was stated:

“Effectiveness of Structured and Unstructured Field Trips:” An Experimental Study

### Objective

The study was taken up with the following objective.

- To study the effectiveness of structured and unstructured field trip to National Science Centre, Delhi in terms of academic achievement of students.

### Hypothesis

There is no significant difference between the post-test mean scores of students who experienced structured and unstructured field trip to National Science Centre.

The study was designed to test the following null hypothesis:

### Methodology

For the collection of data, survey, two groups, randomised post-test design were used.

The basic design used in the study is two groups, randomised subjects post-test only. Two groups were formed as experimental and control group through random selection to increase the internal validity of the results. Independent variable is the treatment variable i.e. structured and unstructured visit. Dependent variable is the criterion test or post-test, (Y<sub>1</sub> and Y<sub>2</sub>). Both the groups were subjected to pre-test to equate the pre experimental status of the groups as well as to measure the previous knowledge of the subject matter. According to Best, Johan

Table 1: Research Design

S. N.	Randomly Assigned	Independent Variable	Post-test
1.	Experimental Group	Structured Field Trip	Y <sub>1</sub>
2.	Control Group	Unstructured Field Trip	Y <sub>2</sub>

W. and Kahn, James V. (1995) analysis of covariance is a method of analysis to equate the pre experimental status of the group which may be determined by pre-test scores in a pre-test-post-test study, or in post-test only studies, by such measures as IQ, reading scores, or previous knowledge of subject matter. In the present research both the groups were measured on the dependent variable. The final mean post test scores of each group on the dependent variable were adjusted for pre-test differences by covariance analysis. The adjusted final means were then compared to determine if differences were statistically significant.

### Sample

There were two types of samples as per the objective of the study.

#### (i) Students Sample

Government Co-Ed. Senior Secondary School, Najafgarh with English as medium

of instruction was selected purposefully because this school was having four sections of English medium with 221 students. From the 221 students, using systematic sampling, 60 students were selected.

#### (ii) Participatory Displays

There were 87 participatory displays in the “fun with science” gallery of National Science Centre, Delhi. Only 20 exhibits were selected purposefully from the 87 other exhibits of the gallery using checklist as a tool. These 20 exhibits so selected were based on the contents and activities which were present in the NCERT science textbooks of Classes VI to VIII. This gallery was purposefully selected for the study from the other galleries because the exhibits present in the gallery were more interactive and participatory in nature. Table 2 shows the selected displays and name of chapters with classes.

**Table 2: Displays and Names of Chapters with Classes**

S. N.	Name of the Display	Chapter	Class
1.	Magnetic lines of force	13	VI
2.	Magnetic repulsion	13	VI
3.	Pull against magnet	14	VII
4.	Magnetic field	13	VI
5.	Wave motion	13	VIII
6.	Fun mirrors	11,15	VI, VII
7.	Iris	16	VIII
8.	Is light visible?	16	VIII

9.	Kaleidoscope	16	VIII
10.	True mirror	16	VIII
11.	See your back	16	VIII
12.	See your side	16	VIII
13.	Head on a platter	11	VI
14.	World of symmetry	16	VIII
15.	Phases of moon	17	VIII
16.	Where do you feel comfort?	11	VIII
17.	Pipes of pan	13	VIII
18.	Xylophone + Organ pipe	13	VIII
19.	Impossible mixture	04	VI
20.	Colour Shadows	15	VII

## Tools Used

1. A survey was conducted in the fun with science gallery using three checklists (Classes VI to VIII) developed by the investigators having all the names of the exhibits; i.e., 87 and name of the chapters present in the science textbooks of Classes VI to VIII followed by checking each exhibit with the contents and each activities present in the chapters of textbooks.
2. Pre-tests and post-tests were developed by the investigators. Pre and post-tests were based on the 20 displays which were selected as sample from the "fun with science" gallery. In pre-test there were 20 multiple choice questions with four alternatives of 20 minutes duration with 20 marks. Structured post-test had the names of the displays followed

by the questions. There were 40 items multiple choice questions with four alternatives of two hours duration with 40 marks. Investigators also developed structured activity sheet for experimental group having the names of the displays and the instructions to be followed display-wise like, name of the display, draw diagram of the display, working of display, description of concepts written on the concept box attached to it.

## Procedure of Data Collection

Sixty Class VIII students were given pre-test at the school before going to visit the National Science Centre. Pre-test was used here to know the initial status of the students (Previous knowledge of the subject based on the contents of Classes VI, VII, and VIII science textbooks and also related with the twenty displays in the "fun with science" gallery).

After this test, the students were divided into two groups by using systematic sampling technique. By flipping a coin one group was assigned as experimental group and another as control group. Structured treatment was given to the experimental group students by giving them prior information and clues regarding what to look for during their visit with activity sheet. Whereas the control group students were not given any prior information and clues regarding what to look for, during their visit. Then students were taken to the National Science Centre, Delhi. Experimental group students were taken directly into the 'fun with science' gallery having structured activity sheet. They were given two hours to complete the task and facilitated to explore, observe and interact with the displays which were already mentioned in their activity sheet. Students enjoyed and interacted with the displays and completed their task within the stipulated time. Control Group students were also sent along with the teachers of the school to visit the galleries of the centre. Control group students also visited 'fun with science' gallery with other galleries, but in the unstructured conditions, i.e. with respect to time and without any structured activity sheet. Control group students visited this gallery as they visited other galleries. After the treatment, students of both the groups were given the post-test of 40 marks of two hours

duration in the seminar room of the centre. After the collection of data, scoring of the responses of students was done. In pre-test, one mark was awarded for the correct option selected by the students. In post-test there were 40 questions carrying one mark and each correct response was awarded one mark.

### Statistical Treatment

Raw scores obtained from the pre-test and post-test were treated with descriptive and inferential analyses like mean, S.D, t' test, F' test, ANCOVA respectively for the analysis of the data.

### Result

Investigators used randomised two groups post-test design for the study. Research hypothesis stated in null form was: There is no significant difference between the post-test mean scores of students who experienced structured and unstructured field trip to National Science Centre.

Pre-test and post-test scores of experimental and control group were analysed through the use of analysis of covariance in which pre- test scores of students were taken as covariate. 't' values were computed between the adjusted means of experimental and control group.

Table 3: Analysis of Variance of Pre-test and Post-test Scores

S. N.	Sources of Variation	Df	SSx	SSy	M.Sx (Vx)	M.Sy (Vy)	Fx
1.	Among Means of Groups	1	3	350	3	350	0.60
2.	Within Groups	58	291	937	5.02	16.16	
	Total	59	294	1287			

(f at 0.05 level = 4.00; 0.01 level = 7.08)

$F_x = 0.60$  in the Table 3 shows that investigators were quite successful to get random sample in groups, e.g. Experimental and Control Group. It means both the groups were equal before the treatment on initial scores, i.e., pre-test. While the value of  $F_y = 21.65$  shows that both the groups differed significantly at 0.01 level.

**Table 4: Analysis of Covariance Post-test Scores**

S. N.	Sources of Variation	Df	SSy	Vy.x	Fy.x	S.Dy.x
1.	Among Means of Groups	1	350	233		3.96
2.	Within Groups	57	937	15.68	14.86	
	Total	58	1287			

(f at 0.05 level = 4.00 ; 0.01 level = 7.08)

From Table 4 it was found that  $F_y$  value of 21.65 has decreased after the adjustment in the among and within variances through the use of ANCOVA to  $F_{y.x}$  to 14.86. Both the values are highly significant at 0.01 levels.

**Table 5: Adjusted Post-test Means of Experimental and Control groups and 't' Value**

S.N.	Group	No. of Students	Mean Pre-test	Mean Post-test	Adjusted Mean Post-test	't' Value
1.	Experimental	30	8.56	16.66	16.72	4.73
2.	Control	30	9.00	11.83	11.89	

( $N=60$ ,  $df 58$ ) ('t' value at 0.05 level = 2.00; 0.01 level = 2.66)

Table 5 reveals that calculated 't' value of 4.73 is greater than the table value of 2.00 and 2.66 at 0.05 and 0.01 levels respectively. It is clear that adjusted mean post-test score of experimental group is significantly higher than mean post-test score of control group. Hence, the null hypothesis is rejected. This shows that structured field trip significantly enhances academic achievement of students.

## Discussion

Present study indicates that structured field trips significantly enhance the mean gain scores of students than the unstructured field trips. Numerous research studies in science

education have documented significant gain in participant's factual knowledge and conceptual understanding after participation in well-planned field trips. Finding of this study more or less corroborates with that of the following research studies. Javelekar,

V.D (1988) found that participatory museum displays helped in conveying scientific concepts more effectively than the other method. Canizales de Andrade (1989) indicated that students who experienced structured visits scored significantly higher on academic achievement test than those who experienced non-structured visits. Paris, et.al. (1993) pointed out that field trips to museums can enrich education, though teachers and parents must guide children's explorations and help them connect their previously gained knowledge with new information from the exhibits. Brooke, et.al, (1996) concludes that, to get the most out of a visit to a hands-on science centre, children need both preparation and follow up. Sangeeta (1999) reported that preparatory stage, museum visits and follow up programmes should be carried out for effective learning. The study also found that pupils taught through museum based teaching strategy have higher achievement level. Storksdieck, M., Robbins, D., Kreisman, S. (2007) have shown that there should be links between the field trip content and the school curriculum; and quality field trips must run smoothly in terms of planning and logistics. A field trip should be designed in such a way that participants can easily make connections between the focus of the field trip and the concepts they are learning in the rest of the educational programme.

## **Educational Implication**

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Structured field trips enhance learning of students. While structuring a field trip, three important stages should be included: pre-trip, trip, and post-trip.

### **Pre-trip Stage**

The pre-trip stage of a field trip involves two major components: administration and

instruction. The administration component involves all of the steps taken by the field trip organiser to arrange the logistics of the field trip. The instruction component of the pre-trip stage is critical in preparing participants for the experience. To increase the educational effectiveness of field trips, it is important for field trip organisers to give participants prior information and clues regarding what to look for during their activities (structured activity sheet).

### **Trip Stage**

Two components should be addressed during this stage: the role of the participant and the role of the organiser. Working in pre-assigned groups of two to three, participants can complete an activity using an activity sheet. The activity sheet should clearly relate to the educational goals of the field trip. During field trips, organisers should function more as facilitators or guides rather than directors.

### **Post-trip Stage**

This stage also contains two components: debriefing and a culminating activity. During the debriefing session, participants should be encouraged to share and discuss their experiences during the field trip. The second component of the post-trip stage is a culminating activity. This activity should give participants an opportunity to apply the content knowledge they gained during the field trip. Follow up work which may be given to students as part of formative assessment are projects, Hindi or English language activities, such as, writing a report on the visit, role-play activity, writing a poem or story. Assignments like model/working exhibit, sketch, etc., can also be given to students to relate it with their content.



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# TALES BUILDING CONCEPTS: A CONSTRUCTIVIST APPROACH TO TEACHING-LEARNING SCIENCE

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The present study is intended to use indigenous pedagogy of story telling as strategy of teaching and learning of science concepts beyond classroom and beyond textbook. The concepts related to properties of light and working of lenses have been selected under this research study. Target population was all learners of Classes VII and IX. The study was completed in three phases. In the first phase the methodological framework to pursue was identified, in the second phase interventions were provided as a story. In the third phase post intervention assessment was carried out. The research findings depict that story telling is an effective way in learning of science concepts and may be used by the teachers for effective teaching-learning process for augmentation of learning.

## Introduction

After the National Curriculum Framework (NCF) 2005, when nationwide orientations about the National Focus Group Position Papers and the post NCF teaching-learning resources and strategies were built and the syllabus and textbooks developed and published by the National Council of Educational Research and Training, New Delhi, were in public domain, NCF had already completed its journey of half a decade in national educational arena for almost 5-6 years (NCERT, 2006b, 2006c, 2006d). The necessity to dig deep and perceive actual feedback about the penetration of implementation and recommendations of the

current curriculum was deeply felt. The idea was utilised as an opportunity to the authors to get first-hand experience of curriculum transaction in any one of the rural schools of India for a period of three months. In this endeavour the researchers had visited rural school Sarvodaya Kanya Vidyalaya, Aaya Nagar in Delhi. The very objective behind this pilot visit was to interact directly with learners and gain first-hand experience as a teacher for deep sited understanding of school system, learners, teachers and learning environment in view of the implementation of recommendations of NCF 2005. The visit was crucial in framing the research framework and developing the structure to collect the feedback about the post NCF books, teaching process and problems in implementing the

recommendations of NCF 2005.

NCF 2005 emerged as a major paradigm shift from teacher centric to learner centric pedagogy. This very shift changed the pattern of textbook writing and brought shifts in the pedagogical impartation of the teaching-learning processes. The syllabus based on NCF 2005 is theme based and translated textbooks in science have reflected six basic criteria of validity as suggested by NCF 2005 and Focus Group Position Paper in Teaching Science, 2006.

The focus of the present study is on establishing content and cognitive validity of NCF 2005. Content and cognitive validity of content is reviewed and emphasised by Field (2011). It was observed that some of the optical instruments, such as, microscope and telescope are used by children as toys even before the upper primary classes and, moreover, the microscope is a necessity to learn many science concepts right from Classes VII, VIII, IX and beyond. But children do not learn the principle of working of these instruments before a much later stage. Even about the lenses they learn very little in secondary classes. This leaves unattended queries in the mind of the child. The kindled curiosity remains unanswered and the child carries doubts in perception of the instruments as: "How we see big using microscope?" and "How can we see galaxy comfortably using telescope?" and also "How are the rainbows formed in the sky?". Thus the process of construction of knowledge is constrained by the lack of perception building and becomes the reason they do not get the opportunity to think out of box and bring innovations.

NCF 2005 also recommends to learn

beyond textbook and beyond the four walls of the classroom to break the monotony of learning in the classroom. The researchers interacted with the learners at upper primary and secondary stages, where they found that learners were clueless about "How light passes through one medium to another impacting visibility of objects to our eyes"? or "How the rainbow appeared during rain under sunlight?" These led the researchers to think of multiple ways in which the learners could get acquainted with the unseen and untold magic of lenses. The aspiration of the researchers to impart the properties of the lenses was not restrained to the functioning of the microscope and telescope but the visible perception of the natural phenomenon of lights.

While engaging learners of Classes VII and IX under multi-grade environment, it became obvious to researchers that all students are using optical instruments but lacked knowledge regarding the awareness of their working. This belief was further reinforced when during the interaction the basic questions remained unanswered in the classroom.

Microscope is an important instrument to understand the intricacies of many concepts related to life which is a part of the curriculum at upper primary and secondary stage learners. It is essential for performing activities to observe under the microscope without which the very objective of learner centric approach cannot be fulfilled as recommended in the present curriculum (NCF 2005). Besides, learners also visited Nehru Planetarium as a part of field visit which is considered as learning beyond classroom (NCERT, 2006), But during the visit also the intricacies and the nuances of the telescope remained unexplained. The questions and the instruments pertained to

the properties of light but not addressed in the curriculum at upper primary stage.

Thus the present study was conceptualised with the research questions that what were the most exciting and innovative ways to impart science lessons to students and what would be their perception towards the basic concepts of science and towards science itself and the results of the intervention that was conducted by the researchers.

After detailed review of literature, story telling as a technique was chosen as the method of intervention and to acquaint them with three major concepts:

- (i) There are combination of lenses in the microscope that works for magnifying the image of an object.
- (ii) There are a combination of lenses in the telescope that works for looking at the farther objects clearer.
- (iii) When light passes from air through water droplet it separates into its component colours.

## Research Methodology

### Research Design

The research design was chosen to be a

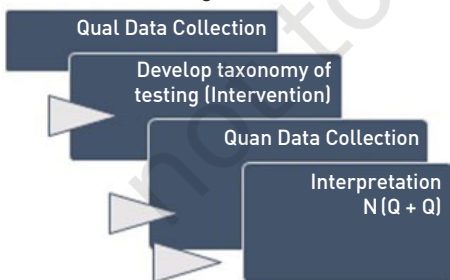


Fig 1: Exploratory design by Creswell and Clark (2007)

- (i) Focus group discussion with learners of Class VII and IX.
- (ii) Interventions.
- (iii) Post-intervention Assessment.

### Sample and Sampling Technique

The sample of the study was of 128 students—66 students were from Class VII and 62 students were from Class IX of the same in which the pilot study was conducted. All the students were following English as a medium of instruction.

The technique of sampling was purposive as the school was a government school from a rural region and where the permission of intervention was granted.

### Tools of Data Collection

- Focus group discussion with learners of Classes VII and IX:

The research question was identified during the interaction of researcher (FGD) with learners. The FGD as in conversation between the researcher and learners in the classroom situation is given below.

*Researcher:* So, how in the microscope do we observe a large size of the object?

*Learners:* No answer from learners

*Researcher:* Do you find that you can see the farther objects are nearer through telescope?

*Learners:* Yes.

*Researcher:* How is it possible through telescope?

*Learners:* No answer from learners

*Researcher:* Have you seen the rainbow?

*Learners:* Yes

*Researcher:* How many colours are there in a rainbow?

*Learners:* Seven colours, VIBGYOR

*Researcher:* Could you count colours in a rainbow?

*Few voices of Learners in chorus:* Yes Ma'am.

*Researcher:* Does the beam of light get separated in seven colours of VIBGYOR?

*Learners:* No answer, but some whispering voices came out as "Kaise hota hai?" (How does it form?)

Thus, the objective of the research study was identified as following:

How to improve learners' perception of following concepts of science?

- (i) Combination of lenses in the microscope works for magnifying the image of an object.
- (ii) Combination of lenses in the telescope works for looking at farther objects clearer.
- (iii) When light passes from air through water droplets it separates into its component colours.

#### • Interventions

Storytelling is an effective pedagogical tool at primary stage (Mohd Roslan and Roslinawati, 2008; Coulter et al; 2007). The science teacher was involved for providing intervention in the class through a story planned by the researchers. After the quarterly test it was the right time and collectively decided by the science teacher and researcher to provide interventions. Teacher wrote a letter to students—

*Dear Students,*

*You had quarterly test last week. Today you had the last paper of the quarterly test. You prepared and worked hard for this test. I feel today you should play outdoors, enjoy and relax. This is a letter from my side to all of you which contains a story entitled: 'An Unusual Journey through Light from Microworld to Galaxy', please go through it definitely before bed and let me know how did you like it? And what all is there in the story? We will discuss in the class tomorrow.*

Story is as under—

That was the last day of school before winter vacation. Vani was very happy as all the students of Classes VIII and IX had a trip for five days to Delhi. Teacher informed all students that all of them will by bus travel as their small village near Alwar in Rajasthan is approximately 150 km from Delhi. Teacher also informed them that they will visit National Science Centre, Nehru Planetarium, National Museum, Red Fort, etc. in Delhi.

They had to leave next morning at eight o'clock. Having so many preparations in mind for the trip, Vani eagerly came home and happily informed her grandmother about all the preparations for the visit. Grandmother was sitting on the small cot below the drumstick tree, where sunlight was sieving and passing through the clumps of leaves and branches of the tree and touching her body. It was pleasing to sit under the tree. It was neither too hot nor too cold. Vani laid herself down on the bed and put her head in the lap of grandma and started chit-chatting about her planned visit to Delhi. She was very excited and happy about the trip. Grandma smiled at her and instructed her to take some precautions and all preparedness when she will be out on tour.

Soon Vani dozed off. She started day dreaming. Vani saw herself flying in the sky. She had two very big wings. She was flying sometimes below clouds and sometimes above clouds. She was enjoying herself. Everything looked small from the height. Oh, look at my school, it is looking so tiny and roads of my village are looking very clear and nice, she thought and smiled. She flapped her wings and flew higher, above the clouds. Oh, my goodness! It is so amazing. See, how the things look so different from here.

Everything was so wonderful that she did not want to blink her eyes even for a moment. Suddenly she saw a water droplet from a cloud jumped and trapped it between both of her eyelids. The temperature at that height was very low but just above zero degree. Thus, the water droplet trapped between the two eyelids was not exactly ice but it was at the transition to be converted to ice.

"Oh, what is this?", she exclaimed with joy! "Do the things look little bigger?" Yes....., she thought for a moment. Things in the sky were really looking bigger to her. In the meantime, one smaller droplet flew in and stuck parallel to the earlier droplet (Fig 2). All objects were magnified and she could even see spores of microbes present in air. She could connect the structure of microbes and their spores she had seen in a science magazine while going through an article on aeroallergens. She could recall that once senior students of her school were putting the slide layered with petroleum jelly on pollen collector located in herbal garden in the school and pollens present in the air were sticking to the slide. The slide was later removed and observed under the microscope.

Vani could recollect things which she had seen in her day-to-day life. She saw her

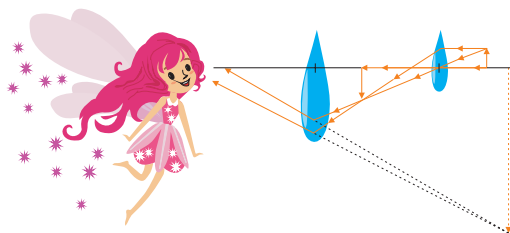


Fig 2: Usage of lens in microscope

grandpapa using convex lens while reading newspaper to magnify letters. She was remembering activities while interacting with her school mates in the science club. She also remembered that few days back she went to physics laboratory in her school and used lenses in various activities with her senior students. She also tried to understand the working of single lens and combination of lenses. By this time she realised that the water droplets are working as convex lenses and combination of lenses are working as microscope in this case.

Vani was enjoying the journey. She was so happy to experience a sense of learning. She could visualize how the combination of lenses actually increased the magnification and the given object looked larger in size. This was actually the principle on which microscope works. She could see the fine and coarse adjustment of microscope automatically working in the air. Sometimes both the droplets working as lens were coming close to each other and sometimes they were going far from each other.

She touched her eyes for that small droplet working as lens. She felt cold and the lens got misstructured. Oh, it is spoiled, she thought.

But of course, it was momentary. She flapped her wings. She could see the sunlight. She was flying below the cloud over the piece of land where it was raining. She surprisingly saw rainbow. Her eyes glared as she could see beautiful colours of VIBGYOR. She thought of beautiful colours, violet, indigo, blue, green, yellow, orange and red. Is she really looking at? She tried to catch them while flying. Mystery of how the rainbow colours appeared was still unresolved in her mind. She could connect it with an activity shown to them on National Science Day that the light is going through water droplets where refraction is taking place resulting in separation of seven colours of visible light. She was enjoying a lot. It wasn't the end of her journey. She was flying high and feeling so lucky having wings like fairy tales she had read many times in the story books.

She looked at the sky. It was infinite. Again, a small water droplet in the form of a lens got fixed near both her eyelids and again bigger lenses parallel to them (Fig 3). "It seems dusk time" she mumbled. She was diving in the sky looking at the galaxy. Apparently the combination of lens is working as telescope now. She was excited with the experience.

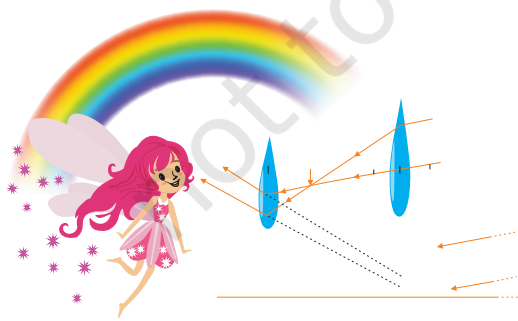


Fig 3: Usage of lens in telescope

Suddenly, with a gust of wind the drumstick tree moved slowly and there was gradient in the sunlight falling on her eyes. It was sunlight continuously alternating with the shadow on her eyes. Due to this she suddenly became conscious after a beautiful dream. She smiled and thought "Oh! it was a dream", she heard voice of *her grandma* "Vani.....Vani get up... .

#### • Post Intervention Assessment

Since the intervention was provided by involving science teacher to the students and in the form of a story so that necessary concepts regarding working of lens and property of light may be learnt by children of Classes VII and IX, the assessment was also done in an interesting and natural way.

**Assessment Tool:** There were six assessment items in the tool — It included three activity based items, one multiple choice (MCQ) one very short answer type and one open ended type of item to be carried out as fun activity without any pressure of assessment. The items were as follows:

- (i) Activity based: Students were provided with coloured pencils to make sketches of rainbows on the paper individually. The colours they had chosen in making the sketch of rainbow were assessed for the colour chosen by them and the serial of the colour they have used in their sketches was examined.
- (ii) Under which of the following conditions perception of rainbow was formed in Vani's eyes?
  1. When sunlight travelled through air to water to air while reaching Vani's eyes.



2. When sunlight passed only through water while reaching Vani’s eyes.
  3. When sunlight passed only through air while reaching Vani’s eyes.
  4. It was just vacuum, there was no medium between vani’s eye and sunlight in the story.
- (iii) Activity based: Two different convex lenses were given to learners and facilitated to move up and down one above the other over a given object.
- The question was asked— “Which fraction of the story is related to this activity?”
- (iv) Very short answer type: Can we relate lens with microscope and telescope? State your answer in ‘Yes’ or ‘No’.
- (v) Open ended: Any guess what makes microscope to magnify an object?
- (vi) Activity based: Learners were provided with the toy telescope and facilitated to observe all lenses of telescope and allowed to see through both the sides.
- The question was asked that “What makes telescope to see farther objects clearer?”

**• Tools of Data Analysis**

Content analysis and thematic analysis was done and frequency was deciphered as per discussions and answers to form opinion in affirmations and negation. The very usage of content and thematic analysis for such purposes is supported by Vaismoradi *et. al.* (2013).

**Interpretation and Discussion**

Results of the study in three phases is presented as under —

**Focus Group Discussion**

In this phase the research question was identified during the interaction with learners in the class. However, they were using both microscope, telescope and all were aware and had seen rainbows a number of times during rains. But they were not knowing the simple fact of this natural phenomena.

**Intervention**

Next day when the researcher reached the combined Classes of VII and IX and asked if they have read the story which their teacher had given to them the day before, all learners discussed the story thoroughly in the class. All had smiles on their faces and eyes were full of curiosity. There was general acceptance that the paper was well liked.

**Post Intervention Assessment**

In this phase an assessment was carried out using six assessment items. Results of frequency of per cent learners’ attainment of concepts for each item is presented in Table 1 for meeting the objectives of the study.

**Table 1**  
Frequency of learners’ attainment of concepts against each item (%)

Item no.	Frequency of learners’ attainment of concepts (%)	
	Class VII	Class IX
1	100	100
2	92.5	100
3	100	100
4	100	100
5	100	100
6	100	100



## Qualitative Analysis

- (i) First item was designed in such a way that there was no stress of any examination and started with a fun activity of sketching. All learners could make the sketch and serially arrange the VIBGYOR colours.
- (ii) Second item was a multiple choice. Questions in which students were asked to tick mark in one correct option out of four options in the answer sheet. All 62 students of Class IX could answer correctly and 61 out of 66 students of Class VII could answer correctly by putting tick mark for first option. In other words total achievement score for this item for Class IX students was 100 per cent and of Class VII students was 92.5 per cent. Rest of the 7.5 per cent students of Class VII opted for either third option or fourth option. That means even after reading the story they could not see clouds as water and few not even air. These 7.5 per cent learners need different intervention to understand the concept. They may have a kinaesthetic learning style and not of the aural and visual style.
- (iii) All learners of Classes VII and IX could answer this item correctly. That means all learners could relate the lenses with the water droplets in the story working as lens.
- (iv) For item IV, all learners agreed and could relate lens with both devices microscope as well as telescope.
- (v) In response to item V, some learners wrote lenses and some wrote

combination of lenses. Over all, they know that it is effect of lens that magnify the object.

- (vi) For this item again learners could relate lenses with the working of telescope.

Thus the answer to the second research question pertained to an overall success in learning through aural-visual style achieving the content and cognitive validity (Field, 2011, 2013) of the NCF 2005. Thus, activity enhanced learning with storytelling technique and narration method may be considered as an effective tool in realising the components of the philosophy of constructivism.

Storytelling is an indigenous pedagogy and play a big role in learning (Wilson, 2004; Aikenhead, 2001). Storytelling by grannies had been contributing since long in over all personality development of children. The same has been employed in the present study as an intervention strategy to learn the concepts that have not been addressed in science textbook at upper primary stage and with very little preliminary information at secondary stage. Thus, teachers also lack training, conceptualisation and creativity to take up the concept in the classroom and not beyond classroom learning. But it is necessary to have a general idea about the functioning of these devices at upper primary and secondary stages. In the present study, the story telling has come out as a successful pedagogy to learn the concepts of science and may be used by the teachers as beyond textbook and beyond classroom teaching-learning process as supported by Freisen (1999) who has discussed the power of traditional story as pedagogical tools.

## Recommendations

This study justifies broad outlook in view of NCF 2005. It builds on learning as free from any fixed boundaries and it should not hamper the understanding of a concept. In the present study, if we see, that the child at birth itself is involuntarily exposed to light through eyes, which is one of the sense organs in human body and can make many observations in the natural world because it can sense light. But keeping in view the content and cognitive validity, the very concepts of working of lenses is spontaneously missing to be a part of upper primary syllabus, but the devices became a part of it to address learner centred pedagogy in the classroom. The basic idea of lens has been given in the *Textbook of Science* for Class IX. However, teachers may take up such concepts in the class as project activities under “learning beyond classroom” and “learning beyond textbook” as per the recommendations of NCF 2005. So that the concept of ‘learning beyond classroom’ and ‘learning beyond textbook’ as recommended by NCF 2005 may be implemented for improving teaching and learning of science in the classroom.

Syllabus and textbook developers may think of bringing such concepts at early stages of school education to which involuntarily a child is exposed to, since birth, as seeds to unveil a very small concept behind which a big world is waiting to be unveiled. This may provide learners to further think into, even in their unconscious minds continuously and naturally construct the knowledge.

The study may be helpful while revising the textbooks of science at upper primary and secondary stages and textbook developers would take into account the concerns raised in the study while developing the textbooks.

Also, storytelling has come out as a powerful pedagogical tool in the present study for learning of some concepts of science, it is recommended that this obliterated indigenous pedagogy may be a part of science teacher capacity building programmes and it is the need of the hour and to bring it back into the live classrooms in teaching learning process again. So that this indigenous pedagogy of learning at the verge of disappearance may be saved.

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# SCIENCE NEWS



## Meet RobERt, the Dreaming Detective for Exoplanet Atmospheres

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Machine-learning techniques that copy human understanding and imagining processes are being set up in the search for livable worlds beyond our solar system. The theory of understanding the semantic network, called RobERt (Robotic Exoplanet Recognition), has been developed by stargazers at UCL to analyse through detections of light emitted from far-away planetary systems and recapture spectral information about the gases present in the exoplanet atmospheres. RobERt was presented at the National Astronomy Meeting (NAM) 2016 in Nottingham by Dr. Ingo Waldmann on Tuesday 25th June.

“Distinctive kinds of molecules consume and transmit light at some particular wavelengths, thereby constituting a unique pattern of lines within the electromagnetic spectrum,” interpreted Dr. Waldmann, who leads RobERt’s advancement group. “We

can take light that has been refined through an exoplanet’s atmosphere or reflected from its cloud-tops, split it like a rainbow and then pick out the ‘fingerprint’ of features associated with the different molecules or gases. Human brains are really good at finding these patterns in spectra and label them from experience, but in real time it will be a tedious job for them to deal with such enormous size of data.

We assembled RobERt to individually or unrestrictedly pick up from given illustrations and to develop based on his own involvement as it encounters with different things. Truthfully, RobERt has adapted properties similar to stargazer or an astronomer, it has been noticed that RobERt has a quite nice sentiment for what molecules are inside a spectrum and which are the most promising data for more detailed analysis. But what usually takes days or weeks to humans RobERt takes mere seconds for analyzing giant sized detailed data.”

Deep belief neural networks, or DBNs, were developed over more than a decade ago and are generally utilised for speech awareness, web or internet-based resources and tracking

client behaviour. RobERT's DBN has three layers of unit processors, or 'neurons'. Data is fed into a base layer of 500 neurons, which make an initial filter of the data and pass a subset behind to the second layer. Here, 200 neurons clarify the selection and pass data up to the third layer of 50 neurons to conclude clearly recognition of the gases most likely to be available on exoplanet's surface.

To train RobERT for his challenge, Waldmann and his teammates at UCL created a total of 85,750 simulated spectra, covering five different types of exoplanet ranging from GJ1214b, a potential "ocean planet," to WASP-12, a hot Jupiter revolving very close to its star. Each spectrum in the training set contained the unique fingerprint impression of an isolated gas species. RobERT's learning progress was proved at intervals during the training with 'control' spectra. At the finishing point of the preparation phase, RobERT had a recognition efficiency of 99.7 per cent.

"RobERT has learned to resolve factors such as commotion, restricted wavelength ranges, and mixtures of gases," said Waldmann. "He can figure out components such as water and methane in a meld atmosphere with a high tendency, even when the input originates from the finite limited wavebands that most space instruments can afford and when it contains overlapping features."

RobERT's DBN can also be reversed so that instead of analyzing data fed into the system, he can enter an 'imagining state' in which he can produce full spectra based on his own understanding.

"Robots truly do dream. We can inquire RobERT to dream up what he considers water spectrum will resemble, and he's proved exactly accurate," interpreted Waldmann.

"This envisioning capacity has been extremely advantageous when an attempt to identify features in inadequate data. RobERT can use his nightmare state to fill in the differences. The James Webb Space Telescope, due for discharge in 2018, will tell us further about the atmospheres of exoplanets, and new facilities like Twinkle or ARIEL will be coming on the internet over the next ten years that are particularly custom to characterising the atmospheres of exoplanets. The measure of data these missions will provide will be astonishing. RobERT will play a vital role in helping us to analyze data from these missions and find out what these distant worlds are really like."

**Source:** Sciencedaily/ Royal Astronomical Society (RAS)

## Mercury's Origins Traced to Rare Meteorite

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<https://www.sciencedaily.com/releases/2016/06/160627132939.htm>

**Source:** Sciencedaily/ Massachusetts Institute of Technology

Over 4.6 billion years ago, our solar system was absolutely uncertain of disintegrated gas and revolved debris. Fine particles of gas and dirt bundled together to form bigger and giant sized meteoroids that in turn crumbled together lead to the formation of planets. According to geologists, soon after they get formed, these planets — and particularly Mercury — were blazing spheres of molten material, that took millions of years to cool.

Geologists at MIT have discovered a bit of Mercury's composition a few billion years ago, soon after the planet formed, was that of an extremely rare meteorite found on

earth. Also, it has been observed that its core temperatures decreased by nearly 240 degrees Celsius, or 464 degrees Fahrenheit.

Researchers probe on the basis of fast cooling rate and the composition of lava deposits on Mercury's surface, that the planet likely has the composition of an enstatite chondrite — a type of meteorite that is present extremely rare here on Earth.

According to Timothy Grove, the Cecil and Ida Green Professor of Geology in MIT's Department of Earth, Atmospheric, and Planetary Sciences, this new information is advantageous for knowing the early background of the earth as well as Mercury's past.

"Here we are today, with 4.5 billion years of planetary evolution, and because the Earth has such a dynamic interior, because of the water we've preserved on the planet, [volcanism] just wipes out its past," Grove says. "On planets like Mercury, early volcanism is much more dramatic, and [once] they cooled down there were no later volcanic processes to uncover the early history. This is the first place where we actually have an estimate of how fast the interior cooled during an early part of a planet's history."

Grove and his colleagues, including researchers from the University of Hanover, in Germany; the University of Liège, in Belgium; and the University of Bayreuth, in Germany, have published their results in Earth and Planetary Science Letters.

### Compositions in Craters

For their analysis, the team employed data collected by NASA's MESSENGER spacecraft. The MErcury Surface, Space ENvironment, GEOchemistry, and Ranging

(MESSENGER) probe orbited Mercury between 2011 and 2015, collecting measurements of the planet's chemical composition with each flyby. During its mission, MESSENGER produced images that revealed kilometre-thick lava deposits covering the entire planet's surface.

An X-ray spectrometer is present on the spacecraft which is used to measure the X-ray radiation from the planet's surface, produced by solar flares on the sun, to determine the chemical composition of nearly more than 5,800 lava deployed on Mercury's surface.

Grove's co-author, Olivier Namur of the University of Hanover, recalculated the surface compositions of nearly all 5,800 locations, and correspond each composition with the type of terrain in which it was found, from heavily cratered regions to those that were less impacted. The density of a region's craters can tell something about that region's age: The more craters there are, the older the surface is, and vice versa. The researchers were able to correlate Mercury's lava composition with age and found that older deposits, around 4.2 billion years old, contained elements that were very different from younger deposits that were estimated to be 3.7 billion years old.

"It's true of all planets that different age terrains have different chemical compositions because things are changing inside the planet," Grove says. "Why are they so different? That's what we're trying to figure out."

### A Rare Rock, 10 Standard Deviations Away

To answer that question, Grove tried to recover a lava deposit's path, from the time

it melted inside the planet to the time it ultimately erupted onto Mercury's surface.

To get some result, he started by exhilarating Mercury's lava deposits in the lab. From MESSENGER's 5,800 compositional data points, Grove selected two extremes: one representing the older lava deposits and one from the younger deposits. He and his co-workers transformed the lava deposits' element ratios into the chemical ingredient that make up the rock, then followed this recipe to create synthetic rocks representing each lava deposit.

The team melted the synthetic rocks in a furnace to simulate the point in time when the deposits were lava, and not yet solidified as the rock. Then, the researchers dialed the temperature and pressure of the furnace up and down to effectively turn back the clock, simulating the lava's eruption from deep within the planet to the surface, in reverse.

Throughout these experiments, the team looked for tiny crystals forming in each molten sample, representing the point at which the sample turns from lava to rock. This represents the stage at which the planet's solid rocky core begins to melt, creating a molten material that sloshes around in Mercury's mantle before erupting onto the surface.

The team found a surprising disparity in the two samples: The older rock melted deeper in the planet, at 360 kilometres, and at higher temperatures of 1,650°C, while the younger rock melted at shallower depths, at 160 kilometres, and 1,410°C. The experiments indicate that the planet's interior cooled dramatically, over 240 degrees Celsius between 4.2 and 3.7 billion years ago — a geologically short span of 500 million years.

"Mercury has had a huge variation in temperature over a fairly short period of time, that records a really amazing melting process," Grove says.

The researchers determined the chemical compositions of the tiny crystals that formed in each sample, in order to identify the original material that may have made up Mercury's interior before it melted and erupted onto the surface. They found the closest match to be an enstatite chondrite, an extremely rare form of a meteorite that is thought to make up only about 2 per cent of the meteorites that fall to earth.

"We now know something like an enstatite chondrite was the starting material for Mercury, which is surprising because they are about 10 standard deviations away from all other chondrites," Grove says.

Grove cautions that the group's results are not set in stone and that Mercury may have been an accumulation of other types of starting materials. To know this would require an actual sample from the planet's surface.

## Global, Evolving, and Historic Make-up of Malaria Species Uncovered

<https://www.sciencedaily.com/releases/2016/06/160627124430.htm>

Source: Sciencedaily/ New York University

"Plasmodium vivax is going to be the last malaria parasite standing," observes Jane Carlton, a professor in New York University's Department of Biology, who led the study. "Our findings show it is evolving in response to anti-malarial drugs and adapting to regional differences, indicating a wide range of approaches will likely be necessary to eliminate it globally."

"The DNA data show that *P. vivax* has clearly had a different history of association with global human populations than other malaria parasites, indicating that unique aspects of its biology may have influenced the ways in which it spread around the world," adds Daniel Neafsey, associate director of the Genomic Center for Infectious Disease at the Broad Institute, who generated the data and co-led the analysis.

*P. vivax* causes an estimated 15.8 million clinical malaria cases each year. However, it remains understudied because it is both less lethal than other species and because it has historically been difficult to analyze since it cannot be grown in the laboratory. Another challenge is separating the parasite's DNA from human DNA.

In their study, which appears in the journal *Nature Genetics*, the research team sequenced approximately 200 DNA samples of *P. vivax* collected from patients—the largest number of *P. vivax* genomes sequenced to date—in 11 countries, including Brazil, Colombia, India, Mexico, Myanmar, Papua New Guinea, Peru, and Thailand. The scientists were able to separate *P. vivax* DNA from its human host by using a set of unique 'sticky baits' that captured the parasite DNA, enabling the human DNA to be washed away.

The researchers collected patient samples through the International Centers of Excellence for Malaria Research, a global network of independent research centres in malaria-endemic settings that provide knowledge, tools, and evidence-based strategies to support in-country researchers working in a variety of settings, especially within governments and healthcare institutions.

The sequencing of the parasite's genome offered an array of new insights into the nature of *P. vivax* as it exists today and also served as a "genetic history book" of the studied regions:

- Central and South American *P. vivax* populations are very genetically diverse and distinct from all other contemporary *P. vivax* populations, suggesting that New World parasites may have been introduced by colonial seafarers and represent a now-eliminated European parasite population.
- Contemporary African and South Asian *P. vivax* populations are genetically similar, suggesting that South Asian *P. vivax* populations may have genetically mingled with European lineages during the colonial era—or, alternatively, reflect ancient connections between human populations in the Eastern Mediterranean, Middle East, and Indian subcontinent.
- The relatively homogeneous genetic makeup of *P. vivax* in Mexico reflects a steady decline of the disease in this country over the last decade, falling to under 10,000 cases.
- By contrast, the Papua New Guinea (PNG) population of *P. vivax* is very diverse relative to other *P. vivax* populations, with implications for developing different methods of control in this region of the world.
- *P. vivax* is significantly more genetically diverse than the more widely studied and deadlier malaria



species *P. falciparum*, which may make it more elusive to methods of control and thus more difficult to eliminate.

- Resistant forms of two genes associated with antimalarial drug resistance have swept through the global population.
- Several genes were identified as adapting to regional differences in the human host and mosquito vector—for example, a gene involved in evasion of the mosquito immune response that enabled the species to successfully adapt to development and transmission in New World mosquito species.

The research was conducted through the National Institute of Allergy and Infectious Diseases (NIAID)/National Institutes of Health (NIH) International Centers of Excellence for Malaria Research (U19AI089676, U19AI089681, U19AI089686, U19AI089672, U19AI089702) and Contract No. HHSN272200900018C, as well as supported by the National Council for Science and Technology Mexico (29005-M SALUD-2004-119), and the Victorian State Government Operational Infrastructure Support and the Australian Government (NHMRC IRIISS), among others.

## Seeds of Black Holes Could Be Revealed by Gravitational Waves Detected in Space

<https://www.sciencedaily.com/releases/2016/06/160627095017.htm>

Source: Sciencedaily/ Durham University

Gravitational waves or ripple detectors can be used in identifying how some of the largest black holes of the universe were born.

Scientists led by Durham University's Institute for Computational Cosmology ran the huge cosmological simulations that can be used to predict the rate at which gravitational waves caused by collisions between the monster black holes might be detected.

The amplitude and frequency of these waves could unveil mass of the origin from which the first black holes developed since they were formed 13 billion years ago and provide further clues about what caused them and where they formed, the researchers said.

The study combined simulations from the EAGLE project — which aims to create a realistic simulation of the known Universe inside a computer — with a model to calculate gravitational wave signals.

Two detections of gravitational waves caused by collisions between supermassive black holes should be possible each year using space-based instruments such as the Evolved Laser Interferometer Space Antenna (eLISA) detector that is due to launch in 2034, the researchers said.

As eLISA will be in space — and will be at least 250,000 times larger than detectors on earth — it should be able to detect the much lower frequency gravitational waves caused by collisions between supermassive black holes that are up to a million times the mass of our sun.

Current theories suggest that the origin of these black holes were the conclusion of either the growth and destruction of the first generation of stars in the universe; collisions between stars in dense stellar clusters; or the

direct collapse of extremely massive stars in the early universe.

As each of these theories anticipated different initial masses for the origin of supermassive black hole seeds, the collisions would produce different gravitational wave signals.

This means that the potential detections by eLISA could help pinpoint the mechanism that helped create supermassive black holes and when in the history of the universe they formed.

Lead author Jaime Salcido, PhD student in Durham University's Institute for Computational Cosmology, said: "Understanding more about gravitational waves means that we can study the universe in an entirely different way.

"These waves are caused by massive collisions between objects with a mass far greater than our sun.

"By combining the detection of gravitational waves with simulations we could ultimately work out when and how the first origin of supermassive black holes formed."

Co-author Professor Richard Bower, of Durham University's Institute for Computational Cosmology, added: "Black holes are fundamental to galaxy formation and are thought to sit at the centre of most galaxies, including our very own Milky Way.

"Discovering how they came to be where they are is one of the unsolved problems of cosmology and astronomy.

"Our research has shown how space based detectors will provide new observations into the nature of supermassive black holes."

Gravitational waves were first predicted 100 years ago by Albert Einstein as part of his Theory of General Relativity.

The waves are concentric ripples caused by violent events in the universe that squeeze and stretch the fabric of space-time but most are so weak they cannot be detected.

LIGO detected gravitational waves using ground-based instruments, called interferometers, that use laser beams to pick up subtle disturbances caused by the waves.

eLISA will work in an analogous way, detecting the small variations in separation between three satellites that will orbit the sun in a triangular pattern associated by beams from lasers in each satellite.

Recently, it was reported that the LISA Pathfinder, the precursor to eLISA, had successfully established the technology that opens the door to the development of a large space observatory accomplished of detecting gravitational waves in space.

## **Scientists just Made it Cheaper to Produce Hydrogen from Water**

<https://www.sciencedaily.com/releases/2016/06/160627095937.htm>

**Source: Sciencedaily/ KTH The Royal Institute of Technology**

A hydrogen-fuel economy could finally become a reality with the innovative discovery of a cheap, stable and efficient way of extracting hydrogen from water.

If a cheap, stable and efficient way could be found to produce hydrogen from water, a hydrogen-fuel economy could definitely become a reality.

Scientists at KTH Royal Institute of Technology in Stockholm now addresses that they have unlocked one major barrier to exploiting this renewable energy source.

Since the highly-efficient catalysts for electrochemical oxidation, or “water splitting,” are expensive crucial metals, the research team led by KTH Professor Licheng Sun is one of many worldwide searching for cheaper alternatives. Sun had earlier developed molecular catalysts for water oxidation (*Nature Chem.* 2012, Vol. 4, pp. 418-423) with an efficiency impending to that of natural photosynthesis.

His team reported in *Nature Communications* that it has discovered that a modern substantial composed of common earth-abundant elements could be used as a catalyst for water splitting, which could help change the economics of large-scale hydrogen fuel production.

Researcher Ke Fan mentions that the new material is a monolayered double hydroxide involving nickel and vanadium, which offers a state-of-art electrocatalyst for water oxidation. The low-cost, highly efficient nickel-vanadium monolayer outperforms other electrocatalysts that are composed of non-precious materials, Fan says. And it attempts an ambitious, economical, alternative to catalysts that trust on more overpriced, crucial materials, such as iridium oxide (IrO<sub>2</sub>) or ruthenium oxide (RuO<sub>2</sub>).

“This is the first time that the metal, vanadium, has been used to dope nickel hydroxide to form a water oxidation catalyst, and it works very well — even beyond our expectations,” Fan says. “No doubt this material can extremely expand the extension of non-precious metal elements of

electrocatalysts, and it opens new areas for water splitting.”

One possibility the discovery hikes is the large-scale production of hydrogen fuel utilizing Sun’s catalyst.

The substance possesses a layered structure with monolayer nickel-vanadium oxygen polyhedron connected together with a thickness below 1 nanometer, interpret researcher Hong Chen.

“This monolayer also features in enhancing the active surface area, but also enhances the electron transfer within the material,” Chen says.

Sun expects the research to “open a new area of more economical water oxidation catalysts, featuring stability and efficiencies that equal or even surpass some of today’s best catalysts including RuO<sub>2</sub> and IrO<sub>2</sub>.”

## Super-slow Circulation Allowed World’s Oceans to Store Huge Amounts of Carbon During Last Ice Age

<https://www.sciencedaily.com/releases/2016/06/160627094834.htm>

Source: Sciencedaily/ University of Cambridge

The manner the ocean carried heat, nutrients and carbon dioxide at the roof of the previous ice age, about several thousand of years ago, is significantly different than what has formerly been suggested, according to two new studies. The conclusions suggest that the brisk ocean circulated at a very sluggish rate, which empowers it to accumulate much more carbon for much longer than the current ocean.

Using the information contained within the shells of tiny animals known as foraminifera, the researchers, led by the University of Cambridge, looked at the characteristics of the seawater in the Atlantic Ocean during the previous ice age, including its ability to store carbon. Since atmospheric CO<sub>2</sub> levels during the period were about a third lower than those of the pre-industrial atmosphere, the researchers were attempting to find if the extra carbon not present in the atmosphere was stored in the deep ocean rather.

They settle that the deep ocean circulated at a much gradual rate at the peak of the previous ice age than had previously been suggested, which is one of the reasons why it was able to store much more carbon for much longer periods. That carbon was accumulated as organisms from the surface ocean expire and sank in the deep ocean where their bodies dissolved, releasing carbon that was in effect 'trapped' there for thousands of years. Their results are reported in two separate papers in *Nature Communications*.

The ability to reconstruct past climate change is an important part of understanding why the climate of today behaves the way it does. It also helps to predict how the planet might respond to changes made by humans, such as the enduring emission of large quantities of CO<sub>2</sub> into the atmosphere.

The world's oceans work like a giant conveyor belt, transporting heat, nutrients, and gases around the globe. In today's oceans, warmer waters travel northwards along currents such as the Gulf Stream from the equatorial zones towards the pole, becoming saltier, colder and denser as they go, causing them to sink to the bottom. These deep waters flow into the ocean basins, eventually ending up in the

Southern Ocean or the North Pacific Ocean. An entire loop can take as long as 1000 years.

"During the period we're looking at, large amounts of carbon were likely carried from the surface ocean to the deep ocean by organisms as they expire, sunk and dissolved," said Emma Freeman, the main author of one of the papers. "This operation discharged the carbon the organisms contained into the deep ocean waters, where it was trapped for thousands of years, due to the very slow circulation."

Freeman and her co-authors used radiocarbon dating, a technique that is more commonly used by archaeologists, in the procedure to determine how old the water was in different parts of the ocean. Using the radiocarbon information from tiny shells of foraminifera, they found that carbon was stored in the slowly-circulating deep ocean.

In a separate study led by Jake Howe, also from Cambridge's Department of Earth Sciences, researchers studied the neodymium isotopes contained in the foraminifera shells, a method which works like a dye tracer, and came to a similar conclusion about the amount of carbon the ocean was able to store.

"We found that during the peak of the previous ice age, the deep Atlantic Ocean was filled not just with southern-sourced waters as previously thought, but with northern-sourced waters as well," said Howe.

What was previously interpreted to be a layer of southern-sourced water in the deep Atlantic during the previous ice age was in fact shown to be a mixture of slowly circulating northern- and southern-sourced waters with a large amount of carbon stored in it.

“Our research looks at a time when the world was much colder than it is now, but it’s still important for understanding the effects of changing ocean circulation,” said Freeman. “We need to understand the dynamics of the ocean in order to know how it can be affected by a changing climate.”

The research was funded in part by the Natural Environment Research Council (NERC), the Royal Society and the Isaac Newton Trust.

## Robots Come to Each Other’s Aid When they Get the Signal

<https://www.sciencedaily.com/releases/2016/06/160627095637.htm>

**Source: Sciencedaily/ KTH The Royal Institute of Technology**

Sometimes all it takes to receive help from someone is to wave at them, or point. Now the same is true for robots. Researchers at KTH Royal Institute of Technology in Sweden have completed work on an EU project aimed at enabling robots to coordinate with each other on difficult tasks, by using body language.

Dimos Dimarogonas, an associate professor at KTH and project coordinator for RECONFIG, adds the research project has developed agreements that enable robots to ask for help from each other and to observe when other robots need cooperation — and change their strategy accordingly.

“Robots can pause what they’re doing and go over to collaborate with another robot which has asked for support,” Dimarogonas says. “This will mean flexible and dynamic robots that act much more like humans — robots capable of constantly facing new choices and

that are competent enough to make decisions.”

As self-governing machines take on more responsibilities, they are bound to encounter tasks that are too big for a single robot. Shared work could include lending an extra hand to lift and carry something, or holding an object in place, but Dimarogonas declare the concept can be proportioned up to include any figure of functions in a home, a factory or other kinds of workplaces.

The project was completed in May 2016, with project partners at Aalto University in Finland, the National Technical University of Athens in Greece, and the École Centrale Paris in France.

In a series of filmed presentations, the researchers establish the newfound capabilities of several off-the-shelf self-governing machines, including NAO robots. One video shows a robot pointing out an object to another robot, conveying the message that it needs the robot to lift the item.

Dimarogonas announces that common perception among the robots is one key to this collaborative work.

“The visual feedback that the robots receive is translated into the same symbol for the same object,” he says. “With advanced vision technology they can understand that one body is the same from different angles. That is translated to the same symbol one layer up to the decision-making — that it is a thing of interest that we need to transport or not. In other words, they have non-cognitive agreement.”

In another manifestation two robots carry an object together. One leads the other, which senses what the lead robot wants by the force it exerts on the object, he adds.

"It's just like if you and I were carrying a table and I knew where it had to go," he says. "You would sense which direction I wanted to go by the way I turn and push, or pull."

The crucial point is that all of these behaviours take place without human interaction or support, he says.

"This is done in real time, autonomously," he says. The project also uses a novel communication agreement that sets it apart from other collaborative robot concepts. "We minimize communication. There is a symbolic communication protocol, but it's discontinuous. When support is needed, a call for help is broadcast and a helper robot transfers the information to another robot. But it's a one-time opportunity."

## Artificial Intelligence May Aid in Alzheimer's Diagnosis

<https://www.sciencedaily.com/releases/2016/07/160706091455.htm>

**Source:** Sciencedaily/ Radiological Society of North America

Machine learning is a type of artificial intelligence that allows computer programs to learn when exposed to new data without being programmed. Now, researchers in The Netherlands have coupled machine learning methods with a special MRI technique that measures the perfusion, or tissue absorption rate, of blood throughout the brain to detect early forms of dementia, such as *mild cognitive impairment (MCI)*, according to a new study published online in the journal *Radiology*.

"MRI can be advantageous with the diagnosis of Alzheimer's disease," said principal investigator Alle Meije Wink, Ph.D., from the

VU University Medical Centre in Amsterdam. "However, the early diagnosis of Alzheimer's disease is problematic."

Scientists have long known that Alzheimer's disease is a continuous process and that the brain undergoes functional changes before the structural changes associated with the disease show up on imaging results. Physicians have no definitive way of analysing who has early dementia or which cases of mild cognitive deterioration will progress to Alzheimer's disease.

"With definite diagnostic MRI, we can see advanced Alzheimer's disease, such as atrophy of the hippocampus," Dr. Meije Wink said. "But at that point, the brain tissue is gone and there's no way to build up it. It would be helpful to recognize and identify the disease before it's too late."

For the new study, the researchers applied machine learning methods to special type of MRI called arterial spin labeling (ASL) imaging. ASL MRI is used to create images called perfusion maps, which show how much blood is delivered to specific regions of the brain.

The automated machine learning program is taught to recognize patterns in these maps to distinguish among patients with varying levels of cognitive impairment and predict the stage of Alzheimer's disease in new (unseen) cases.

The study involves 260 of 311 participants from the Alzheimer Center of the VU University Medical Center dementia cohort who underwent ASL MRI between October 2010 and November 2012.

The study group included 100 patients diagnosed with probable Alzheimer's disease, 60 patients with mild cognitive impairment

(MCI) and 100 patients with subjective cognitive decline (SCD).

SCD and MCI are examined to be early stages of the dementia process and are diagnosed based on the severity of subjective symptoms, including memory loss and thought- and judgement-making difficulties.

The self-generative system was able to categorize adequately among candidates with Alzheimer's disease, MCI and SCD. Using classifiers based on the automated machine learning training, the researchers were then able to predict the Alzheimer's diagnosis or progression of single patients with a high degree of accuracy, ranging from 82 per cent to 90 per cent.

"ASL is a promising alternative functional biomarker for the early diagnosis of Alzheimer's disease," Dr. Meije Wink said.

He added that the application of automated machine learning methods would be useful as a potential screening tool.

"ASL MRI can diagnose brain variations that appear early in disease process, when there's a window of opportunity for intervention," Dr. Meije Wink said. "If the disease process from SCD to MCI to Alzheimer's disease could be deflected or slowed, this technique could play a vital role in shielding."

## Replacing Oil with Wood for the Production of Chemicals

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<https://www.sciencedaily.com/releases/2016/07/160706091729.htm>

### Swiss National Science Foundation (SNSF)

Petroleum means fuel, but not only: petrochemicals are a core component of the

chemical industry. In the absence of oil, there would be no plastics and few pharmaceuticals or fertilisers. Looking for a renewable resource as an alternative to oil will be vital to look the foreseeable deterioration in oil extraction.

Two research projects of the National Research Programme "Resource Wood" (NRP 66) have made significant advances towards replacing oil with biomass derived from plants, in particular from wood. Their goals are complementary, as each one uses one of the two main constituents of wood: cellulose and lignin. These are the two most common organic components on earth and, importantly, are renewable.

Sviatlana Siankevich of EPFL has designed new catalytic processes to efficiently transform cellulose into hydroxymethylfurfural (HMF), a very important precursor for the production of plastics, fertilisers or biofuels. Inspired by the action of fungi degrading rotting wood, the team of Philippe Corvini at FHNW in Muttenz (BL) has selected enzymes capable of cutting lignin into aromatic compounds useful for making solvents, pesticides, plastics such as polystyrenes as well as active pharmaceutical ingredients.

### Chemicals Instead of Paper

Cellulose is a long chain of carbohydrate (sugar) molecules and accounts for about two-thirds of wood's weight. "It is mainly used for paper production, and the residuals could be better valorised by being transformed into useful chemicals," says Sviatlana Siankevich of EPFL's Institute of Chemical Sciences and Engineering. With colleagues from Queen's University in Canada and the National University of



Singapore, the EPFL team led by chemist Paul Dyson synthesised several types of ionic liquids (molten salts) to convert cellulose into HMF, an important molecule for the production of commodity chemicals. In a single step, their reaction reached a 62% yield, a new record.

“Our procedure operates at mild conditions, that is, without very high temperatures or pressure or strong acids,” says Siankevich. “We’ve also been able to reduce the amount of undesired by-products, an important point if the reaction is to be scaled up for industrial processes. Our process can work with wood, but it’s often easier to use cellulose extracted from herbaceous plants.”

### Greener Chemistry

At the Fachhochschule Nordwestschweiz (FHNW) in Muttenz, Philippe Corvini and his PhD student Christoph Gasser are developing ways to use lignin, a long molecule which gives trees their rigidity and makes up around 15%-40% of the wood content. “Until now, lignin was not very much valorised, but often simply burned,” says Corvini. “But it can be cut into aromatic structures, molecules based on the famous carbon hexagon ubiquitous in organic chemistry. These components represent huge volumes for the chemical industry, and have been so far almost exclusively obtained from petroleum. Lignin is presently the most serious alternative.”

Some fungi secrete a combination of enzymes to degrade lignin and chop it into smaller pieces. Corvini’s team at FHNW screened the combinations of dozens of such enzymes to select the most efficient. By adding a further

catalytic step, they managed to transform 40% of the lignin into very small molecules such as vanillin. The process is of interest to the chemical industry, and collaboration with a lignin producer is already underway. “Most of the lignin today is obtained from wheat or rice straw,” says Corvini. “But soft wood such as spruce could prove useful as its lignin is easy to break down.”

The FHNW team also developed a way to reuse the enzymes. “We have attached them onto iron nanoparticles coated with silica,” explains the researcher. After the reaction, we simply approach with a magnet to attract the particles and recover the enzymes.” As these can be reused up to ten times, the energy and resources needed to produce them is significantly reduced and fits well into the concept of “green chemistry.”

### All of the Wood

To be economically viable, wood as a replacement for petrochemicals must be used to the greatest extent possible. “Extracting only one component from wood in small quantity is not enough,” says Sviatlana Siankevich. “We need to find complementary processes to use all of it.” But more aspects must be considered to assess whether wood can serve as an economically viable substitute for oil. A third project of NRP 66 has recently carried out a sustainability assessment of the production of succinic acid, another important chemical, from wood residues. The study from ETH Zurich and EPFL shows that smart process design can lead to energy savings and environmental benefits, key factors for biorefineries to be competitive.



## Children's Purchasing Behaviour 'Significantly Impacted' by Social Media, Mobile Apps

<https://www.sciencedaily.com/releases/2016/07/160706114619.htm>

**Source:** Sciencedaily/ University of Leicester

Exposure to prompts to make in-app purchases in mobile games has a significant impact on children's purchasing behaviour, according to a recent study funded by the European Commission involving Dr Giuseppe Veltri, who now works at the University of Leicester Department of Media Communication.

The study examined the impact on children of in-game adverts in advergames, mobile apps and social media games.

The results suggest that children are often exposed to a number of problematic marketing practices in online games, mobile apps and social media sites which are not always understood by the child consumer.

The researchers found that out of the 25 most popular online games, all 'advergames', all social media games and half of the games provided through popular application platforms contained embedded or contextual advertisements.

Dr Giuseppe Veltri, Senior Lecturer in Social Psychology of Communication at the University of Leicester Department of Media and Communication said: "This is a significant study on an already pressing policy issue. The study demonstrated the large impact that online marketing practices can have on children and the difficulty in managing such

effects from the perspective of parents and sheds light on their coping strategies.

"Both these aspects represent a crucial input for policymakers interested in regulating this area."

Dr Veltri was a member of the London School of Economics and partners consortium in which they were one of the experts that carried out the study.

The study finds that across Europe children do not receive an equal level of protection from the adverse effects of online marketing, given that marketing to children is regulated in a slightly different manner between countries and because parents apply different models of oversight of their children's online activities.

In general, most parents involved in the study did not see online marketing targeting their children as a major risk, and thought that their children are not affected.

For example, parents in France were found to intervene less in their children's online activities, while Swedish parents are more actively engaged in their children's online activities and apply more restrictions.

The research suggests that although parents have an important role in protecting their children online, they are often not prepared to do so.

The findings are based on data collected through various methods including behavioural experiments with children in two countries (The Netherlands and Spain); focus groups with children and with parents in eight countries (UK, Spain, Italy, France, Poland, The Netherlands, Germany

and Sweden); a survey with parents in the same eight countries; an in-depth analysis of the most popular games in the main online platforms; a literature review, and a regulatory review covering the 28 EU Member States, Norway and Iceland.

The study confirms the need for a strong and harmonised protection of children as consumers, and it brings new evidence that advances the understanding of children as potentially vulnerable consumers and of marketing practices that can be considered unfair from the perspective of child consumers.

The study also provides evidence to support the ban on product placement in programmes with a significant children audience in the proposed Directive on Audio-Visual Media Services, and is relevant for the ongoing review of EU consumer and marketing law.

## Science Could Help Search for the Next Tennis Champions

<https://www.sciencedaily.com/releases/2016/07/160706131922.htm>

**Source:** Sciencedaily/ University of Bath

Grouping young tennis players according to their physical maturity rather than their chronological age could help us develop future tennis champions, says research by the University of Bath.

Boys and girls can vastly vary in their rates of growth and maturity during adolescence. Those that mature early are taller, quicker, bigger and stronger, giving them a significant

advantage over their late maturing peers. This means that later maturing players are often overlooked in the elite tennis selection process.

Now the Lawn Tennis Association (LTA) is collaborating with scientists at the University of Bath to use statistics to avoid selection bias towards early maturing players.

Dr Sean Cumming, Senior Lecturer in Health at the University of Bath commented: "Tennis is a sport that favours youth who are taller and mature earlier than their peers. Our data show that this selection bias impacts girls from the age of 10 and boys from the age of 12.

"Every extra inch in height of a player increases the velocity of their serve by five per cent. At the elite level, it is quite common to find junior players, especially adolescent boys, who are six foot or greater in height.

"The challenge for those working with young tennis players is to look beyond differences in maturity, and recognise those players who may have the greatest potential for success as an adult. While early maturing boys and girls have initial advantages, the pressure to win can lead them to play to their physical strengths at the expense of their technical development.

"In contrast, talented, yet late maturing players might be excluded or overlooked by talent spotters on the basis of physical characteristics that are not fully realised until adulthood."

The research team, which includes mathematicians from Bath's Institute for Mathematical Innovation, is developing new statistical methods to allow practitioners

to better assess and account for individual differences in biological maturity and help ensure players are evaluated on the basis of their physical development, and not just their chronological age.

Gill Myburgh, a Strength and Conditioning coach at the LTA and part-time PhD student at Bath, said: "Being able to more accurately assess and account for individual differences in growth and maturity, is really important when assessing talent. It also helps us design and implement more effective and developmentally appropriate training programmes.

"Growth spurts can increase the risk of injuries, so monitoring players' growth trajectories and adjusting their training programmes accordingly is vital in getting the best out of all players, and could be key in spotting and nurturing the next UK tennis star."

Myburgh also sees potential benefits in periodically matching players by maturity status, rather than age, in training and competition. This process, known as bio-banding, is currently being trialled by a number of Premier League football academies.

"Having early maturers occasionally train with and compete against players who are older but of similar maturity level stretches them as they can no longer rely on their physical advantages.

"It challenges them more and encourages the development of their tactical, technical and psychological skills. Bio-banding also provides late maturing players with more opportunity to use their skills and demonstrate their true potential. Of course, when implementing such strategies it is

equally important to consider psychological and technical development, as not all players will benefit from playing in an older or younger age group."

The team has recently published its research in the journal *Pediatric Exercise Science*.

The University of Bath's research team is also investigating using bio-banding techniques in other disciplines such as rugby, football and ballet.

## Your Smartwatch is Giving Away Your ATM PIN

<https://www.sciencedaily.com/releases/2016/07/160706131951.htm>

**Source: Sciencedaily/ Binghamton University**

Wearable devices can give away your passwords, according to new research.

In the paper "Friend or Foe?: Your Wearable Devices Reveal Your Personal PIN" scientists from the Stevens Institute of Technology and Binghamton University combined data from embedded sensors in wearable technologies, such as smartwatches and fitness trackers, along with a computer algorithm to crack private PINs and passwords with 80-percent accuracy on the first try and more than 90-percent accuracy after three tries.

Yan Wang, assistant professor of computer science within the Thomas J. Watson School of Engineering and Applied Science at Binghamton University is a co-author of the study along with the lead researcher, his advisor Yingying Chen, from the Stevens

Institute of Technology. There are three other students from Stevens Institute of Technology working on this project together. The group is collaborating on this and other mobile device-related security and privacy projects.

“Wearable devices can be exploited,” said Wang. “Attackers can reproduce the trajectories of the user’s hand then recover secret key entries to ATM cash machines, electronic door locks and keypad-controlled enterprise servers.”

“This was surprising, even to those of us already working in this area,” says the lead researcher Chen, a multiple time National Science Foundation (NSF) awardee. “It may be easier than we think for criminals to obtain secret information from our wearables by using the right techniques.”

With extensive real experiments, the team was able to record millimeter-level information of fine-grained hand movements from accelerometers, gyroscopes and magnetometers inside the wearable technologies regardless of a hand’s pose. Those measurements lead to distance and direction estimations between consecutive keystrokes, which the team’s “Backward PIN-sequence Inference Algorithm” used to break codes with alarming accuracy without context clues about the keypad.

According to the research team, this is the first technique that reveals personal PINs by exploiting information from wearable devices without the need for contextual information.

The findings are an early step in understanding security vulnerabilities of wearable devices. Even though wearable devices track health and medical activities,

their size and computing power doesn’t allow for robust security measures, which makes the data within more vulnerable to attack.

The team is working on countermeasures for the problem in the current research. An initial approach is to, “inject a certain type of noise to data so it cannot be used to derive fine-grained hand movements, while still being effective for fitness tracking purposes such as activity recognition or step counts.”

The team also suggests better encryption between the wearable device and the host operating system.

The paper was published in Proceedings of — and received the “Best Paper Award” — the 11th Association for Computing Machinery (ACM) Asia Conference on Computer and Communications Security (ASIACCS) in Xi’an China, (May, 2016)

## Local Consumption, Global Consequences: Examining Impacts of an Interconnected World

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<https://www.sciencedaily.com/releases/2016/07/160706131926.htm>

**Source: Sciencedaily/ Yale School of Forestry and Environmental Studies**

Everything, from the food we eat to the clothes we wear to cars we drive, has global implications, requiring resources from distant places and generating pollution far from our homes. But while these impacts have been known for a long time, our understanding of the complex ripple effect throughout the global economy and on natural and social systems remains rudimentary.

In a new special issue, "Linking Local Consumption and Global Impacts," Yale's *Journal of Industrial Ecology* examines the virtual shrinking of distances between places — arising because of trade, telecommunication and travel — and the widening gap between where products are made, where they're used, and where the impacts occur.

The articles link consumption and/or production activities to a wide range of environmental impacts, including water, energy and land use; various pollutants; and economic and social indicators, such as child labour, social costs of carbon, and loss of human life.

"The focus is on 'tele-connected systems,'" said Prof. Klaus Hubacek of the University of Maryland and lead guest editor for the special issue. "This is a concept from atmospheric sciences referring to climate phenomena being related to one another at large distances. Recently, this idea has been used to represent the strengthening of connectivity between distant locations and, at the same time, the growing physical separation between places of consumption and production."

### Highlights of the Issue

An assessment of the impacts of the 21st century Great Recession on income inequality and households' carbon footprint.

An examination of the global implications of China's future food demand.

Tracking of water footprints at the micro- and meso-scale through combining MRIO (multiregional input output analysis) and geographical information system (GIS).

An assessment of child labour's role in Indian production and global consumption.

A look at the unequal carbon exchanges of iconic US consumption items.

Discussion on the role of trade openness in the context of climate-change mitigation

An analysis of households' direct and indirect material, water, and land use requirements and GHG emissions.

Research that links a consumer expenditure survey to a global MRIO database to assess the carbon footprint for different household categories.

A global framework for reconciling top-down with bottom-up approaches for identifying and evaluating the effectiveness of different scenarios about the future.

"Much of the research in this special issue uses a technique called environmentally-extended multi-regional input-output analysis," said Reid Lifset, Editor in Chief of the *Journal of Industrial Ecology*. "This method, a hallmark of the field of industrial ecology, is especially well-suited for linking the local to the global because it allows tracing of supply chains and the attendant resource use and emissions within and across countries."

### Radiocarbon Dating Suggests Joint Cartilage Can't Renew

<https://www.sciencedaily.com/releases/2016/07/160706172034.htm>

**Source:** Sciencedaily/ American Association for the Advancement of Science

Using radiocarbon dating as a forensic tool, researchers have found that human cartilage rarely renews in adulthood, suggesting that

joint diseases may be harder to treat than previously thought.

The technique, which dates tissues by tracing radioactive carbon and measuring it against levels of carbon-14 in the atmosphere from the nuclear bomb testing in the 1950s and 1960s, reveals that cartilage is an essentially permanent tissue in healthy and osteoarthritic adults alike.

The findings may help explain the limited success of cartilage transplant and stem cell therapy for osteoarthritis, and may redirect treatment efforts to preventing cartilage disease and protecting joints from further damage. Whether cartilage, the tissue lining the surface of joints, regenerates or remains “fixed” throughout life is a subject of debate.

Less still is known about the effects of joint diseases on cartilage turnover.

Katja Heinemeier and colleagues turned to the bomb pulse method, which exploits the fact that all living things through their diet incorporate carbon-14 from the atmosphere.

During the Cold War, atmospheric levels of this carbon isotope spiked due to the testing of nuclear bombs, leaving a detectable imprint in all organisms living at the time. The technique has been used to estimate the age of fat, muscle, the eye lens, and other tissues.

Heinemeier, *et al.* now apply it to cartilage in knee joints from eight healthy and 15 osteoarthritic individuals born between 1935 and 1997. Across all individuals, the researchers detected virtually no formation of new collagen in cartilage, even in disease or under high loads, suggesting that the tissue is an essentially permanent structure.

The findings help explain why human cartilage has poor healing capacity after injury and present new challenges for treating osteoarthritis and other joint diseases.

## Rapid Test for Pathogens: Could Be Used to Detect Diseases Used by Bioterrorists

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<https://www.sciencedaily.com/releases/2008/08/080821164611.htm>

**Source: Sciencedaily/ Kansas State University**

At present, bacteria, fungi or viruses can generally only be detected with certainty by way of elaborate laboratory tests or animal experiments. The food and pharmaceutical industries would like to have faster tests to check their products. Fraunhofer researchers are therefore developing a stick that works like a pregnancy test and quickly delivers a result. In the future, it is also to be used for detecting allergens and disease pathogens in the blood.

Researchers at the Fraunhofer Institute for Interfacial Engineering and Biotechnology IGB in Stuttgart are developing a test which rapidly and cost-effectively identifies bacteria, fungi or viruses. It can be carried out directly in situ without laboratory equipment and specialist knowledge. “The ImmuStick can even detect pathogens outside the body — on medical devices or in hospital rooms for example. However, the technology would certainly also be of interest for testing human blood for germs or allergies,” says Dr Anke Burger-Kentischer.

### As Easy as a Pregnancy Test

The method works as simply as a pregnancy test. The ImmuStick is a test strip onto which

a few drops of fluid are applied. If the fluid contains pyrogens, fragments of pathogens, this is shown by a coloured strip in a viewing window. First of all, human immune receptors sensitive to certain pyrogens are applied to the surface of the stick. These are laboratory-produced immune receptors which are synthesised on the basis of the biological model. During production, at the docking point of the immune receptors to which the pyrogens normally bind, a type of placeholder is mounted which is marked with a dye. When drops of a fluid containing pyrogens are then applied to the test strip, the pyrogens rush to the docking point on the immune receptor. The placeholders marked with the dye migrate with the fluid through the test strip until they are visible in the viewing window. The colour signal thus indicates that pyrogens that have docked on the immune receptors are present.

The ImmuStick project was financed with money from the Discover program. In this way the Fraunhofer-Gesellschaft is supporting projects for the duration of one year in order to demonstrate the feasibility of a technology. The ImmuStick has passed this test. "We were able to show that it works very well for the bacterial pyrogen LPS. Together with industrial partners, we now want to develop it into a product," says project manager Burger-Kentischer. "We are currently testing further immune receptors that are specific for other pyrogens."

### **Detecting Blood Poisoning and Allergies**

Currently envisaged are applications in the food and pharmaceuticals sector or in medical technology, as a complete absence of germs or pyrogens is required there. In

principle, the ImmuStick would also be of interest for blood analysis. Pyrogens in the blood often lead to blood poisoning, sepsis, from which many people still die today, especially weakened intensive care patients. "However, blood is a special challenge as it is complex and contains many constituent parts. But in the medium term we are aiming at blood analysis," says Burger-Kentischer.

As pyrogens also include certain allergy trigger factors, an application here would also be conceivable. In the food and pharmaceutical industries, for example, it is important that products are free of allergens. With the ImmuStick these could be detected quickly, cost-effectively and simply. Costly and laborious laboratory tests would therefore no longer be needed or could be supplemented. At present the IGB researchers are seeking cooperation partners who want to further develop the ImmuStick to make it ready for the market.

Pyrogens become a problem when hygiene is of particular importance — in the food and pharmaceutical industries for example, or on intensive care wards in hospitals. Especially people with weakened immune systems can become severely ill. For this reason, tests are frequently carried out and the surfaces of machines or medical devices are tested for pyrogens using swabs. However, to date these tests have been costly and laborious as pyrogens can only be detected with laboratory equipment. A widely used standard test is the detection of LPS, a structure that is present in the membrane of certain bacteria. At present this test takes up around two hours. Other pyrogens can even only be detected in animal experiment.



## From Climate Killer to Fuels and Polymers

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<https://www.sciencedaily.com/releases/2016/07/160704083006.htm>

**Source:** Sciencedaily/ Ruhr-Universitaet-Bochum

Researchers have discovered a catalyst that performs highly selective conversion of the greenhouse gas carbon dioxide into ethylene — an important source material for the chemical industry. In the journal *Nature Communications*, a team headed by Prof Dr Beatriz Roldan Cuenya from Ruhr-Universität Bochum describes how plasma-treated copper can be used for this purpose.

Catalysts traditionally used for the electrochemical conversion of carbon dioxide into useful chemicals were not efficient enough. The reason: the materials do not have high selectivity; they produce a little ethylene and too many unwanted side products. This has now been changed.

### More Selectivity through Plasma Treatment

PhD student Hemma Mistry from the Institute for Experimental Physics IV in Bochum used copper films treated with oxygen or hydrogen plasmas as catalysts. Through these plasma treatments, she altered the properties of the copper surface, rendering it rougher or less rough, for example, and oxidizing the material. The researcher varied the plasma parameters systematically until she hit on the optimal surface properties.

Her best catalyst boasts a higher ethylene production rate than traditional copper catalysts. At the same time, it acts in a highly selective manner, which means that

the amount of unwanted side products is considerably reduced. "It's a new record for this material," concludes Beatriz Roldan Cuenya.

### Mechanism Decoded

The researchers also identified the reason why this form of plasma treatment has been successful. Using synchrotron radiation, they analysed the copper film's chemical state during the catalysis of the reaction. Through these measurements, they detected the cause of the higher ethylene selectivity. The key component was positively charged copper ions at the catalyst surface.

It had been assumed that copper can only exist in its metallic form under reaction conditions. The researchers' discovery has now disproved this assumption, and their findings were confirmed by additional microscopic analysis. "The results open up new possibilities for designing catalysts on the nanoscale with specific activity and selectivity," says Beatriz Roldan Cuenya.

## New Technology Could Deliver Drugs to Brain Injuries

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<https://www.sciencedaily.com/releases/2016/06/160628114832.htm>

**Source:** Sciencedaily/ Sanford Burnham Prebys Medical Discovery Institute

A new study led by scientists at the Sanford Burnham Prebys Medical Discovery Institute (SBP) describes a technology that could lead to new therapeutics for traumatic brain injuries. The discovery, published in *Nature Communications*, provides a means of homing drugs or nanoparticles to injured areas of the brain.



"We have found a peptide sequence of four amino acids, cysteine, alanine, glutamine, and lysine (CAQK), that recognizes injured brain tissue," said Erkki Ruoslahti, M.D., Ph.D., distinguished professor in SBP's NCI-Designated Cancer Center and senior author of the study. "This peptide could be used to deliver treatments that limit the extent of damage."

About 2.5 million people in the US sustain traumatic brain injuries each year, usually resulting from car crashes, falls, and violence. While the initial injury cannot be repaired, the damaging effects of breaking open brain cells and blood vessels that ensue over the following hours and days can be minimised.

"Current Interventions for acute brain injury are aimed at stabilising the patient by reducing intracranial pressure and maintaining blood flow, but there are no approved drugs to stop the cascade of events that cause secondary injury," said Aman Mann, Ph.D., postdoctoral researcher in Ruoslahti's lab and the study's co-first author, together with Pablo Scodeller, Ph.D.

More than one hundred compounds are currently in preclinical tests to lessen brain damage following injury. These candidate drugs block the events that cause secondary damage, including inflammation, high levels of free radicals, over-excitation of neurons, and signaling that leads to cell death.

"Our goal was to find an alternative to directly injecting therapeutics into the brain, which is invasive and can add complications," explained Ruoslahti. "Using this peptide to deliver drugs means they could be administered intravenously, but still reach the site of injury in sufficient quantities to have an effect."

The CAQK peptide binds to components of

the meshwork surrounding brain cells called chondroitin sulfate proteoglycans. Amounts of these large, sugar-decorated proteins increase following brain injury.

"Not only did we show that CAQK carries drug-sized molecules and nanoparticles to damaged areas in mouse models of acute brain injury, we also tested peptide binding to injured human brain samples and found the same selectivity," added Mann.

"This peptide could also be used to create tools to identify brain injuries, particularly mild ones, by attaching the peptide to materials that can be detected by medical imaging devices," Ruoslahti commented. "And, because the peptide can deliver nanoparticles that can be loaded with large molecules, it could enable enzyme or gene-silencing therapies."

This platform technology has been licensed by a startup company, AivoCode, which was recently awarded a Small Business Innovation Research (SBIR) grant from the National Science Foundation for further development and commercialisation.

Ruoslahti's team and their collaborators are currently testing the applications of these findings using animal models of other central nervous system (CNS) injuries such as spinal cord injury and multiple sclerosis.

## Researchers Identify Possible Link between the Environment and Puberty

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<https://www.sciencedaily.com/releases/2016/06/160628114122.htm>

**Source:** Sciencedaily/ University of Copenhagen The Faculty of Health and Medical Sciences

Danish researchers have discovered a feasible epigenetic network between the environment and pubertal timing. To a large measure, pubertal timing is genetic, but the underlying genetic causes are still unexplored. Researchers have now examined how chemical alterations of the human genome (so-called epigenetic alterations) change when girls and boys enter puberty. The results indicate that such epigenetic changes are involved in defining the onset of puberty.

Danish girls' pubertal onslaught has decreased from 11 to 10 years. Similar, but less pronounced, variations have been detected in boys. This has led researchers to investigate the involvement of genetics and recognize that genes are not alone in influencing a child's pubertal timing.

In this new investigation from EDMaRC at Rigshospitalet, Copenhagen, researchers therefore concentrate on the role of epigenetics and have found a number of regions in the human genome, which is controlled epigenetically during puberty. The researchers found that these epigenetic changes cause the upregulation of genes that are important for pubertal development. One of the newly discovered 'puberty genes' is TRIP6 (Thyroid Hormone Receptor Interactor 6), which is progressively disclosed through puberty, due to alterations in the epigenetic regulation of the gene.

Epigenetics is a dominant mechanism by which our environment communicates with our genes. Environmental and lifestyle factors in the broadest sense can influence the epigenetic regulation of genes and thereby control whether, where and to what extent the genes are expressed. The identified epigenetic alterations during puberty are therefore our best

lead towards understanding how environmental factors can influence pubertal onset.

"To our intelligence, this study is the first to determine how the environment can affect the pubertal onset in humans. It gives us a significant insight in to the crucial role of epigenetic factors on our reproductive development," says Professor Anders Juul, senior author of the study.

"We've seen a tendency of especially girls starting puberty earlier than before and this study emphasises the importance of understanding the role of environmental impact on pubertal development," he adds.

Highly precise changes in methylation of a child's DNA could discriminate children according to whether they had entered puberty or not and thus may be used to predict a child's pubertal phase.

"Changes in the DNA methylation patterns can be caused by many different factors. However, we could see very specific changes when children went through puberty, and have afterwards shown that this also leads to alterations in the expression of the methylated genes," says Senior Researcher in epigenetics Kristian Almstrup, who led the study.

## 2009 Swine Flu Pandemic Originated in Mexico, Researchers Discover

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<https://www.sciencedaily.com/releases/2016/06/160627160935.htm>

**Source:** ScienceDaily/The Mount Sinai Hospital / Mount Sinai School of Medicine

The 2009 swine H1N1 flu pandemic – main cause for more than 17,000 deaths worldwide

– firstly arises in pigs from a very small area in central Mexico, a research team headed by investigators at the Icahn School of Medicine at Mount Sinai is reporting.

The scientists add their findings, published in the special journal *eLife*, represent the first time that the cause of an influenza pandemic virus has been monitored in such detail.

Researchers used advance genetic investigation to search for the proper location and the main molecular transformations that allowed a pig influenza virus to transfer into humans. They establish that the virus responsible was a mix of one North American swine virus that had jumped between birds, humans, and pigs, and a second Eurasian swine virus, that circulated for more than 10 years in pigs in Mexico before jumping into humans. Previously, the most closely related ancestor viruses to the 2009 H1N1 virus were identified in Asian swine, but they were not as close genetically to the human 2009 pandemic H1N1 virus as the swine Mexican isolates found in this study.

The only other H1N1 pandemic flu known to date was the ‘Spanish flu’ of 1918 that killed between 50 and 100 million people — 3 to 5 per cent of the world’s population.

Influenza viruses infect up to 500 million people annually.

“Knowing where and how an animal influenza virus infects humans and spreads all over the world helps us understand how we can reduce risk of these pandemics,” says the study’s senior author, Adolfo García-Sastre, PhD, Director of the Global Health and Emerging Pathogens Institute, Irene and Dr Arthur M. Fishberg Chair and Professor of Medicine (Infectious Diseases), and Professor

of Microbiology at the Icahn School of Medicine at Mount Sinai.

Finding the actual location of the 2009 swine flu, known as an A/H1N1 pathogen, contribute a note of caution to evolving efforts to track problematic animal and bird viruses, Dr Garcia-Sastre says. “This virus came from, and was confined to, a very small geographic area and had been there 10 years before one emergent strain gained the capacity to infect humans,” he says. “The virus was completely under the radar.”

Dr Garcia-Sastre directs the Icahn School of Medicine’s Center for Research on Influenza Pathogenesis, one of five National Institutes of Health (NIH) Centers of Excellence for Influenza Research and Surveillance. In association with the NIH and Avi-Mex, a Mexican veterinarian company, he and his team obtained 58 perfect-genome arrangements from influenza A viruses collected in the Mexican pigs and found viral arrangements formally not known to survive in Mexico or in any other part of the world.

Flu viruses have eight mini chromosomes and when two distinct strains infect the same cell they can swap genetic segments — a process called reassortment. “All the pandemic flu viruses that we have tracked have had reassortments,” adds Dr. Garcia-Sastre.

The 2009 A/H1N1 was also a subordinate of two different strains of swine influenza — one that had been circulating in Europe and Asia and another that was circulating in the Americas, especially North America. “There is a lot of surveillance in North American pigs, and we know that this virus was actually a reassortment that occurred years ago between a bird (avian), human and a swine virus,” he says.

The 2009 swine virus was therefore a “quadruple” reassortment, Dr. Garcia-Sastre says.

They also discovered that the ancestor virus had been present in the pigs in central Mexico for at least 10 years before a strain was generated that could jump into humans, and that the parent strains still exist in the pigs there today. The findings make sense, he says, because the first human flu infections were seen in Mexico before the 2009 pandemic transmitted rapidly to the United States and then around the globe.

“Part of the complication in determining origin of pandemic influenzas is that the virus had been silent for so long,” he says. “This is accurate for all former pandemics. The actual precursors of the viruses are unsure — we know there are reassortments but which ones and where the reassortment took place has been unclear.”

By solving the origins and the reassortments that led to the 2009 A/H1N1 pandemic, researchers might be able to study existing “brothers and sisters” of the virus to understand the type of alterations needed to allow a virus to jump into humans.

Worldwide surveillance of active flu in pigs is vital because swines are a common global commodity, Dr Garcia-Sastre says. “We need to examine the viruses that are circulating, and try to stop combining influenza strains from different geographic locations,” he says. “This investigation also shows that you cannot overlook small geographic areas with pig farms — places in which the 2009 pandemic arose and which the next, perhaps more severe global flu, may come from.”

## Biologists Explain Function of Pentagone

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<https://www.sciencedaily.com/releases/2016/06/160628141235.htm>

**Source: ScienceDaily/ BLOSS - Centre for Biological Signalling Studies**

How do the cells in a human embryo know where they are located in the body and how they should develop? Why do certain cells form a finger while others do not? Freiburg biologists have explained the mechanisms that control these steps by showing why veins form at particular points in the wing of a fruit fly. The protein Pentagone spreads a particular signal in the wing that tells the cells how to behave. “The proteins Dpp and Pentagone, which are crucial for this developmental step in the organism *Drosophila melanogaster*, are also present in a similar form in humans,” says the Freiburg biologist Dr Giorgos Pyrowolakis. “The fundamental principles elucidated in this study are also active in humans, where they might control things like where cells form fingers.” Pyrowolakis and a team including Jennifer Gawlik, Dr. Mark Norman, Alexander Springhorn, and Robin Vuilleumier published their findings in the journal *eLife*. In the future, the results could contribute to our understanding of the origin of developmental disorders.

The protein Dpp is located in a cellular field in various concentrations. The cells located in the middle of the future wing produce Dpp. The protein spreads to the rest of the cells in the tissue, becoming less concentrated in the process. In mathematical terms, this

phenomenon is referred to as a concentration gradient. A cell activates different genes depending on where it is located in the gradient. Each cell develops as specified by the genes activated in it, and veins develop when certain thresholds have been reached. Hence, the gradient determines the distance between the veins of the fruit fly wing.

The cells located furthest from the Dpp source produce Pentagone. Without this protein, there would be no concentration gradient in the cell network and Dpp would be stuck at the point of its production. If the gene for Pentagone is switched off in fruit flies, the wings of the insects are smaller and the external vein is missing. "Pentagone causes Dpp to keep spreading," explains Pyrowolakis, "thus extending the distribution-range of the protein."

The Freiburg biologists elucidated the molecular mechanisms behind these processes in their study. Dpp binds to

receptors located on the surface of the cell in the future wing and initiates a signal cascade in the cell. The signal cascade activates different genes depending on how many receptors are bound by Dpp. Pentagone binds to a particular part of the receptors, the so-called co-receptors. They function like tentacles, 'grabbing' proteins and passing them on to the receptor. Pentagone causes the co-receptors to be pushed into the cell to be broken down. This reduces the amount of co-receptors that can bind and pass on Dpp on the cell, causing the receptors to be less active. The concentration gradient of Pentagone is opposite than that of Dpp. The closer a cell is located to the point where Pentagone is produced, the less Dpp it can bind. The amount of Pentagone is adjusted to match that of Dpp. "When the wing grows, the Dpp gradient also expands," says Pyrowolakis. "Pentagone regulates the gradient in a similar way a thermostat adjusts the temperature."

## 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.



- <https://www.howstuffworks.com>

HowStuffWorks creates great content that can live on just about any platform. This website is reliable, easy-to-understand answers and explanations of how the world actually works.

- <https://www.testmybrain.org/>

TestMyBrain aims to engage and collaborate with citizen scientists throughout the world by providing measurement tools that allow people to engage in science and learn about themselves.

- <https://kids.nationalgeographic.com>

Nat Geo Kids inspires young adventurers to explore the world through award-winning magazines, books, apps, games, toys, videos, events, and a website, and is the only kids brand with a world-class scientific organisation at its core.

- <http://www.makemegenius.com>

The purpose is to spread science education, to make it easier and to make it accessible to everybody. The site involves several science videos for kids, cool facts, educational power-points, jokes, see and learn science videos and most important Science Test, Quiz, Questions.

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<b>भारतीय आधुनिक शिक्षा (त्रैमासिक)</b> (Bhartiya Aadhunik Shiksha) A Quarterly Journal in Hindi	₹50.00	200.00
<b>Primary Teacher</b> A Quarterly Journal for Primary Teachers	₹65.00	260.00
<b>प्राथमिक शिक्षक (त्रैमासिक)</b> (Prathmik Shikshak) A Quarterly Journal in Hindi for Primary Teachers	₹65.00	260.00

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