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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 mathametics and their teaching, and serves as a useful forum for the exchange of readers' views and experiences in science and mathametics education and science projects.

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Contents

EDITORIAL

In the present issue of School Science we have included articles from various disciplines of science. You will get to read educative as well as research articles along with the regular features like 'Science News', 'Web Watch' and 'You have Asked'.

Three research articles have been included in this issue viz. "Effectiveness of Tree-Chart for Teaching Botany at Higher Secondary Level", "Impact of Microscale Laboratory Kit on Students' Achievement in Chemistry Practical" and "Is Teaching-Learning of Mole Concept Really Difficult?"

"Effectiveness of Tree-Chart for Teaching Botany at Higher Secondary Level" explains the effectiveness of tree chart for teaching of topics related to systematic botany. The researcher has experimented on two groups of students during which one group was taught via tree-chart method while for control group the same topic was taught without using a tree-chart. The study revealed that the tree-chart is an effective tool in teaching-learning process.

In the article entitled "Impact of Microscale Laboratory Kit on Students' Achievement in Chemistry Practical", the researchers have tried to examine the impact of microscale chemistry kit, developed by the Workshop Department of NCERT, New Delhi, on students and came out with a positive impact showing the students' improved practical skills in the laboratory.

"Is Teaching-Learning of Mole Concept Really Difficult?" is an interesting article, which suggests an activity that simplifies the teaching-learning process of mole concept, generally taken as a difficult topic to teach.

The article Acid-Base Homeostasis in Human, discusses about the proper equilibrium between acids and bases in human body i.e. balance of hydrogen ion concentration. The body is very sensitive to its pH level, so strong mechanisms exist to maintain it. This article gives an account of these mechanisms which protect the body against life threatening changes in hydrogen ion concentration viz. buffering system in body fluids, respiratory responses and renal responses. It also gives an account of acid-base disorder in brief.

"Motion in Two and Three Dimensions" is a physics curriculum based article. In this article the author has discussed some important aspects of motion in two and three dimensions under the headings such as vectors, frame of reference and co-ordinate systems. The author has also discussed the hard-spots the students face in these topics and their possible remedies. This article can prove to be a good teaching aid.

Pedagogical competency is the ability of a teacher to apply the attitude, knowledge and skills that promote the learning of the students. An article entitled "Assessing Pedagogical Competency of Science Teachers at Secondary Level" has also been included, where the authors have developed a tool to assess and map the pedagogical competency of science teachers based on five criteria having 36 indicators.

A review article "Assessment Concept and Strategies" is also added which discusses about assessment in day-to-day teaching and learning in the classroom with an example of assessment in Mathematics.

The article "Environment Friendly Cost Effective Aqueous Hydrogen Sulphide Reagent for Qualitative Analysis for Cations" describes the preparation of non-toxic aqueous hydrogen sulphide reagent which can be used in laboratories for identification of various cations in place of hydrogen sulphide gas. Various aspects of using aqueous hydrogen sulphide in place of hydrogen sulphide gas has also been discussed in this paper.

We sincerely hope that our readers would find the articles, features and news items interesting and educative. Your valuable suggestions, observations and comments are always a source of inspiration which guide us to bring further improvement in the quality of the journal.

EFFECTIVENESS OF TREE–CHART FOR TEACHING BOTANY AT HIGHER SECONDARY LEVEL

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The present research article explains the effectiveness of Tree–Chart for teaching Botany topics like plant classifications. In the present study, the researcher developed a Tree–Chart of Class-Dicotyledons, after giving specimens and pictures and thereafter collecting opinion from the students by adopting activity method. In the present study, the investigator adopted parallel group design. From the results obtained it was concluded that Tree Chart is an effective tool for teaching Botanical classifications at higher secondary level.

Introduction

One of the aims of learning Science is to cultivate the ability to apply what is learned to community situations (Kalra, 1976). Much of the schools, Science is not at all sciencing (Lansdown etal, 1971) to the pupil. Rather, Science is presented as a catalogue of facts to be memorised and subsequently regurgitated on the test sheets or the examination papers. This instructional strategy of Science teaching is contrary to the process of Science. Science is product and process, therefore ignoring the later reduces Science merely to the factual knowledge (Panchaury, 1979).

The new Science curriculum for Biology, Chemistry and Physics are organised around the learner with 'activity centeredness'. Ivowi (1979) observed that active student participation through experimentation and discussion with the teacher, playing the role of the teacher, is encouraged in the transaction of curriculum. The practical work in Science is based on certain process of Science. These processes help the students in sequencing their knowledge in their cognitive structure. The process includes observing, classifying, measuring, predicting, hypotheses making, hypotheses testing, drawing inferences, applying, computing and describing. Certain studies have reported that there has no successful integration of teaching aids into the curriculum (Roberts, 1974; Cartor, 1988; Ramana, 1995). It has been reported that teachers lack that right expertise in the construction of model and using teaching aids and do not make efforts to prepare for the classes. In this context, it is important to highlight research studies with flexible teaching styles by the teachers having high achievement scores. In the present study, the researcher had developed a tree chart of Class-Dicotyledons after giving specimens and collecting opinion from the students by adopting Activity Method for

Experimental group, and Control group was taught by Lecture Method.

Objectives of the study

1. To prepare a Tree–Chart for Botany for higher secondary school students
2. To test the effectiveness of Tree–Chart for teaching Botany at higher secondary school students by comparing the pre-test achievement scores of Experimental group with that of Control group, which is taught by the traditional Lecture Method.
3. To test the effectiveness of Tree–Chart for teaching Botany at higher secondary school students by comparing the post-test achievement scores of Experimental group with that of Control group, which is taught by the traditional Lecture Method.
4. To test whether there is any significant difference among the Tree–Chart group and Control group with regard to post-test achievement scores.
5. To test the effectiveness of Tree–Chart by comparing the post-test achievement scores of the Experimental group(sub-sample) based on the variables sex and locality.

Hypotheses

1. There will be a significant difference between the means of Experimental and Control groups with regard to pre-test achievement score.
2. There will be a significant difference between the means of Experimental and Control groups with regard to post-test achievement score.
3. There will be a significant difference between the means of in pre and post-test achievements scores of Experimental group.
4. There will be a significant difference between the means of in pre and post-test achievements scores of Control group.
5. There will be a significant difference between pre and post-test achievements of Experimental group with regard to the variables sex and locality.

Methodology

Tools

The following tools were used for the present study:

1. Tree Chart of Class-Dicotyledons.
2. Pre-test and post achievement test in Botany.

Sample

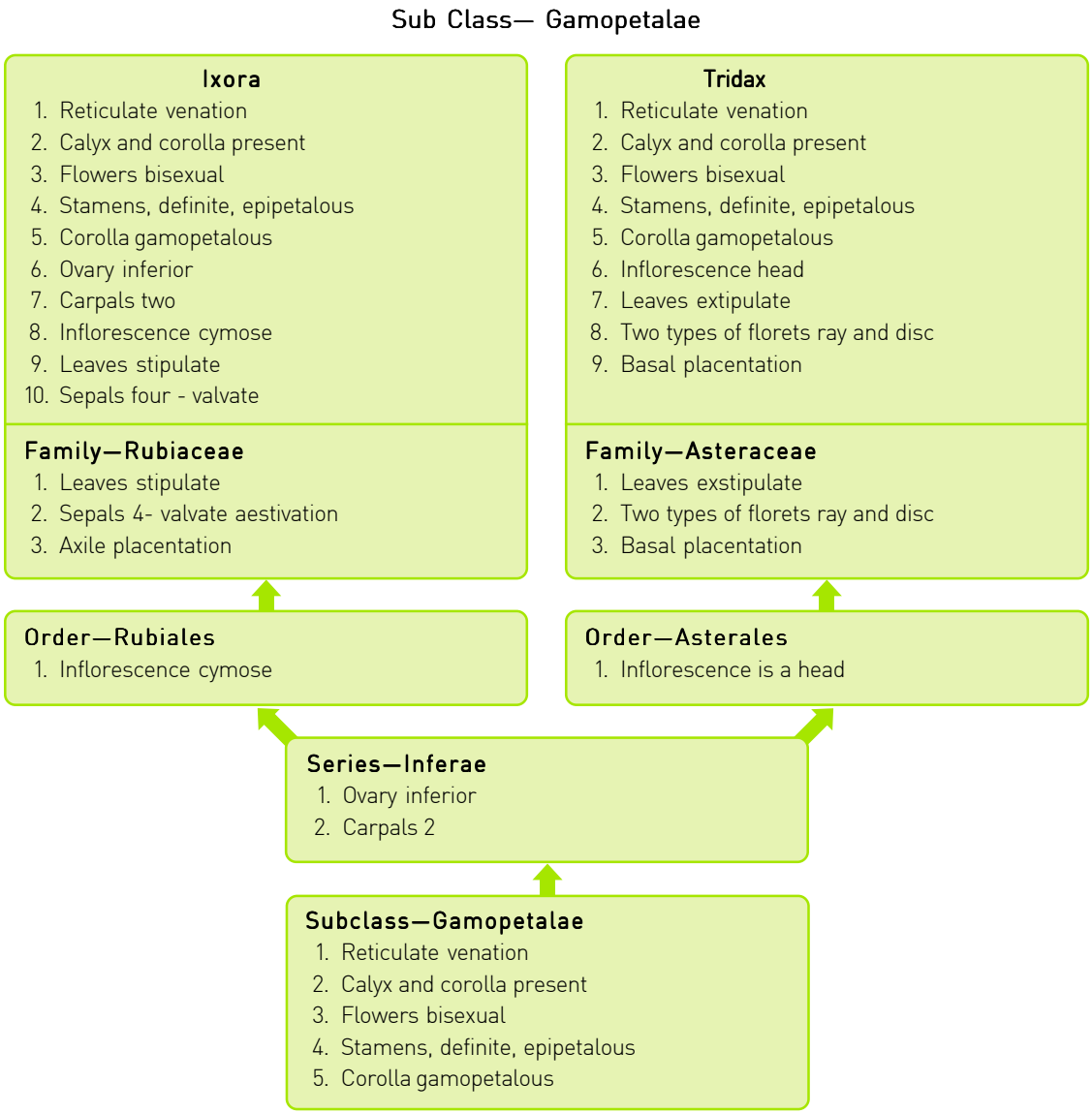
The sample selected for the study consists of 62 students of Class XII from a Government Higher Secondary School, Thiruvananthapuram (Kerala). The age of the students ranged from 16-18 years. The students were classified into two groups one as Control and other as Experimental.

Procedure of Study

For the present study, the investigator adopted parallel group design of experimental method. The investigator developed a Tree–Chart of Class-Dicotyledons after collecting opinion of students by giving plant specimens (Activity Method) for Experimental group and Control group was taught by Lecture method. The investigator conducts pre and post achievement test in Botany for measuring the entry and terminal behaviour of students.

Tool for the Present Study – Tree Chart of Class - Dicotyledons (Contain 3 Sub Classes Polypetalae, Gamopetalae, Monochlamedeae)

Sub Class — Polypetalae


Sub Class— Gamopetalae
Ixora
1. Reticulate venation
2. Calyx and corolla present
3. Flowers bisexual
4. Stamens, definite, epipetalous
5. Corolla gamopetalous
6. Ovary inferior
7. Carpals two
8. Inflorescence cymose
9. Leaves stipulate
10. Sepals four - valvate
Tridax
1. Reticulate venation
2. Calyx and corolla present
3. Flowers bisexual
4. Stamens, definite, epipetalous
5. Corolla gamopetalous
6. Inflorescence head
7. Leaves extipulate
8. Two types of florets ray and disc
9. Basal placentation
Family—Rubiaceae
1. Leaves stipulate
2. Sepals 4- valvate aestivation
3. Axile placentation
Family—Asteraceae
1. Leaves exstipulate
2. Two types of florets ray and disc
3. Basal placentation
Order—Rubiales
1. Inflorescence cymose
Order—Asterales
1. Inflorescence is a head
Series—Inferae
1. Ovary inferior
2. Carpals 2
Subclass—Gamopetalae
1. Reticulate venation
2. Calyx and corolla present
3. Flowers bisexual
4. Stamens, definite, epipetalous
5. Corolla gamopetalous

Sub Class—Monochlamedeae

Euphorbia

1. Reticulate venation
2. Flowers incomplete
3. Flowers unisexual
4. Petals absent
5. Plant contain milky latex
6. Inflorescence is a Cyathia
7. Male and female flower occur in same cyathia
8. Male flower contain single stamen
9. Tricarpellary, styles three stigma bifid
10. Axile placentation

Family—Euphorbiaceae

1. Plant contain milky latex
2. Inflorescence is a cyathia.
3. Male and female flowers occur in same cyathia
4. Male flower contains single Stamen.
5. Tricarpellary, styles three, stigma bifid
6. Axile placentation

Series—Unisex ales

1. Flowers incomplete
2. Flowers unisexual
3. Petal absent

Sub Class—Monochlamydeae

1. Reticulate venation
2. Flowers incomplete
3. Flowers unisexual
4. Petals absent

Analysis of the Study

Table: 1'

T-test between the mean scores of Experimental and Control groups in Pre-test achievement.

Group				Critical Ratio	Level of Significance
Experimental Group		Control Group			
Mean 1	Standard Deviation 1	Mean 2	Standard Deviation 2		
7.10	0.16	6.45	0.11	0.22	N.S.

The above Table-1 reveals that the obtained critical ratio is 0.22, which is found not significant. It indicates that there is no significant difference between Experimental and Control group for pre-test achievement scores, so the Hypothesis -1 is rejected.

Table : 2

T-test between the mean scores of Experimental and Control groups for Post-test achievement.

Group				Critical Ratio	Level of Significance
Experimental Group		Control Group			
Mean 1	Standard Deviation 1	Mean 2	Standard Deviation 2		
16.99	0.25	15.06	0.4	4.11	0.01

Table: 2 reveals that the obtained critical ratio is 4.11, which is significant at 0.01 level. It indicates that there is a significant difference between Experimental and Control group for post-test achievement scores, so the Hypothesis -2 is accepted.

Table:3

T-test between the means of in pre-test and post-test achievements scores of Experimental

Group				Critical Ratio	Level of Significance
Post-Test		Pre-Test			
Mean 1	Standard Deviation 1	Mean 2	Standard Deviation 2		
7.10	0.17	17.49	0.25	9.89	0.01

Group.

Table: 3 reveals that the obtained Critical ratio is 9.89, which is significant at 0.01 level. It indicates that there is a significant difference pre-test and post-test achievement scores of Experimental group, so the Hypothesis -3 is accepted.

Table:4

T-test between the means of in pre-test and post-test achievements scores of Control Group.

Group				Critical Ratio	Level of Significance
Post-Test		Pre-Test			
Mean 1	Standard Deviation 1	Mean 2	Standard Deviation 2		
6.55	0.12	14.07	0.4	7.78	0.01

Table: 4 reveals that the obtained Critical ratio is 7.78, which is significant at 0.01 level. It indicates that there is a significant difference between pre-test and post-test achievement scores of control group, so the Hypothesis -4 is accepted

Table: 5

Sex wise comparison of students on post-test achievement

Sex	Mean	Standard Deviation	Critical Ratio	Level of Significance
Male	18.99	0.50	1.83	N.S
Female	19.50	0.61		

Table: 6

Locality wise comparison of students on post-test achievement

Locality	Mean	Standard Deviation	Critical Ratio	Level of Significance
Rural	16.47	0.53	1.69	N.S
Urban	18.31	0.59		

Table: 5 and 6 reveals that the obtained 't' value is not significant. It indicates that the variable sex and locality have no influence on experimental study. So the Hypothesis -5 is rejected.

Results

1. Comparison of the mean scores of Experimental group and Control group with regards to pre-test achievement revealed that there is no significant difference with their achievements.
2. Comparison of the post-test achievement scores of Experimental group and Control group indicates that the two groups differ significantly in their achievement i.e., the present Tree–Chart is found suitable for teaching Botany at higher secondary level.
3. Comparison of the mean scores of Experimental group with regards to pre and post-test achievement revealed that there is significant difference with their achievement scores.
4. Analysis of the post –test achievement scores of Experimental group (sub sample) with regard to the variables sex and locality revealed that there is no impact on the variables viz., sex and locality on the achievement of the students.

Discussion and Conclusion

From this study, it is clear that Tree–Chart group is significantly superior to Control group with

regard to post-test achievement. Therefore, Tree–Chart can be used for teaching classifications of Botany. Darthy (1929) studied the relative effectiveness of model, chart and teacher's drawing as an aid to the teaching of Botanical structure in High School classes, and the result is similar to the present investigation. Thomson (1976) tested the effectiveness of Flow Chart; the study, revealed that there is the significant difference between the two groups. From the present study it is concluded that Tree–Chart is an effective tool for teaching Botanical plant classifications at higher secondary level and suitable programmes must be arranged to make the teachers aware of the preparation and use of Tree–Chart.

Educational Implications

Tree–Chart on Botany at higher secondary level serves as a repertoire of instructional approaches for teachers to the teaching learning environment in accordance with the predisposition of learners to achieve a variety of learning objectives. Instruction with the help of Tree–Chart makes the classroom as a joyful experience. The results of the present study might help the curriculum planners and policy makers of Kerala to modify their educational policies related to classroom instruction. The result might help the academicians and teachers to understand the effect of their method of instruction on the performances of the children. Therefore, these aspects are to be taken into consideration for designing curriculum in Science education.

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IMPACT OF MICROSCALE LABORATORY KIT ON STUDENTS' ACHIEVEMENT IN CHEMISTRY PRACTICAL

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Microscale Chemistry Laboratory Kit was designed and developed by the Workshop Department of NCERT for Senior Secondary level. An attempt has been made in this paper to examine the impact of working with Microscale Chemistry Kit on Students' achievement in Cognitive and Practical Skills. Using a sample of 172 students of senior secondary classes, it was seen that working with Microscale Chemistry Kit for one academic year helped students to improve their Chemistry Practical Skills but it did not seem to help the students in improving their Cognitive Skills related to Chemistry Practical. It was also observed that the achievement score in Practical Skills of students from tribal areas significantly differed from that of their counterparts from non-tribal areas. The experiences of students and post-graduate teachers and the implications of the present study for teachers and teacher educators are also discussed.

Keywords: Microscale, Microscale kit, Microscale technique, Microscale chemistry kit, Cognitive and Practical skills, Microscale kit and Students' Achievement

Introduction

Practical forms an integral and indispensable part of any science curriculum at senior secondary stage. This is more so in chemistry, as it is an experimental science. The present day conventional chemistry laboratory work suffers from certain disadvantages like wastage of chemicals, increased pollution in the lab, accidents due to fire and chemicals, financial constraints for purchase of chemicals and glassware, replacement of broken equipments etc. To overcome many of these problems, Microscale chemistry laboratory kit is an answer. The Microscale technique is being followed in many parts of the world. This new approach was pioneered by Mayo and Pike[1] for undergraduate practical Organic Chemistry course. Since then, many symposia[2] and conferences[3] have been held all over the world. Many articles have been published focusing on Microscale experiments in chemistry as the need of the millennium[4]. As a part of Microscale, many new ideas and techniques are suggested[5,6,7]. The Microscale laboratory technique is followed in many countries because of its numerous advantages.[8,9] Keeping in view its importance, the Workshop Department of NCERT has designed and developed a **Microscale Chemistry Laboratory Kit,** which enables the students to perform Chemistry experiments related to Senior Secondary classes in a pollution free environment

using small quantities of chemical substances without compromise on the quality of work. The NCERT has also published a Teacher's Handbook[10] which serves as a guide for teachers in using the kit. The new and innovative kit is administrator friendly as it greatly reduces expenditure on laboratory materials, lowers breakages and saves storage space. There are a total of 42 items in the kit and some of the highlights of the items of Microscale Chemistry kit include:

- A small portable wooden box with revolving top for easy access to chemicals and apparatus / equipment replacing big almirahs and racks.
- The solid reagents / chemicals stored in small plastic bottles and liquid reagents stored in polythene dispensing bottles (squeeze type). The liquid chemicals can be dispensed drop-wise thereby avoiding wastage and contamination.
- Fibre-glass transparent well-plate (micro–test plate) for fast and easy detection of anions / cations and organic functional groups.
- A novel W tube for fast gas absorption without leakage.
- Micro-burner which produces blue flame without much fuel consumption.
- Two micro-burettes (5ml capacity and least count 0.2 ml) for volumetric analysis.
- Micro test-tubes
- Micro titration flask
- Aluminum Heating block for heating test-tubes and for easy determination of boiling point and melting point.

The kit can be used for carrying out experiments from upper primary level to senior secondary level. Since the kit has gained popularity among many senior secondary schools, it was decided to conduct a study of the impact of Microscale Chemistry Kit developed by NCERT on students' achievement in Cognitive and Practical skills at senior secondary level.

Micro Scale Chemistry laboratory Kit (Wooden box with revolving top)

Kerosene burner

W-Tube

Micro filtration unit

Inside view of the Kit

Dispensing bottle

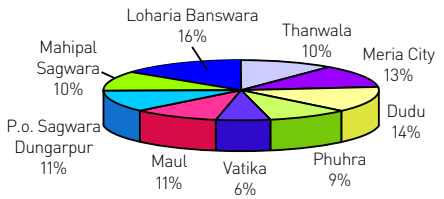
Micro test plate (Well plate)

Alumimium block

Method

The study was conducted on a sample of 172 students drawn from nine Government Senior Secondary Schools across different districts of Rajasthan state. The composition of sample and school location is given in Fig.1.

Composition of Sample



The selection of schools was made through purposive random sampling method. Out of a total of 172 students, 85 belonged to Experimental group and 87 were from the Control group. Out of nine government schools selected for the study, four schools were located in tribal areas of the state. The post-graduate teachers (PGTs) teaching chemistry subject in the selected schools were given five days intensive training in the use of Microscale Chemistry laboratory kit at Regional Institute of Education (NCERT), Ajmer. The experiments which were prescribed in the Rajasthan State Board Chemistry Syllabus for Classes XI and XII were carried out by teachers using the kit. After the training on the kit, two laboratory kits were donated to each school free of cost to enable the teachers to conduct regular chemistry practical in their own schools using the kit. A Control and Experimental group design was used in the study. The senior secondary students in each selected school were divided into an experimental group and a Control group. The distribution of students was done randomly so that the mean score at the entry level (based on board exam) was same in both. Both the Experimental and Control groups conducted the same laboratory exercises as per the prescribed syllabus and the practical classes were handled by the same teacher. The experimental group performed the regular chemistry practical throughout the academic year using the supplied Microscale Chemistry Lab Kits. The control group performed the practical by conventional methods using the infrastructure / equipment available in their chemistry laboratory. The syllabus of chemistry practical for senior secondary level includes the following:

1. Qualitative Inorganic Analysis (Identification of two anions and two cations without involving interfering radicals)
2. Quantitative Inorganic Analysis (Acid-base titrations, Permanganametry and Dichrometry)
3. Synthetic Chemistry (Preparation of iodoform, acetanilide, Mohr's salt and Potassium ferrocyanide)
4. Qualitative Organic Analysis (Identification of functional groups: alcohols, phenols, carboxylic acids, amides, aldehydes, ketones, nitro compounds, amines and carbohydrates)
5. Analysis of Food Materials: carbohydrates, fats and proteins.

A group consisting of one of the authors as a team member visited these schools to monitor the lab sessions of the Experimental and Control groups and finally carry out the evaluation of both the groups in the end. Both the groups were given, simultaneously, the same multiple choice type test and exercises related to practical demonstration of some simple experiments. The present study used both qualitative and quantitative methods to answer the research

question: How does the promotion of Microscale Chemistry experiments in regular practical classes affect the students' achievement in cognitive and practical skills? Qualitatively, the research question was addressed by conducting a survey and interviews of students and teachers. The data on the experiences of teachers and students during practical sessions was also collected. Quantitatively, statistical tests such as Mean, Standard Deviation, t-tests and one-way Analysis of Variance (ANOVA) were employed to measure the effect of working with Microscale Chemistry Kit on Students' achievement in cognitive and practical skills using data derived from a multiple choice test consisting of 15 items on content knowledge related to practical and another test consisting of five items related to demonstration of practical skills.

Results and Discussion

To study the effect of Microscale Chemistry experiments on students' achievement in cognitive skills related to chemistry practical, a multiple choice type questionnaire consisting of 15 items was designed and administered to both the groups at the end of practical session for the year. The maximum score possible for an individual is 15. The topics / areas focused in the questionnaire include:

- detection of carboxyl group
- chemical test for detecting carbon dioxide gas
- detection of unsaturation
- detection of S as Sulphide ion
- detection of halides
- test for phenol using ferric chloride
- calculations in titrimetry
- detection of carbohydrates
- Reduction of nitro group under acidic conditions
- detection of alcohols
- normality of C. sulphuric acid
- oxidation of chloride ion
- preparation of standard solution
- indicator in permanganametric titrations
- Iodoform test

The achievement score of all students school-wise and group-wise was recorded in a spreadsheet. For the null hypothesis it was postulated that no difference existed between the achievement scores in cognitive skills for the Experimental group and the Control group. A t-test was run to compare the mean achievement on the questions related to cognitive skills. Table 1 shows the Mean score and Standard Deviation, school-wise, for all the questions related to cognitive skills.

Table 1: Comparison of Experimental and Control Group Responses on Cognitive Skill

Sl No.	School Code	Student Achievement				t-value
		Experimental Group		Control Group		
		Mean	SD	Mean	SD	
1	A	5.87	1.72	7.44	1.06	2.31 **
2	B	8.69	1.84	5.30	1.70	4.51 *
3	C	4.91	1.97	4.75	1.71	0.22
4	D	6.0	1.92	5.25	1.83	0.79
5	E	5.25	2.12	3.66	1.15	1.2
6	F	4.62	2.87	5.18	1.77	0.52
7	G	9.44	1.87	10.2	2.04	0.83
8	H	10.0	0.57	9.09	1.70	1.35
9	I	7.08	2.39	5.61	1.93	1.69
10	**ALL**	**6.89**	**2.68**	**6.45**	**2.57**	**1.08**

* Significant at 0.01 level

** Significant at 0.05 level

The t-test for equality of Means indicated that the achievement scores of students belonging to only two schools coded A and B out of nine schools were significantly different for the two groups. In one school coded A, mean score of students in the control group was significantly higher than the mean score of students in the experimental group. The converse was true in the second school coded B. Whereas, in all other schools of the sample and all schools taken together (Sl. No. 10), the Mean score of students in experimental group did not differ significantly from that of Mean score of students in control group. Further analysis of the data showed that there is no significant difference in the mean scores between the Experimental and Control groups of non-tribal schools. Same was true for the groups belonging to schools located in tribal areas. These results are in favour of the proposed null hypothesis. A one way ANOVA was also used to test the null hypothesis and the results were identical. However, students of Experimental group belonging to schools located in tribal areas had significantly higher mean scores than their counterparts from non-tribal schools (t = 2.42, significant at 0.01 level).

The students were asked to demonstrate certain activities / experiments in practical and the scores were used to compare the effectiveness of working with lab kit on student achievement. The maximum possible score for each student was five. For the null hypothesis it was postulated that the mean achievement on practical skills scores were equal between the experimental and control groups. To test the hypothesis, students of both the groups were given five tasks related to demonstration of practical skills correctly in a given time. The tasks assigned were same for all the students and they need to be demonstrated individually. The tasks given to each student in both the groups include:

- Testing carboxyl group with bicarbonate and detecting CO_2 liberation with limewater
- Unsaturation test with bromine / permanganate
- Determination of Normality of given solution by titrimetry
- Detecting N element in the given organic compound
- Detection of carbohydrate by Molisch's test / detection of alcohol or phenol

The scores obtained by students were used to compare the effectiveness of working with Microscale Chemistry Lab Kit on student achievement in Practical skills. School-wise achievement of students belonging to experimental and control group in demonstrating practical skills is given in Table 2.

Table 2: Comparison of Experimental and Control Group Performance on Practical

Sl No.	School Code	Student's Achievement				t-value
		Experimental Group		Control Group		
		Mean	SD	Mean	SD	
1	A	4.75	0.46	2	1.22	5.96*
2	B	4.61	0.65	2.1	1.19	6.46*
3	C	3.08	0.79	0.91	.0.79	6.69*
4	D	4.37	0.74	3.12	0.99	2.85**
5	E	3.5	0.53	2.33	0.47	3.04**
6	F	4.62	0.51	2.81	0.6	7.00*
7	G	4.55	0.72	3.8	0.42	2.8**
8	H	4.57	0.53	2.63	0.67	6.75*
9	I	4.75	0.45	3.15	0.37	9.63*

** Significant at 0.01 level*

** Significant at 0.05 level

From Table 2 it appears that the scores of students on the practical test were significantly different for both the groups. Students in the Experimental group scored higher than students in control group on all the items of demonstration in each school. Majority of students in the Experimental group had a higher score because they could complete the given tasks correctly in a given time using improvised / innovative kit items like W tube, well plate, micro burettes for double titration etc. The null hypothesis is therefore, rejected. A one way ANOVA was also used to test the null hypothesis and the results were identical. School-wise comparison of the Experimental and Control group mean scores on practical skills is given in Fig. 2

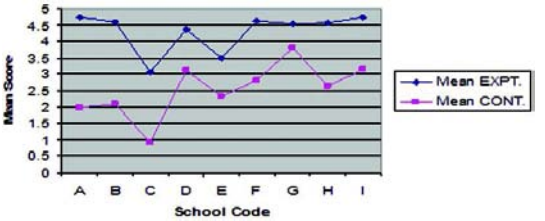


Fig. 2 : Comparision of Students' Mean Scores in Practical Skills

To test the null hypothesis:

(i) there is no effect of teaching methodology followed in practical class on students' achievement in Practical skills.

(ii) there is no effect of location of school on students' achievement in Practical skills.

(iii) there is no interaction effect of methodology used for conducting practical class and location of school on students' achievement in Practical skills.

A two factor ANOVA technique was used for data analysis and the results are summarised in Table 3.

Table 3 Summary of Two – Factor ANOVA

Source of variation	SS	df	MS	F	F crit
Sample (Practical Methodology)	126.56	1	126.56	141.34	3.90
Columns (School location)	27.56	1	27.56	30.78	3.90
Interaction	3.67	1	3.67	4.10	3.90
Within	125.36	140	0.89		
Total	283.15	143			

From Table 3, it can be seen that F values corresponding to Practical methodology and location of school are higher than the corresponding critical values (F crit) and hence it can be concluded that the methodology used in conducting the practical classes and the location of school have significant effect on the students' Mean score. The third source of variation viz., interaction – which is a joint effect of teaching methodology and location of school on students' achievement in practical skills – is also significant to some extent because the F value obtained is slightly higher than the critical value. The null hypothesis is, therefore, rejected.

The generation, collection and testing of gases by conventional methods generally involve certain issues like assembly of gas apparatus, consumption of more reagents than what is actually required, disposal of waste products and unconsumed reagents. W tube[11], popularly called "wonder tube", is an answer to these problems. Using W tube, one can complete the task in a very short time using small amounts of chemicals and least wastage.

Two micro burettes were used for volumetric estimations by double burette method. This

method did not involve the usage of pipette and so the errors committed by students due to wrong handling of pipettes were minimised. The well plate helped in easy detection of colour changes or precipitate formation even with solutions of fairly low concentration. In the control group many students could not complete the first two tasks successfully in the given time due to the leakage of gas to be absorbed. Some students of control group encountered problems while handling the pipette and as a result, exact volumes could not be transferred for titration. Table 4 summarises the Mean scores of Experimental and Control groups in cognitive and practical skills across social context.

- By using small amounts of chemicals, students could get good results and this has created more interest in practical.
- Microscale kit helped the students to learn the concept of minimising the quantity of chemicals for analysis.
- W tube was much useful in conducting tests like carbonate test, sulphite test, chromyl chloride test, etc.
- Precipitate formation could be easily detected using W tube and well plate.
- In volumetry by double burette method, students could get good results in a short time.

Table 4 Differences in the Mean Scores of Experimental and Control Groups in Cognitive and Practical Skills across Social Context

Group	Cognitive Skills					Practical Skills				
	Non-tribal		Tribal		t-value	Non-tribal		Tribal		t-value
	Mean	SD	Mean	SD		Mean	SD	Mean	SD	
Experimental	6.30	2.37	7.69	2.90	2.42*	4.04	0.93	4.63	0.54	3.43**
Control	5.47	1.87	7.37	2.81	3.68**	1.95	1.24	3.08	0.66	5.34**

* Significant at 0.05 level

** Significant at 0.01 level

The results show that the students studying in schools located in tribal areas had significantly higher mean scores as compared to their counterparts studying in non-tribal schools irrespective of the group in which they were placed.

An opinionnaire was administered to post-graduate teachers to get a feedback on the Microscale Chemistry lab kit. The analysis of responses given by teachers showed that students as well as teachers enjoyed using the kit. The responses received from the teachers are summarised below.

- Students' ability to analyse radicals and functional groups is enhanced.
- There is an improvement in the students' understanding of the basic concepts related to practical.
- Some of the items given in the kit are delicate and hence more care is required to handle them.
- Kit is saving space, time and chemicals.

All the teachers who were involved in the study felt that Microscale chemistry lab kits should be given to all the schools in the state especially to schools in rural areas where infrastructure facilities are poor.

The data on students' interview reveal a positive impact on the students. Some of the opinions repeatedly expressed by the students after working with microscale chemistry kit for one academic year are as follows:

- I enjoyed working with the kit.
- My working time on some experiments is reduced.
- I could repeat the experiment twice in a short time to verify my result.
- My cleaning time after the practical is reduced.
- Now I can work in the lab without fear of chemical spills and other hazards.
- I feel I am working in a safe and pollution free lab environment.
- I am getting quick and good results with microscale kit.
- Many of my friends from the control group are tempted to use the new kit.
- Microscale kit made our practical classes more interesting.
- It helped me to gain more confidence.

The results of the present study suggests that working with NCERT's Microscale Chemistry Laboratory Kit during the practical classes for one academic year helped the students to develop stronger practical skills. The analysis of the quantitative data indicates the enhancement of practical skills while the cognitive skills related to practical did not. In other words, the usage of Microscale kit regularly in the laboratory increased students' ability to demonstrate / perform experiments in the practical classes. This shows that practical skills were mastered better by the students, but not the content knowledge related to practical. Another interesting observation is that students who belonged to schools located in tribal areas have performed better than their counterparts from schools located in non-tribal areas as evidenced by statistically significant higher mean scores in cognitive and practical skills.

Implications

In view of the positive impact of microscale chemistry laboratory kit on students and teachers and also on the students' achievement especially in practical skills, one can conveniently and comfortably switch over to microscale kit from conventional methods. The factors like increasing cost of chemicals and glassware, and lack of availability of proper space for storage of materials and performing chemistry experiments in the lab are in favour of using Microscale kit as an alternative. To facilitate the effective use of kit by students, teachers need to be trained first on the kit as to how to use various components of the kit for conducting different experiments in chemistry as per the prescribed syllabus. Microscale chemistry kit will also facilitate the teacher to introduce the concept of 'Green Chemistry' to the students. Protection of Environment is one of the important issues and concerns of chemistry education. While working with the kit students should get a feel that they have reduced pollution in the laboratory and are

working in a safe environment and their health is protected. Teachers should utilise the opportunity to teach about safety measures in the laboratory and promote in students better cognitive and practical skills, creative thinking and awareness about environmental protection.

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IS TEACHING-LEARNING OF MOLE CONCEPT REALLY DIFFICULT?

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'Mole' concept is very simple, but it is generally the most feared and misunderstood concept. It is usually considered to be difficult to teach. In this article an attempt has been made to explore the answers to the following questions –

i) Why do teachers usually find teaching-learning of mole concept difficult?

ii) Why are teachers unable to design the activity for teaching the mole concept?

A common perception is that, since it is an abstract concept, it cannot be taught by activity based method. Therefore, making concrete to abstract link is not possible. This article provides suggestions to design activity to simplify the teaching-learning process of mole concept.

Introduction

National Council of Educational Research and Training (NCERT) conducts training programmes to develop master trainers so that improvement in teaching-learning process of Science and Mathematics can be brought about. These programmes are conducted with the hope that the master trainers will organise similar training programmes for the teachers belonging to their respective organisations and to the schools of nearby areas. In 2011-12 a need-based training programme in Science at Secondary Stage was planned. A questionnaire was developed to identify training needs and sent to different stake holders. Teachers identified some topics/ concepts which they felt were difficult to teach. One of these was *Mole Concept*. Feedback received from teachers showed that students do not easily understand the mole concept. However, this topic finds place in NCERT textbooks of secondary stage science[1] and higher secondary stage chemistry[2]. The mole concept is abstract and students find it difficult to learn; therefore, they develop a kind of fear for it. We think that, if proper transactional strategies are adopted, the problem can be solved to some extent. Therefore, teachers participating in the orientation programme conducted for Master Trainers in Science at Secondary Stage in 2012 were involved in the process. Written responses of the teachers on the transactional strategies that they usually follow to deliver the mole concept were collected. The collected responses of the teachers helped us to find out the reason for the difficulty arising in teaching- learning of the mole concept. To

solve the difficulty, teachers were assigned an activity related to the mole concept. They were given freedom to modify the activity if required.

Methodology

Before starting the discussion on transaction of mole concept, teachers were asked to write their responses about the following questions :

- What are the *key concepts* that should be dealt in the class to make the students understand the mole concept?
- What *previous knowledge* should students have before learning the mole concept?
- What *strategy* do you usually adopt for teaching the mole concept?
- Which *activity/activities* do you demonstrate in the class or ask the students to perform either individually or in groups during the teaching – learning process of mole concept?

The responses (in original) obtained from the teachers about the key concepts, previous knowledge and teaching strategies are tabulated in Table 1.

Table -1: Responses of Teachers about Key Concepts, Previous Knowledge and Teaching Strategies

S.No.	Key Concepts	Previous Knowledge	Teaching Strategy
1.	• What is a mole? • Why mole (terminology) is used? • How is mole related to Avogadro number? • How the value varies when the matter is taken in grams, moles and atom?	• Students are only aware of atoms, molecules, elements and compounds. • Students know that every element is made of their own type of atoms. • Students are also aware that atoms are very tiny particles and we cannot weigh them by either spring balance or physical balance, so some method is required to weigh the atoms.	**Activity** Examples of (A) No of bricks, (B) 1 dozen of Bananas (C) 1 kg Sugar Start with an activity that above things can be weighed but not the atoms so we need to know mole concept which is measurement for weighing the atom 1 mole = 6.023×10^{23} number then explain the concept.
2.	• Mole • Mole number • Molecular mass • No. of electrons, protons and neutrons in mole	• Students know small particles of substance. • Teachers give knowledge about mass of substance	Demonstration and lecture method. Teacher is teaching sub particles constituted by small particle atom. Mole of the sub particle prepared atomic mass of the substance or element e.g. H_2O - 1 mole Oxygen - 2 mole Hydrogen CO_2 - 1 mole Carbon - 2 mole Oxygen

3.	• What is mole? • Where we use the concept of mole in school in life. • Formulas to calculate (a) mole (b) number of particles in mole (c) weight in grams in mole. • Scientific importance of mole in chemistry laboratory	• How many articles are there in one dozen? • How many grams are there in one kg? • Knowledge about other S. I. units and their relation with other C.G.S. units	• To make them understand the concept of mole, first discuss the other SI units. • Some examples • Formulas • Numericals
4.	What is atom, proton?	Daltons Theory, previous structure of atom	• By drawing energy level shell of atom it can be compared with the solar system • Avogadro no of atom • Molecular mass-atomic mass • Mass and weight difference.
5.	Known to unknown : • Concept of atomic mass • Number atoms in one gram atomic weight is called one mole • Concept of gram atomic mass.	• Concept of unit • Unit of mass • Concept of one gram • Concept of atom • Concept of atomic mass • Concept of gram atomic mass • Number of atoms in gram atomic mass.	• Project method • Heuristic method
6.	• Mole concept— no. of moles present in an atom of an element/ compound/ ion • Avogadro number	Concept of atom, element, compound, ion	Heuristic method—from known to unknown
7.	• Definition • Inter-relationship between amount of matter (mole), mass of the substance • (molar mass), number of particles constituting that amount and mass of substance	Students know about different materials/substances.	• Provide an insight on mole concept by emphasising on important concepts on mole concept. • Demonstrate that substances appearing different in size and volume are of same mole through–theory, experiment

8.	• Mole a collection of 6.023×10^{23} particles of atom / molecules. • A mole of an atom =1 atom of that element = gram atomic mass = atomic number	Mole a collection of a) Atom, molecule b) Symbol of atom, formula of molecule c) Atomic number, atomic mass.	Mole = number of particles. I II III IV 4 Oranges 4Bananas 4Apples 4 Figs Number in all containers is same=4, but the item is different, its mass is different so 1 mole of O = 16u = 6.023×10^{23} O So 1 mole of O_2 = 6.023×10^{23} O_2
9.	• What is mole? • Avogadro number • What is n,N,m,M,N_0? • Formulas to solve problems • Why Avogadro number is called magic number?	• How to calculate atomic mass/molar mass? • What does the different symbols (n, N, m, M,N_0) mean?	• Blackboard work done by students while solving the problems. • Interaction
10.	Mole of any element means the amount of number elements present in 1 atomic weight in grams or molecular weight in gram is called mole. Previous knowledge required.	Students must know the molecular / atomic weight of few elements like for C=12, O = 16.	Suppose the atomic weight of O = 16 and molecular weight = 32 Therefore, 32g of O_2 = 1 mole of O_2.
11.	• Concept of mole as a number. • Relation between mole of an atom / molecule • Relation between the number and mass • Molar mass.	• Concept of atom and molecule. • Atomic and molecular mass.	• Clearing the concept of mole as a number (Avogadro number) • Using atomic structure models (kit) to clear that molecule has atoms in it. • Atomic mass – not measurable for practical purposes. • Concept of molar mass • Relation of Avogadro no with molar mass. • Numerical relations – Students try to derive the mathematical relations for each calculation
12.	• Mole concept • Number of atoms or molecules or ions in an element or compounds	• It is equal to number of atoms or molecules or ions present in an element or compounds	

	• Equivalent of Avogadro number i.e. 6.023×10^{23} atoms. • It is like measurement of other matter like 1 dozen =12, 1 gross = 144. • Number of atoms equivalent to C-12 (Carbon -12) molecule. • It is the unit for measurement of number of atoms / molecules present in an atom.	• It is used for the measurement of number of atoms with C-12 as standard unit for measurement.	
13.	—	—	• We know elements are made by group of atoms, but how many atoms grouped together. • During chemical reactions how many elements or molecules react to form how many element or molecules. • This know form mole concept – each element or molecules contain fix number of atoms or element or molecules known as mole constant $\text{No. of moles} = \frac{\text{Given mass}}{\text{Atomic mass (Molecular mass)}}$
14.	States of matter and examples	States of matter and examples	• Take the examples from children and divide with the help of children and explain the definition of different types of matter with arrangement of particles. • Definition of building blocks of particles: By using above concept we explain how the particle is formed with drawing figure • Atomic number: By using above concept we can explain with figure • Mass no: By using above concept we can explain with figure

			Mole: By using all above can give conclusion of the mole concept with definition.
15.	• Weight in grams – interconnection with mole. • Molar mass interconnection with mole. • Difference between weight in gram and molar mass.	Knowledge of using the balance	—

Expected Responses

Key Concepts

- Mole is the method of 'counting' items and finding the mass of items that cannot be seen.
- Analogy between mole concept and familiar counting units such as dozen, gross, rim, etc.
- Relationship between:
  (a) Mass of a Mole of an item and mass of single item.
  (b) Inter-conversion of mass of the substance into number of moles
- Application of mole concept to measure a given substance.

Previous Knowledge Required for Teaching Mole Concept

Before learning about mole concept students should have :

- knowledge of basic mathematics,
- understood concept of atomic mass, molecular mass, formula mass,
- knowledge about calculation of formula mass
- knowledge of using the chemical balance.

Table-1 indicates that most of the teachers are not clear about the relationships that need to be developed while teaching mole concept. Discussion on the methodology reported by them (Table-1) also shows that they are not focusing on child-centred method of teaching-learning process. In general, they use chalk and talk method only. Almost all of them are neither performing any activity nor are they motivating the child to perform any activity. To motivate the teachers to use child-centred method of teaching and to suggest strategies for removing the difficulty they face in teaching the mole concept, teachers were asked to carry out the following activity.

Activity

Teachers were advised to work in groups, in order to give them feel of collaborative learning which also leads to learning of time management.

Three packets of different types of seeds were provided to them – Green gram (*Moong dal*), Kidney beans (*Rajma*), Gram(*Channa*). The activity was performed in the following steps.

Step-1: Each group was asked to choose the packet of seeds of their own choice.

Step -2: Groups were told to look for the new unit^3 for counting the seeds in the packet. They discussed and decided to make the unit of eight

items. The new unit was given the name 'ASHTAK'. The word ASHTAK means eight in Hindi, which is appropriate for eight items. This means if we have a packet of one ASHTAK pencils, the packet will have eight pencils. To make them more familiar with the new unit 'ASHTAK', they were given following exercise to solve.

Exercise

1. Two ASHTAK of pencils will have _____ pencils.

   (Answer – 16 pencils)

2. Three ASHTAK of pencils will have _____ pencils

   (Answer – 24 pencils)

3. One ASHTAK of water molecules means _____ molecules.

   (Answer – 8 water molecules)

4. One ASHTAK of particles means _____ particles.

   (Answer – 8 particles)

5. One and a half ASHTAK particles means _____ particles.

   (Answer – 12 particles)

6. One ASHTAK of sodium atoms means _____ atoms.

   (Answer – 8 sodium atoms)

7. Six ASHTAKS of sodium atoms have _____ sodium atoms.

   (Answer – 48 sodium atoms)

8. Two and a half ASHTAKS of sodium atoms have _____ atoms.

   (Answer – 20 sodium atoms)

9. One ASHTAK of formula units of a salt has _____ formula units.

   (Answer – 8 formula units)

10. One fourth ASHTAK of formula units of a salt has _____ formula units of a salt.

    (Answer – 2 formula units)

11. How many molecules are present in 800 ASHTAKS?

    (Answer – 6400 molecules)

12. How many formula units are present in 600 ASHTAKS?

    (Answer – 4800 formula units)

13. How many oxygen molecules are present in 0.5 ASHTAK?

    (Answer – 4 molecules)

14. How many chlorine atoms are present in 0.25 ASHTAK molecules of chlorine?

    (Answer – 4 atoms)

16. 64 atoms of chlorine are equal to how many ASHTAK molecules?

    (Answer – 4 ASHTAK molecules)

Through this exercise it was emphasised that we are proceeding towards the counting of the number of particles which we are unable to see. It was highlighted that since one cannot see eight water molecules, sodium atoms or chlorine molecules etc. with the naked eye, therefore, scientists use bigger unit for counting the small

particles like atoms, molecules and ions etc. so that one can see the bulk of these small particles. This unit is named as **mole. It contains 602,200,000,000,000,000,000,000 particles or 6.022 × 10 ^{23} particles.** This number is called Avogadro number. In other words we can say- 'one mole contains Avogadro number of particles'.

Step-3: Each group was asked to fill Table-2 by weighing the required number of seeds.

Table 2 : Name of the seed

S. No.	Number of seeds	Mass of seeds	Mass of one seed
1.	Eight (one ASHTAK)		
2.	16 (two ASHTAK)		
3.	Any number of seeds picked up without counting (Random Number)		

Step -4: The teachers were asked to count the number of seeds picked up randomly (S.No.3, Table 2) and find out how many ASHTAKS it contains. They were asked to find out the mass of one seed and complete the Table 2. Once the activity was over, they were asked to answer the following questions.

1. Do you find any relationship between mass of one ASHTAK and two ASHTAK?
2. Do you find any relationship between the mass of one ASHTAK and the number of ASHTAKS in random sample?
3. Is there any similarity in the mass of one seed obtained from each observation of Table 2?
4. Compare your results with the results of other groups having the same seeds.
5. Is the activity useful for explaining the relationships-
   (a) Mass of a Mole of an item and Mass of single item
   (b) Inter-conversion of mass of the substance into Number of Moles

Table 3 (Group-1) : Observations and Data submitted by groups

S. No.	Name of the seed	Number of seeds	Total Mass of seeds/g	Mass of one seed/g
1.	*Moong Dal* (Green Gram)	8	0.2984	0.0373
		16	0.5553	0.0347
		Randomly picked number (62)*	2.2205	0.0358
2.	*Rajma Seed* (Kidney Bean)	8	2.5892	0.3237
		16	5.1237	0.3202
		Randomly picked number (19)*	5.7603	0.3032
3.	*Chana Seed* (Gram)	8	5.0576	0.6322
		16	8.4990	0.5312
		Randomly picked number (21)*	11.5135	0.5483

* Number in the brackets shows actual count of seeds in the random sample

Table 4 (of Group-2)

Group-2 worked with only *Channa* seeds

S. No.	Name of the seed	Number of seeds	Total Mass of seeds/g	Mass of one seed/g
1.	*Chana Seed*	8	4.8260	0.6032
		16	10.2045	0.6378
		24	12.9245	0.5385
		Randomly picking (21)*	13.1790	0.6278

* Number in the brackets shows actual count in the random sample

Explanations Given by Teachers Using Data Tables- 3 and 4:

1. Mass of one seed calculated from the mass of one ASHTAK seeds, two ASHTAK seeds of same kind etc. is approximately same since mass of seeds of the sample is approximately same.
2. Mass of different kind of seeds is different therefore, mass of one ASHTAK of different kind of seeds differs.
3. Mass of a mole of substance depends on the abundance of different isotopes present in the sample.

It can be seen from the Tables-3 and 4 of Group-1 and 2 respectively that mass of one seed calculated from the mass of one ASHTAK, two ASHTAK etc. is very close but not the same. Teachers highlighted that mass of all seeds in the sample of same kind of seeds may not be same; therefore, there may be slight difference in the mass of one ASHTAK of seeds. Teachers could also explain that slight difference in the calculated mass of one seed may be observed because all the seeds in an ASHTAK may not have same mass. Similarly, mass of a mole may differ depending upon the abundance of heavy or lighter isotopes present in the sample. Mass of one mole of a substance depends on the abundance of different isotopes of atoms present in the sample.

(4) Relationship between Mass of a Mole of an item and Mass of single item.

Number of seeds in the given mass of seeds can be calculated by dividing the given mass of the seeds by average mass of one seed as follows;

(*Only close readings were used for calculating the average mass of one seed in all cases)

Calculations from Table 3 (Data of Group-1)

Average mass of one *Moong Dal* seed

$$= \frac{0.0373 + 0.0347 + 0.0358}{3} = 0.0359$$

Average mass of one *Rajma* seed

$$= \frac{0.3237 + 0.3202}{2} = 0.3219$$

Average mass of one *Channa* seed

$$= \frac{0.5312 + 0.5483}{2} = 0.5398$$

Calculation of number of seeds in randomly picked up sample from the total mass of sample

Number of seeds in randomly picked up *Moong Dal* $= \frac{2.2205}{0.0359} = 62.02514$ (Actual count 62)

Number of seeds in randomly picked up *Rajma* seeds $= \frac{5.7603}{0.3219} = 18.99835$ (Actual count 19)

Number of seeds in randomly picked up *Channa* seeds $= \frac{11.5135}{0.5483} = 20.99854$ (Actual count 21)

Calculations from Table 4 (Data of Group-2)

Average mass of one channa seed

$$= \frac{0.6032 + 0.6378 + 0.6278}{3} = 0.6229$$

Number of seeds in randomly picked up *Channa* seeds $= \frac{13.1790}{0.6278} = 20.99235$ (Actual count 21)

Now, it can be explained very easily that if we know the mass of a substance we can calculate the number of atoms present in the sample by dividing the given mass by the average mass of single atom.

4. Inter-conversion of mass of the substance and number of Moles

Mass of two ASHTAK seeds of same kind is approximately double the mass of one ASHTAK seeds of that kind as can be seen from the following calculations.

Calculations from Table-3 (Data of Group-1)

$$\frac{\text{Mass of two Ashtak } \textit{Moong Dal}}{\text{Mass of one Ashtak } \textit{Moong Dal}} = \frac{0.5553}{0.2984} = 1.8609$$

$$\frac{\text{Mass of two Ashtak } \textit{Rajma Seed}}{\text{Mass of one Ashtak } \textit{Rajma Seed}} = \frac{5.1237}{2.5892} = 1.9789$$

$$\frac{\text{Mass of two Ashtak } \textit{Channa Seed}}{\text{Mass of one Ashtak } \textit{Channa Seed}} = \frac{8.4990}{5.0576} = 1.6804$$

Calculations from Table 4 (Data of Group-2)

$$\frac{\text{Mass of two Ashtak } \textit{Channa Seeds}}{\text{Mass of one Ashtak } \textit{Channa Seeds}} = \frac{10.2045}{4.8260} = 2.1145$$

$$\frac{\text{Mass of three Ashtak } \textit{Channa Seeds}}{\text{Mass of one Ashtak } \textit{Channa Seeds}} = \frac{12.9245}{4.8260} = 2.6780$$

Therefore, we can find the number of moles in a sample of substance by dividing the total mass of that sample by mass of one mole of that substance. As can be seen from the following calculations, we can calculate the number of ASHTAKS in the randomly picked up seeds by dividing the mass of the seeds by mass of one ASHTAK of seeds and compare it with the actual number of ASHTAKS in the randomly picked up sample.

Calculations from Table 3 (Data of Group-1)

$$\frac{\text{Mass of randomly picked up } \textit{Moong Dal seeds}}{\text{Mass of one Ashtak } \textit{Moong Dal seeds}} = \frac{2.2205}{0.2984} = 7.43$$

Actual value of ASHTAKS $= \frac{62 \text{ seeds}}{8 \text{ seeds}} = 7.75$

$$\frac{\text{Mass of randomly picked up } \textit{Rajma seeds}}{\text{Mass of one Ashtak } \textit{Rajma seeds}}$$

$$= \frac{5.7603}{2.5892} = 2.2247$$

$$\text{Actual value of ASHTAKS} = \frac{19 \text{ seeds}}{8 \text{ seeds}} = 2.38$$

$$\frac{\text{Mass of randomly picked up } \textit{Channa seeds}}{\text{Mass of one Ashtak } \textit{Channa seeds}}$$

$$= \frac{11.5135}{5.0576} = 2.2784$$

$$\text{Actual value of ASHTAKS} = \frac{21 \text{ seeds}}{8 \text{ seeds}} = 2.63$$

Calculations from Table 4 (Data of Group-2)

$$\frac{\text{Mass of randomly picked up } \textit{Channa seeds}}{\text{Mass of one Ashtak } \textit{Channa seeds}}$$

$$= \frac{13.1790}{4.8260} = 2.7308$$

$$\text{Actual value of ASHTAKS} = \frac{21 \text{ seeds}}{8 \text{ seeds}} = 2.63$$

- Teachers reported that they were not aware of any such activity and responded that they would like to use such activities in their teaching-learning process.
- They suggested that average mass of several single seeds of same kind can be compared with the mass of one seed calculated from the mass of an ASHTAK of seeds.
- They found that the activity is very useful for explaining the mole-mass and item- mass relationship and they could explain that, how mass could be converted into mole and mole number could be converted into mass.
- They could explain that, mass of one mole of a substance depends on the types of isotopes of the substance present in the sample.

Using mass of one seed, they explained that mass of all seeds in the sample of same kind of seeds may not be same, therefore, there may be slight difference in the mass of one ASHTAK of seeds. Similarly, mass of a mole may differ depending upon the abundance of heavy or lighter isotopes present in the sample.

Same activity was tried with another group of 24 teachers. This time four kinds of seeds were taken for the activity. Again similar results were obtained. Data obtained by different groups for different seeds are given in Tables 5, 6, 7 and 8

Table 5 : Name of seed: *Moong dal* (Green Gram)

Group Number	Average mass of one seed	Mass of random sample	Calculated number of seeds in random sample	Actual number of seeds in the sample
1.	0.0416	0.8736	21.0	21
2.	0.0417	1.5430	37.0	37
3.	0.0431	2.2976	53.3	54
4.	0.0456	1.3413	29.4	31

Table 6 : Name of seed: *Channa* (Gram)

Group Number	Average mass of one seed	Mass of random sample	Calculated number of seeds in random sample	Actual number of seeds in the sample
1.	0.5954	11.9978	20.20	20
2.	0.5560	11.4816	20.70	20
3.	0.5536	11.5047	20.80	20
4.	0.6127	9.1769	14.97	15

Table 7 : Name of seed: *Rajma* (Kidney bean)

Group Number	Average mass of one seed	Mass of random sample	Calculated number of seeds in random sample	Actual number of seeds in the sample
1.	0.3186	7.3322	23.01	24
2.	0.3199	3.4286	10.70	11
3.	0.3223	6.9991	21.70	22

Table 8 : Name of seed: *Urad Dal* (Black lentils)

Group Number	Average mass of one seed	Mass of random sample	Calculated number of seeds in random sample	Actual number of seeds in the sample
1.	0.0505	1.8408	45.60	41
2.	0.0438	2.3172	52.90	53
3.	0.0469	2.4378	51.97	52

CONCLUSION:

We worked with a very small group of teachers. Hence, any kind of generalisation is not possible, but one can surely conclude that teachers find difficulty in recognising the key concepts and the essential previous knowledge required by the students to understand the mole concept. This may be the cause of the difficulty in learning of mole concept by students. Therefore, in order to find out the cause of difficulty arising in teaching-learning of some topics, it is important to carry out some kind of research for finding out the capability of teachers in recognising the key concepts. It is also important to know how far teachers need training for understanding and using the child-centred strategies for teaching–learning process. This paper also highlights how understanding of a difficult topic can be simplified by activity based teaching–learning process, which is one of the concerns of National Curriculum Framework – 2005[4]

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ACID-BASE HOMEOSTASIS IN HUMAN

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Introduction

Organism can be defined as a physical-chemical system that exists in the environment in a steady state. It is this ability of living systems to maintain steady state in an ever-changing environment that determines their survival. To ensure a steady state in all organisms – from morphologically most simple to the most complex – to elaborate a variety of anatomical, physiological and behavioural adaptations that serve one purpose – the preservation of the constancy of internal environment. This relative constancy of the dynamic internal environment (blood, lymph, tissue fluid) and the stability of the basic physiological functions (circulation, respiration, thermoregulation, metabolism, etc.) of the human and animal is called homeostasis.

What is pH?

Many chemical reactions are affected by the acidity of the solution in which they occur. In order for a particular reaction to occur or to occur at an appropriate rate, the pH of the reaction medium must be controlled. The term pH represents the negative logarithm of the hydrogen ion (H^+) concentration, and reflects acidity and alkalinity. The "p" stands for potential and "H" stands for Hydrogen-the potential of the solution to attract hydrogen ions. Body pH refers to the pH of the fluids inside and outside of the cells. Since most of the body is water-based, the pH level has profound effects on all body chemistry, health and disease. All biochemical reactions are influenced by the pH of their fluid environment as all functional proteins (enzymes, hemoglobin, cytochromes and others) because of their abundant hydrogen bonds are influenced by H^+ concentration. The normal pH of arterial blood is 7.4, that of venous blood and interstitial fluid (IF) is 7.35, and that of intracellular fluid (ICF) averages 7.0. The lower pH in cells and venous blood reflects their greater amounts of acidic metabolites and CO_2, which combines with water to form H_2CO_3. Whenever the pH of the arterial blood rises above 7.45, a person is said to have alkalosis or alkalemia. A drop in arterial pH to below 7.35 results in acidosis or acidemia. Because pH 7.0 is neutral, chemically speaking 7.35 is not acidic. However, it is a higher-than-optimal H^+ concentration for most cells, so any

arterial pH between 7.35 and 7.0 is called physiological acidosis.

Sources of Hydrogen Ions in the Body

Ingested foods carry small amounts of acidic substances into the body but most hydrogen ions originate as metabolic by-products or end-products. For example, (a) breakdown of phosphorous containing proteins releases phosphoric acid into the extracellular fluid (ECF), (b) anaerobic respiration of glucose produces lactic acid, (c) fat metabolism yields other organic acids, such as fatty acids and ketone bodies, and (d) the loading and transport of CO_2 in the blood as HCO_3^- liberates hydrogen ions (H^+). In the stomach, the HCl produced is a source of H^+ that must be buffered if digestion is to occur normally in the small intestine.

Defenses Against Changes in H^+ Concentration

In a healthy person, several mechanisms help maintain the pH of systemic arterial blood between 7.35 and 7.45. Because metabolic reactions often produce a huge excess of H^+, the lack of any mechanism for the disposal of H^+ would cause H^+ level in the body fluids to rise quickly to a lethal level. Homeostasis of H^+ concentration within a narrow range is thus essential to survival. There are three primary systems that regulate sequentially the H^+ concentration in the body fluids to prevent acidosis or alkalosis:

1. ***Buffer systems***: Chemical buffers act within a fraction of a second which immediately combine with acid or base to prevent excessive changes in H^+ concentration and are the first line of defense.
2. ***The respiratory centre***: By increasing the rate and depth of breathing, more CO_2 can be exhaled. Within minutes this reduces the level of H_2CO_3 in blood, which raises the blood pH (reduces blood H^+ level). This forms the second line of defense.
3. ***Renal mechanism***: The kidneys are the third line of defense, which can excrete either acidic or alkaline urine, thereby readjusting the extracellular fluid H^+ concentration toward normal during acidosis.

A. Buffer systems of acid-base homeostasis

Acids are molecules containing hydrogen atoms that can release H^+ in solutions i.e., acids are proton donors. A strong acid is one that rapidly dissociates and releases especially large amounts of H^+ in solution (eg. HCl). Weak acids have fewer tendencies to dissociate their ions and, therefore, release H^+ with less vigour (eg. H_2CO_3).

A ***base*** is an ion or molecule that can accept an H^+ i.e., proton acceptors. A strong base is one that reacts rapidly and strongly with H^+ and therefore, quickly removes these from a solution. Conversely, weak bases are slower to accept protons.

A ***buffer*** is any substance that can reversibly bind H^+. Most buffer systems in the body consist of a weak acid and the salt of that acid, which function as a weak base. Buffers prevent rapid, drastic changes in the pH of body fluids by converting strong acids and bases into weak acids and weak bases within fraction of a second. They do this by binding to H^+ whenever the pH drops and releasing them when pH rises. The principal

buffer systems of the body fluids are the bicarbonate buffer system, phosphate buffer system and protein buffer system.

Bicarbonate Buffer System

It works in the blood, lymph, tissue fluids, and kidneys. Bicarbonate ions are generated in the red blood cells from carbon dioxide (CO_2) and diffuse into the plasma to act as an alkaline reserve against hydrogen ions. The carbonic acid-bicarbonate buffer system is a mixture of carbonic acid (H_2CO_3) and its salt, sodium bicarbonate ($NaHCO_3$) in the same solution. H_2CO_3 act as a weak acid is formed in the body by the reaction of CO_2 with H_2O.

$$Co_2 + H_2o \xrightleftharpoons{\text{Carbonic anhydrase}} H_2Co_3$$

H_2CO_3 ionizes weakly to form small amounts of H^+ and HCO_3^-.

$$H_2CO_3 \rightleftharpoons H^+ + HCO_3^-$$

The second component of the system, bicarbonate salt, act as a weak base, occurs predominantly as $NaHCO_3$ in the ECF. $NaHCO_3$ ionizes almost completely to form HCO_3^- and Na^+, as follows:

$$NaHCO_3 \rightleftharpoons Na^+ + HCO_3^-$$

Carbonic acid, a weak acid, does not dissociate to any great extent in neutral or acidic solutions. When a strong acid such as HCl is added to the bicarbonate buffer system, most of the existing carbonic acid remains intact. However, the bicarbonate ions of the salt act as weak bases to tie up the H^+ released by stronger acid (HCl), forming more H_2CO_3:

$$\underset{\text{Strong acid}}{HCL} + \underset{\text{Weak base}}{NaHCO_3} \longrightarrow \underset{\text{Weak acid}}{H_2CO_3} + \underset{\text{Salt}}{Nacl}$$

As HCl is converted to the weak acid H_2CO_3, it lowers the pH of the solution only slightly.

When a strong base, such as sodium hydroxide (NaOH), is added to the bicarbonate buffer solution, a weak base such as $NaHCO_3$ does not dissociate under the alkaline conditions and so does not contribute to the rise in pH. However, the added base forces the carbonic acid to dissociate further donating more H^+ to tie up the OH^- released by a strong base:

$$\underset{\text{Strong base}}{NaOH} + \underset{\text{Weak acid}}{H_2CO_3} \longrightarrow \underset{\text{Weak base}}{NaHCO_3} + \underset{\text{Water}}{H_2O}$$

Thus, the strong base (NaOH) is replaced by a weak base ($NaHCO_3$), so the pH of the solution rises very little.

At a pH 7.4 HCO_3^- concentrations is about 24 mEq/liter and H_2CO_3 concentration is about 1.2 mmol/liter, so bicarbonate ions out number carbonic acid molecules by 20 to 1. Because CO_2 and H_2O combine to form H_2CO_3, this buffer system cannot protect against pH changes due to respiratory problems in which there is an excess or shortage of CO_2.

Phosphate Buffer System

The phosphate buffer system acts via a mechanism similar to the one for the carbonic acid-bicarbonate buffer system. The components of the phosphate system are the sodium salts of dihydrogen phosphate ($H_2PO_4^-$) and mono-hydrogen phosphate (HPO_4^{2-}). NaH_2PO_4 acts as a weak acid. Na_2HPO_4, with one less hydrogen atom, acts as a weak base.

When a strong acid such as HCl is added to a mixture of these two substances, the hydrogen is accepted by the base HPO_4^{2-} and converted to H_2PO_4 .

$$\underset{\text{Strong acid}}{HCL} + \underset{\text{Weak base}}{Na_2HPO_4} \longrightarrow \underset{\text{Weak acid}}{NaH_2PO_4} + \underset{\text{Salt}}{NACL}$$

The result of this reaction is that the strong acid, HCl is replaced by an additional amount of a weak acid, NaH_2PO_4 and the decrease in pH is minimised.

When a strong base, such as NaOH, is added to this buffer system, the OH^- is buffered by the $H_2PO_4^-$ to form additional amount of HPO_4^{2-}.

$$\underset{\text{Strong base}}{NAOH} + \underset{\text{Weak acid}}{NaH_2PO_4} \longrightarrow \underset{\text{Weak base}}{Na_2HPO_4} + \underset{\text{Water}}{H_2O}$$

In this case, a strong base, NaOH is converted to a weak base, Na_2HPO_4, causing only a slight increase in pH.

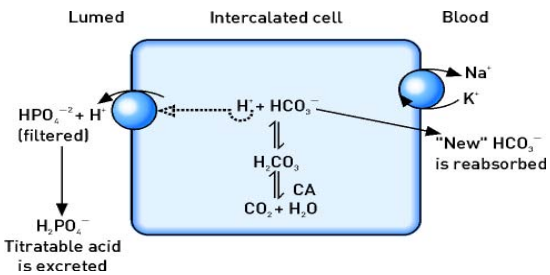
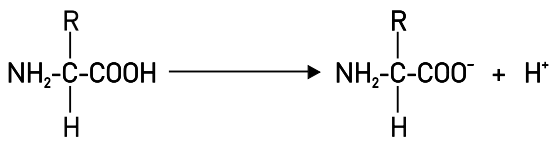


Fig. 1 Action of phosphate buffers in the elimination f H^+.

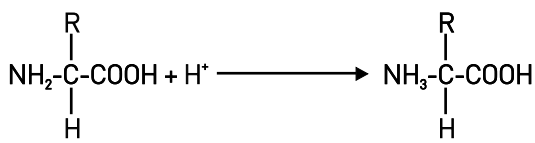
The concentration of the phosphate buffer system in the ECF is low in comparison to carbonic acid-bicarbonate buffer system. Therefore, the total buffering power of the phosphate system in ECF is much less than that of the carbonic acid-bicarbonate buffering system. However, the concentration of the phosphates is highest in ICF, the phosphate buffer system is an important regulator of pH in the cytosol. The phosphate buffer is especially important in the tubular fluids of the kidneys.

Protein Buffer System

The protein buffer system is the most abundant buffer in ECF and blood plasma. Proteins are polymers of amino acids, that contain at least one carboxyl group (-COOH) and at least one amino group ($-NH_2$), these groups are the functional components of the protein buffer system. The free carboxyl group at one end of a protein functions like an acid which dissociates to release H^+ when the pH begins to rise:



The H^+ released is then able to react with any excess OH^- in the solution to form water. The free amino group at the other end of a protein can act as a base by combining with H^+ when pH falls, as follows:



Because this removes free H+ from the solution, it prevents the solution from becoming too acidic. Consequently, a single protein molecule can function reversibly as either an acid or a base depending on the pH of its environment. Molecules with this ability are called **amphoteric molecules.**

Hemoglobin (Hb) is an excellent example of a protein that act as a intracellular buffer in RBCs. CO_2 passes from tissue cells into the plasma of blood and then into RBCs, where it combines with water to form carbonic acid. H_2CO_3 dissociates

into H^+ and HCO_3^-. Meanwhile, Hb is unloading O_2 to tissue cells becoming reduced Hb, which carries a negative charge. The reduced Hb (deoxyhemoglobin) picks most of the H^+, minimising the pH change.

$$H_2O + CO_2 \longrightarrow H_2CO_3 \longrightarrow H^+ + HCO_3^-$$

$$\underset{\text{Oxyhemoglobin}}{Hb\text{-}O_2} + \underset{\text{(From carbonic acid)}}{H^+} \longrightarrow \underset{\text{Reduced Hb}}{Hb\text{-}H} + \underset{\text{(Released to tissue cells)}}{O_2}$$

In this case, H_2CO_3, a weak acid is buffered by even weaker acid, hemoglobin.

B. Respiratory regulation of acid-base homeostasis

Respiratory system regulation of acid-base balance provides a physiological buffering system. CO_2 is formed continually in the body by intracellular metabolic processes. After it is formed, it diffuses from the cells into the interstitial fluids of blood, and the blood transport it to the lungs, where it diffuses into the alveoli and is transferred to the atmosphere by pulmonary ventilation. An increase in the CO_2 concentration in the ECF increases H^+ concentration and thus lowers the pH making it more acidic. Conversely, a decrease in the CO_2 concentration of ECF raises the pH making it more alkaline.

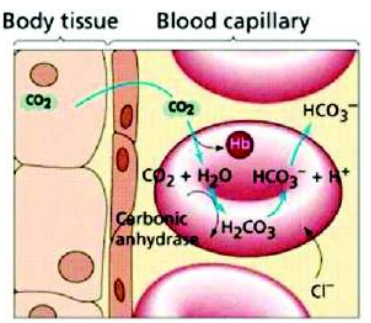


Fig. 2 *Carbon dioxide transport*

$$CO_2 + H_2O \rightleftharpoons H_2CO_3 \rightleftharpoons H^+ + HCO_3^-$$

The rate and depth of breathing (ventilation) can alter the pH of body fluids. With increased ventilation, more CO_2 is exhaled. Thus, during CO_2 unloading, the above reaction is pushed to the left, reducing the H^+ concentration and blood pH increases. If the rate of ventilation decreases below normal, less CO_2 is exhaled. This result in accumulation of CO_2 in ECF, the reaction is driven to the right, the H^+ concentration increases, the blood pH decreases.

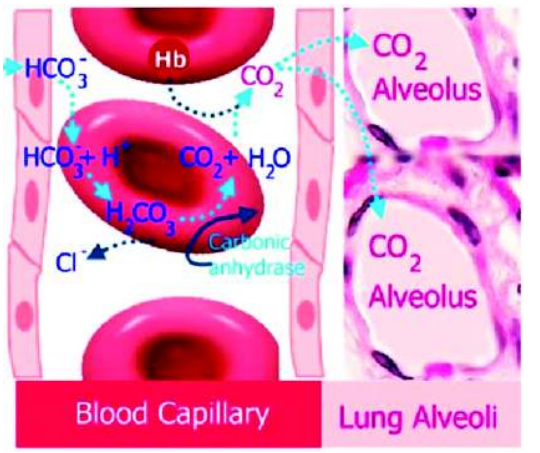


Fig. 3 *Carbon dioxide exchange in lungs.*

Renal Mechanism of Acid-base Homeostasis

Chemical buffers can bind excess acids or bases temporarily, but they cannot eliminate them from the body. The kidneys control acid-base balance by excreting either acidic or basic urine. Amount of acid in ECF is reduced by excreting acidic urine, whereas base is reduced by excreting basic urine. Each day body produces about 80 milliequivalents of nonvolatile acids, mainly from the metabolism of proteins. These acids are called nonvolatile because they are not H_2CO_3 and therefore, cannot be excreted by the lungs. The primary mechanism for removal of these acids from the body is renal excretion.

The most important renal mechanisms for regulating acid-base balance of the blood involve H^+ secretion and bicarbonate reabsorption. Each day the kidneys filter about 4320 milliequivalents of bicarbonate; under normal conditions, almost all this is reabsorbed from the tubules thereby conserving the primary buffer system of the ECF. About 80 to 90 per cent of the bicarbonate reabsorption (and H^+ secretion) occurs in the proximal convoluted tubule (PCT) of nephrons, so that only a small amount of bicarbonate flows into the distal convoluted tubules (DCT) and collecting ducts (CD). In the thick ascending loop of Henle, another 10 per cent of the filtered bicarbonate is reabsorbed, and the remainder of the reabsorption takes place in the DCT and CD.

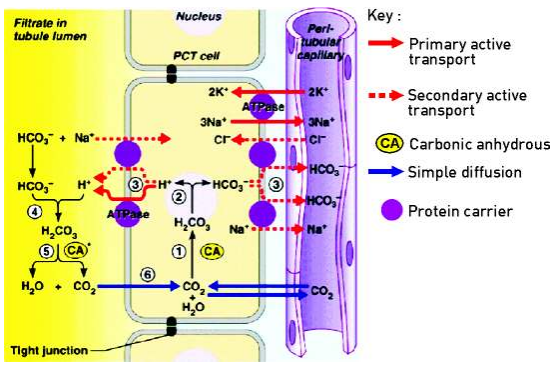


Fig. 4 Reabsorption of HCO_3^- and secretion of H^+ in the renal tubular cells.

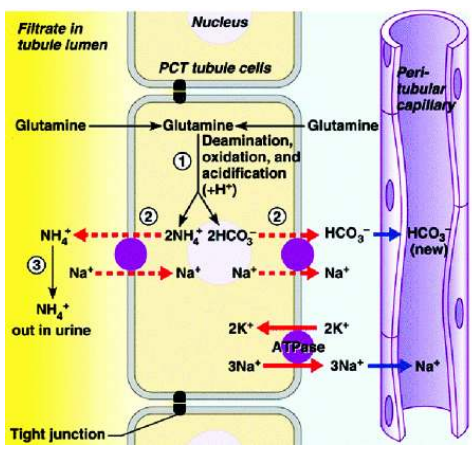


Fig. 5 Excretion of H^+ in the form of NH_4^+

Reabsorption of Bicarbonate and Secretion of H^+

The epithelial cells of the PCT, thick segment of ascending limb of loop of Henle and initial part of DCT secrete H^+ into the tubular fluid by secondary active transport process with the help of Na^+/H^+ antiporters. These antiporters carry filtered Na^+ down its concentration gradient from tubular fluid into cells as H^+ is secreted from the cytosol into the tubular lumen. The epithelial cells produce H^+ in the following way. CO_2 diffuses from peritubular blood or tubular fluid or is produced by metabolic reactions within the cells. In the cytosol of cells, the enzyme carbonic anhydrase catalyses the reaction of CO_2 with water to form H_2CO_3, which then dissociates into H^+ and HCO_3^-:

$$CO_2 + H_2O \xrightarrow{\text{carbonic anhydrase}} H_2CO_3 \longrightarrow H^+ + HCO_3^-$$

After H^+ is secreted into the tubular fluid within the lumen, it reacts with filtered HCO_3^- to form H_2CO_3, which readily dissociates into CO_2 and H_2O. CO_2 then diffuses into the tubule cells and join with H_2O to form H_2CO_3, which dissociates into H^+ and HCO_3^-. As the level of HCO_3^- rises in the cytosol, it exits via facilitated diffusion transporters in the basolateral membrane and diffuses into the blood. Thus, for every H^+ secreted into the tubular fluid, one HCO_3^- is reabsorbed (one Na^+ also reabsorbed).

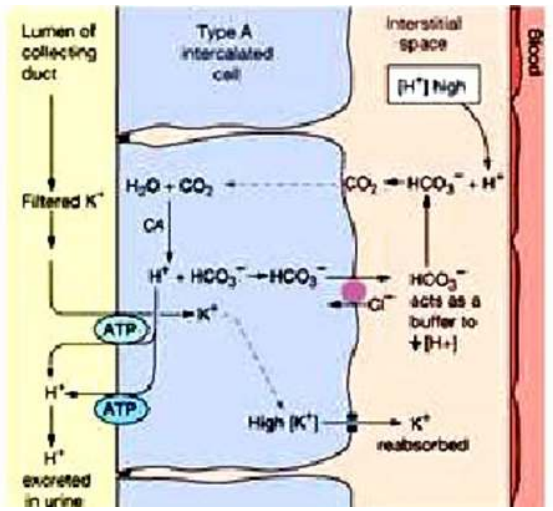


Fig. 6 Type A intercalated cell function in acidosis. H^+ is excreted, HCO_3^- and K^+ reabsorbed

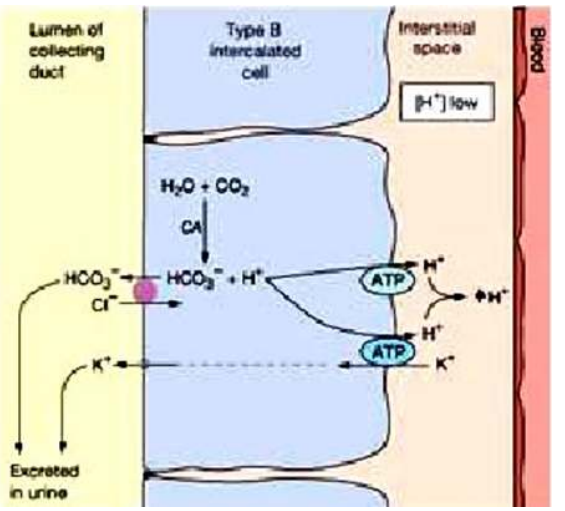


Fig. 7 Type B intercalated cell function in alkalosis. H^+ is reabsorbed, HCO_3^- and K^+ excreted

The apical membranes of intercalated cells (type A) present in the last part of DCT and CD contains proton pumps (H^+ pumps) that secrete H^+ into the tubular fluid. The HCO_3^- produced in the cytosol of intercalated cells by dissociation of H_2CO_3 crosses the basolateral membrane into the interstitial fluid by means of Cl^-/HCO_3^- antiporters and then diffuses into blood. Although the secretion of H^+ in the last part of DCT and CD account for only about 5 per cent of the total H^+ secreted, this mechanism is important in forming a maximally acidic urine.

When the body is in alkalosis, a second type of intercalated cells (type B) present in CD has H^+ proton pumps in its basolateral membrane and Cl^-/HCO_3^- antiporters in its apical membrane play an important role in acid-base balance. These intercalated cells secrete HCO_3^- and reabsorbs H^+. Thus, the two types of intercalated cells help maintain pH of body fluids in two ways: by excreting excess H+ when pH of body fluids is too low and by excreting excess HCO_3^- when pH is too high.

Some H^+ secreted into tubular fluid of the CD are buffered, but not by HCO_3^-, most of which has been filtered and reabsorbed. Two other buffers combine with H^+ in the CD. The most plentiful buffer in the tubular fluid of the CD is HPO_4^- (monohydrogen phosphate ion). In addition, a small amount of NH_3 (ammonia) also is present. H^+ combines with HPO_4^- to form $H_2PO_4^-$ (dihydrogen phosphate ion) and with NH_3 to form NH_4^+ (ammonium ion). Because these ions cannot diffuse back into tubule cells, they are excreted in the urine.

Acid-base Disorders

A change in blood pH leads to acidosis or alkalosis which can be classed according to cause as respiratory or metabolic.

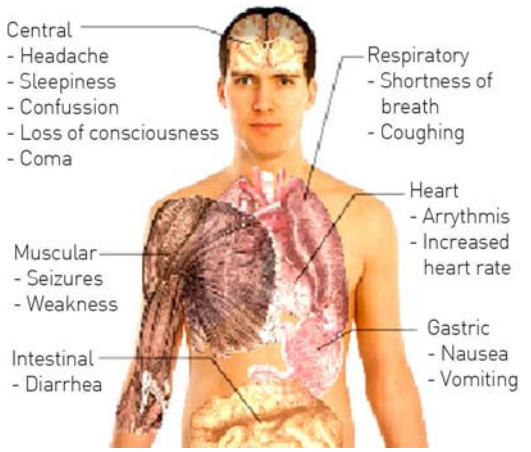


Fig. 8 Symptoms of acidosis.

A. Respiratory acidosis and alkalosis

Respiratory pH imbalances results from some failure of the respiratory system to perform its normal pH balancing role. Both respiratory acidosis and alkalosis are disorders resulting from changes in the Pco_2 in the systemic arterial blood (normal range is 35-45 mm of Hg).

Respiratory acidosis is caused by a buildup of carbon dioxide in the blood. This is a result of decreased lung function, which can be caused by emphysema or chronic bronchitis, neurological and neuromuscular diseases that affect the muscles of the chest, as well as drug or alcohol overdose. Respiratory acidosis causes headaches and drowsiness, which can quickly lead to stupor and coma.

Respiratory alkalosis occurs when the body hyperventilates (breaths too quickly), and expels too much carbon dioxide from the blood. This can occur in cases of extreme anxiety, pain, fever and aspirin overdose. Respiratory alkalosis can cause dizziness; however, it usually corrects itself with the return of normal breathing.

B. Metabolic acidosis and alkalosis

Metabolic pH imbalances are disorders resulting from changes in HCO_3^- concentration (normal range is 22-26 mEq/liter in systemic arterial blood).

Metabolic acidosis occurs when the body produces an excessive amount of organic acids, when an acid is ingested or when the kidneys are not functioning correctly. Metabolic acidosis causes nausea, vomiting and fatigue. People with mild metabolic acidosis may also have changes in respiration, breathing faster and deeper. These symptoms will progressively worsen and eventually lead to shock, coma and death.

Metabolic alkalosis occurs when the body loses too much acid, such as stomach acid lost during vomiting, or has too much bicarbonate in the blood. Kidney problems can also lead to metabolic alkalosis. Metabolic alkalosis causes irritability, muscle cramps and spasms and muscle twitching.

Effects of Acidosis and Alkalosis

When blood pH falls below 7.0, the CNS is so depressed that the person goes into coma and death soon follows. When blood pH rises above 7.8, the nervous system is over excited and causes muscle tetany, extreme nervousness, and convulsions.

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MOTION IN TWO AND THREE DIMENSIONS

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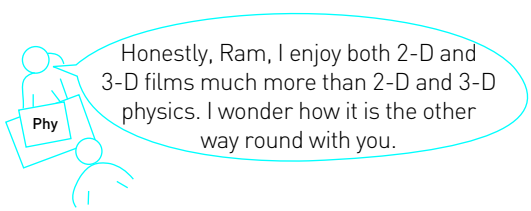
Introduction

We live and work in a three-dimensional world. Laws of physics enable us to describe motions of bodies in one, two and three dimensions. Though motions in two and three dimensions may appear to be extensions of motion in one dimension, there are subtle differences between them, and special kinds of motion, like rotation, are possible in two and three dimensions only. Moreover vectors can be used to describe motions in two and three dimensions. As such students have difficulties even in one-dimensional motion. Because of the additional complications, motions in two and three dimensions become much harder for the learners. Lack of adequate thinking and visualisation leads to misconceptions or alternative conceptions not only in the minds of students but also in the minds of the teachers.



In this section, we would like to discuss some important aspects of motion in two and three dimensions vis-à-vis that in one dimension. The focus shall be on the conceptual hard spots, which are often ignored in textbooks. We shall address here only some of the ideas and issues relevant to the higher secondary level, such as *vectors, reference frames, coordinate systems* in the current article as a part under the title motions in two and three dimensions, while discussion on other issues will be given in the coming articles. In the discussion of motion along a straight line, the displacement of a point from a position x_1 to x_2 on the line joining these two positions is independent of the origin chosen on the line. Because of this fact, such a displacement can be considered as an entity on its own, without reference at all to the origin. As such, it is specified completely by a *length* and a *sense,* since displacements are considered positively conventionally when motion is from left to right, and negative when motion is from right to left. Thus an *arrow* having a length equal to the magnitude of the displacement and having arrowhead in the direction of motion can be used to represent the displacement. For any choice of origin, both length and sense are given simply by $x_2 - x_1$; changing the origin (i.e., the reference point about which studies are being made) will simply add the same constant quantity to both x_1 and x_2 and without in any way changing the displacement. For this reason, the usual notation of elementary algebra is quite sufficient for the representation of displacements along a line. But

when motion is generalised to that in two or three dimensions, introduction of a new notation, vector, is convenient.

1. Vectors

For a displacement represented by an arrow, as in Fig.1, the notation $\vec{x}$ is standard although it is often convenient to call it simply $\overrightarrow{TH}$ when referring to a diagram. *T* is the 'tail' and *H* is the 'head' of the arrow.

Fig. 1

With this convention, the displacement $-\vec{x}$ is just $\overrightarrow{HT}$. Because the origin has been dispensed with, no meaning can be attached to the 'position' of the displacement; it may be drawn anywhere along the line. A quantity considered in this way is called a *vector* and can be represented by an arrow or a line with an arrowhead and of a definite length. Thus displacement is a vector. Quantities that do not require a direction or *sense* are called *scalars.* Thus ordinary numbers are scalars; distance and speed are scalars. Time is also considered as a scalar quantity. Since velocity is displacement divided by a time and acceleration is velocity divided by a time, both velocity and acceleration are vectors and may be represented by arrows and symbols $\vec{v}$ and $\vec{a}$ respectively.

Time appears to have characteristics somewhat similar to those of the displacement vector $\vec{x}$. In fact, time (t) can be plotted along a time axis or t-axis just like the coordinate *x* along the *x*-axis. One may choose the reference point or origin ($t = 0$) at any instant or at any point on the t-axis, and from that instant to future is time forwards (t *+ve*) whereas from that instant to past is time backwards (t *-ve*). Thus time appears to have a 'direction' as well as a magnitude like $\vec{x}$. So, some may argue, why do we consider time as a scalar and not as a vector? The reason is that a vector like $\vec{x}$, $\vec{V}$, or $\vec{a}$ has a direction in space, say *north, south,* 30^0 *to east,* etc. But time has no such direction in space. A point in space does not have a time coordinate. Moreover, whereas a vector has as many components as there are dimensions defining the space (1, 2 or 3 as the case may be), time has no components; it is denoted by a single notation *t*. A clock placed at point *P* in space keeps the same time as the one placed at another point *Q*, hence time is considered a scalar parameter, independent of the space coordinates in Newtonian mechanics.

Although a vector is considered as independent of the choice of the origin, it depends on the 'frame of reference' (FOR) from which one happens to regard it. This important idea of FOR may be explained as follows. The displacement shown in Fig.1 may be thought of as the displacement of a fly that has crawled horizontally across the page of the book. The page of the book is the FOR for this displacement and this has no consequence where the origin is located on the line of the arrow. But, as the fly crawls on the page, the whole book may be moved from left to right on the table. The table is a different FOR, and the displacement of the fly seen from the table will not agree with that seen from the page of the book. If the displacement of the book on the table is denoted by $\vec{X}$, then, with reference to the table, i.e., as seen from the table, the displacement of the fly will be $\vec{X} + \vec{x}$, where $\vec{x}$ denotes the displacement of the fly on the page of the book.

Similarly, we can treat the velocity vector. If the velocity of the fly relative to the page is $\vec{v}$ and the velocity of the book relative to the table is $\vec{V}$, then the velocity of the fly relative to the table will be $\vec{v} + \vec{V}$.

So long as the motion is along a straight line, all of the above reasoning is perfectly obvious and already contained in the concept of *x* as a coordinate. Nevertheless, the new notation introduced is a very powerful aid to think when we tackle problems in two and three dimensions. There are many more directions in a plane or in space than just the two possibilities in the case of one-dimensional motion. Therefore, a sound knowledge of vector notation and method is regarded as essential for all science students and teachers. This can be learnt easily with the help of knowledge of reference frames (or FOR) and coordinate systems.

Mathematically there is no difference between one-dimensional vectors and scalars which admit +ve, -ve and zero values. Rules of operation are similar in both the cases

Alternative conceptions/weak points and possible remedies:

- Relative sizes and orientations of vectors are often incorrectly represented in diagrams by students.

  For example, when two vectors of unequal magnitudes are given, the one with greater magnitude should not look similar to or shorter than the other in their diagrammatic representation. For example, when angle between two vectors is given to be 30^0, the same should not look like 60^0 or 90^0 in the diagram. For that matter, a straight line should look like a straight line to the extent possible. Unmindful-ness or carelessness might be the reason for the situation. Though exact accuracy is not possible, nor essential, care must be exercised while drawing vector diagrams lest incorrect diagrams should induce incorrect thinking. The teacher should not only impress upon the learners the importance of this aspect but should also make use of it while teaching vectors.

- Pupils often ignore or forget to attach the vector symbol (arrowhead) to a vectorial quantity. They ought to recognise that though it is possible to represent vectors by **boldface** letters in print form, as is done in many books on physics, the arrowhead option is easier and more practicable while writing by hand.

- Another error commonly committed is that in a vectorial equation, the left hand side correctly denotes a vector whereas the right hand side is devoid of the corresponding symbols or notations, and vice versa. The teacher as well as the students ought to note that this is inconsistent and incorrect both mathematically and physically, and hence should be avoided.

2. Frame of Reference (FOR)

We accept the local surroundings – a collection of objects attached to the earth and therefore at rest relative to one another – as defining a FOR. This is a reference frame with respect to which changes of position of other objects can be observed and measured. It is clear that the choice of FOR, to which the motion of an object is referred, is entirely a matter of taste and convenience, but it is

often advantageous to use a FOR in which description of motion is the simplest. A very commonly used FOR is the 'laboratory frame' or 'lab frame', i.e., a FOR attached to the laboratory in which motions of bodies are observed. Another useful FOR is the 'centre of mass frame' or the 'CM frame' attached to the centre of mass of the system. There are powerful theoretical reasons for preferring some FOR to others. The 'best' choice of FOR becomes ultimately a question of dynamics i.e., dependence on actual laws of motion and force. But the choice of a particular FOR is often made without regard to the dynamics, and for the present, we shall just concern ourselves with the purely kinematics problems of analysing positions and motions with respect to any given frame.

Alternative conceptions / weak points and possible remedies:

In 1994, a Bombay (now Mumbai) group of researchers (Panse et. al., 1994) studied alternative conceptions of students in Galilean relativity in the context of FOR. Though their subjects were physics undergraduates, some of their findings are relevant for higher secondary level too, both in Newtonian or non-relativistic as well as relativistic mechanics.

- Students in general have a hazy idea about the concepts of FOR and observer. The following simple activity may help them in this regard.

Activity

Draw a circle on a piece of paper placed flat on a table. Look at it vertically down. Clearly you see the circle. Now, if you tilt your head at different angles with respect to the paper, the circle may look like ellipses of different eccentricities. For some position of your head, the circle may even look like a straight line! Remember that it is the same circle being looked at from different angles or with different perspectives. Each position of your head may be considered to be a different FOR. Although you are the one who observes all this, each such FOR can be associated with an independent 'observer'. Clearly, the same thing may look different to observers in different FOR.

- Students have a tendency to think that an observer has to be a human being (anthropomorphic view). This is in spite of the statement made in standard textbooks that an observer can be either a person or an instrument.

It is important to recognise that measurements, which comprise observations, are carried out by impersonal instruments, and the persons behind the instruments are irrelevant for physics (unless you want to include the effects of human errors in the measurements). This reflects the principle of *objectivity in science*. It may thus be better to replace the notion of 'observer' by the notion of FOR. For example, 'a passenger in a train' may be replaced by the 'train's FOR' and 'observer on ground' by 'ground's FOR' etc.

- Students often picture a FOR as something *physically* attached to the observer or on object and *localised* by the physical extensions of the object.

This misconception should be removed as early as possible. FOR is an *abstract concept* and is not something *attached* to the observer or on object, nor is it *limited* by the physical extensions of the object. It should be *imagined* or *visualised*. For

instance, in a three-dimensional space, it is like a system of rigid rods sticking out from a point in three mutually perpendicular directions and stretching from - ∞ to + ∞. The origin of an object's FOR may be inside or outside the object. The origin can be anywhere in space and orientation of the axes denoting the FOR can be chosen arbitrarily. It ought to be recognised that the FOR shares no other property of the object except its state of motion.

Questions

In order to check the comprehension of the learners, the following questions may be put to them. The teacher should first find the answers himself/herself, compare them with those provided by the learners, and then conduct discussions as necessary.

(i) When a food packet is dropped from a helicopter during flood relief work, the packet is no longer at rest with the FOR of helicopter. True/False

If your answer is 'True', what would you do to keep the packet in the helicopter's FOR?

(ii) Fig. 2(a) and Fig. 2(b) depict two FORs for a box at rest. Tick the correct option.

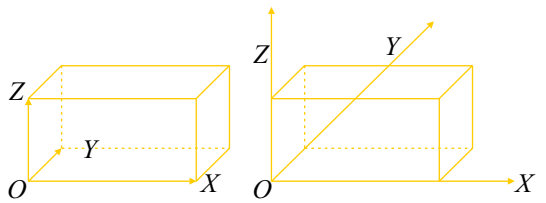


Fig. 2(a) Fig. 2(b)

a) FOR of the box is given by Fig. 2 (a) only.

b) FOR of the box is given by Fig. 2 (b) only.

c) FOR of the box is given by both Fig. 2 (a) and 2 (b).

d) FOR of the box is given by none of these figures.

iii) Would you accept that frame as a FOR of the box, referred to above, whose origin lies outside the box? Why?

iv) While moving on your bicycle you raised your hand. This event occurred in the bicycle's FOR only. True / False,

Give reasons.

3. Coordinate Systems and Unit Vectors

A FOR, as we have said, is defined by some array of physical objects that remain at rest relative to one another. Within any such frame we make measurements of position and displacement by setting up a *coordinate system* of some kind. In doing this, we have a free choice of origin and of the kind of coordinate system that is best suited to the purpose at hand. Since the space of our experience has three dimensions, we must in general specify three separate quantities in order to fix uniquely the position of a point.

This will reduce to two separate quantities in a two-dimensional plane. The quantities are the Cartesian coordinates (x, y) or the polar coordinates (r,θ). The square grid basis of Cartesian coordinates is shown in Fig. 3(a) and the circular grid of the plane polar coordinates is shown in Fig. 3(b). These are the two standard coordinate systems used in two dimensions.

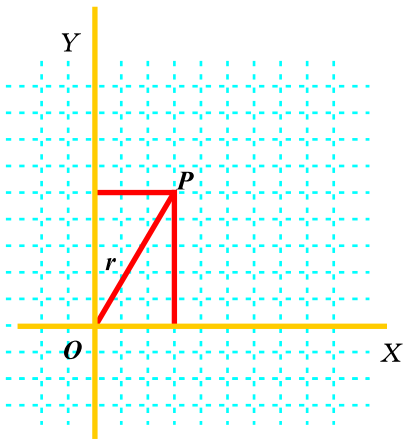


Fig. 3(a) Square Grid

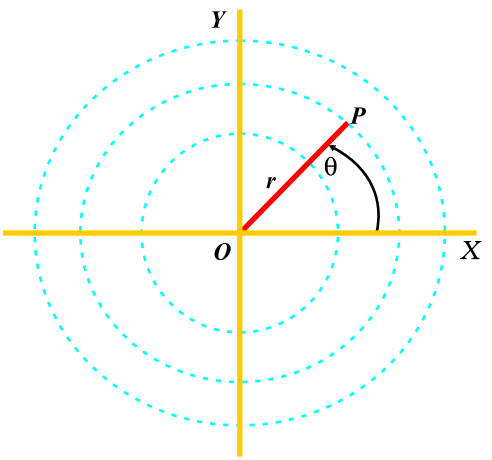


Fig. 3(b) Circular Grid

In polar coordinates, r varies form 0 to ∞ i.e. $0 < r < \infty$ and θ varies form 0 to 2π i.e. $0 < \theta < 2\pi$.

In two dimensions, with reference to Fig. 3 (a) and 3 (b), we have the familiar relations:

$r^2 = x^2 + y^2$, (1a)

$\tan\theta = y/x$, (1b)

$x = r\cos\theta$, $y = r\sin\theta$ (1c)

Similarly, in three dimensions, the standard systems used are Cartesian coordinates (*x, y, z*) and spherical polar coordinates (*r*, θ, ϕ) which are together presented in Fig. 4.

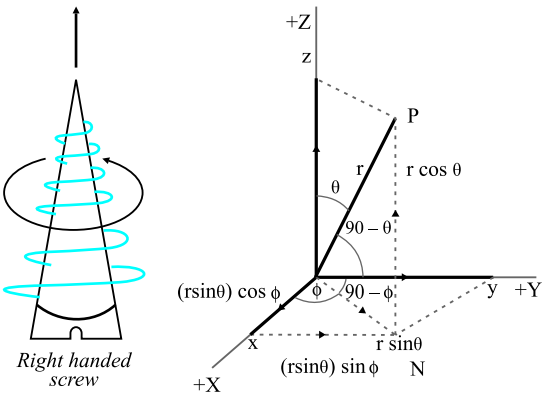


Fig. 4

Line *ON* is the projection of *r (OP)* on the *x-y* plane. The angles θ *and* ϕ are called polar angle and azimuth respectively. Similar to the set of equations in two dimensions [(1a) – (1c)], we have, in three dimensions,

$r^2 = x^2 + y^2 + z^2$, (2a)

$\tan\theta = \sqrt{(x^2 + y^2)}/z$ (2b)

$\tan\phi = y/x$, (2c)

$x = r\sin\theta\cos\phi$, $y = r\sin\theta\sin\phi$, $z = r\cos\theta$. (2d)

The Cartesian system chosen here is a right-handed system by which we mean the following: the positive *Z* direction is chosen so that, looking upward along it, the process of rotating from the positive *X* direction toward the positive *Y* direction corresponds to that of a right-handed screw (see Fig. 4). It then follows that the cyclic permutations of this operation are also right-handed from *+Y to +Z looking along +X, and from +Z to +X looking*

along + Y. You may note that the two-dimensional coordinate system, as shown in Fig. 3 (a) would, in this convention, be associated with a positive *Z* axis sticking up toward you out of the plane of the paper.

Now we come to the concept of *unit vectors.* Conventionally, the alphabets *A, B, C, ...* or *a, b, c, . . .* are used to represent constants, *U, V, W, X, Y, Z* OR *u, v, w, x, y, z* etc. to represent variables. Alphabets *a* to *z* are used to represent real numbers excluding *i, j, k, l, m, and n* which are used to represent integers. Usually, we make use of these integer symbols to represent unit vectors along the various coordinate axes or directions in the Cartesian systems. Various options are further exercised in this regard: some represent a unit vector in the form $\vec{i}$ (i with an arrowhead), some prefer the form **i** (bold *i*), whereas some others put it as $\hat{i}$ (*i* with a carat or cap or hat). Here we shall prefer the carat version since it is likely to produce minimal confusion and is easier to write, and shall denote unit vectors along the *X, Y* and *Z* axes as $\hat{i}$, $\hat{j}$, and $\hat{k}$ respectively. Then referring to Fig. 4 in three dimensions, we shall have the position vector of point *P* with respect to the origin *O* as

$$\vec{r} = x\hat{i} + y\hat{j} + z\hat{k} \qquad (3)$$

In two dimensions [Fig. 3 (a)], the position vector becomes

$$\vec{r} = x\hat{i} + y\hat{j} \qquad (4)$$

In the plane polar coordinate system [Fig. 3 (b)], one uses the symbol e_r to denote a unit vector in the direction of increasing r at constant θ, and the symbol e_θ to denote a unit vector in the direction of increasing θ at right angles to $\vec{r}$. The use of the symbol *e* for this purpose comes from the German word 'Einheit' which stands for 'unit'.

In this system of coordinates, the vector $\vec{r}$ is simply equal to re_r, and one might wonder why the unit vector e_θ is introduced at all. However, it becomes very important as soon as we consider motions rather than static displacements. For motions we will often have a component perpendicular to *r*. It may be noted that, even in Cartesian systems, some like to use the symbols e_x, e_y and e_z to denote unit vectors along the *X, Y* and *Z* axes respectively. Some even write these unit vectors as $\hat{x}$, $\hat{y}$ and $\hat{z}$ respectively. In the plane polar coordinate system, another version of unit vectors is possible: $\hat{r}$ and $\hat{\theta}$ in place of e_r and e_θ respectively. Obviously, the former is easier to write than the latter. We thus recognise that there are multiple acceptable ways of denoting unit vectors in a given coordinate system, and one can pick and choose depending upon convenience.

Alternative conceptions/weak points and possible remedies:

- Students often confuse between the various systems of unit vectors and the various symbols used for vectors and are likely to mix them up. The teacher should see that this does not happen. A good tactic is to instruct them to explain all symbols and notations, used by them, explicitly while preparing notes and answering questions. They should also practice to read and speak the notations correctly (for example, $\hat{i}$ as '*i* cap').
- The same symbol θ in two and three dimensions may be confusing. The students ought to recognise that this is a standard practice in mechanics and the two situations are distinct.
- Students often use the components ($r\cos\theta$) and ($r\sin\theta$) mechanically without correctly

locating the angle θ. This leads to wrong conclusions. Correct conceptualisation and visualisation of the given situation is necessary for avoiding similar problems and this can come through practice.

- It is not only difficult for the teacher to draw a three-dimensional coordinate system on the two-dimensional plane of a board, the students also find it difficult to visualise and perceive.

The following activity may help in this context.

Activity

Take a blob of plasticene or putty and place it on a plane like a table or a floor. By inserting straight sticks into it at appropriate angles, a three-dimensional space can be modelled. Various projections can also be depicted with the help of smaller size blobs and other sticks. Permanent hollow tube-like structures may also be prepared from a metal or plastic which can be used along with sticks or rods for the same purpose.

Questions

(i) In $x-y$ plane, a line of length *1 m* originates from the origin and makes an angle of 30^0 with the *y*-axis. What are the lengths of the corresponding *x* and *y* components?

(ii) In a three-dimensional space, a line of length *1 m* starts from the origin and makes an angle of 60^0 with respect to the $x-y$ plane. Its projection on the $x-y$ plane makes an angle of 30^0 with the *y*-axis. Find the lengths of the corresponding *x, y* and *z* components.

(iii) Is it possible to describe a two-dimensional plane by means of a grid of non-perpendicular straight lines? Give a demonstration.

(iv) Looking at the relations among the various variables in two and three dimensions, as quoted in our discussion above, how can you reduce a three-dimensional coordinate system to a two-dimensional one?

(v) Design a left-handed Cartesian coordinate system by looking at the right-handed Cartesian coordinate system we have discussed above.

(vi) Obtain expressions for e_r *and* e_θ (or equivalently $\hat{r}$ and $\hat{\theta}$) in terms of $\hat{i}$ ***and*** $\hat{j}$**.** Test that they are orthogonal to each other.

It is interesting to note that in Cartesian systems all the coordinates (*x, y, z*) have the dimensions of length, whereas in plane polar and spherical polar systems, only one of the coordinates (*r*) has the dimensions of length and others (like θ or θ and φ) are dimensionless angular measures. These are examples of what are called 'generalised coordinates' used very often in advanced mechanics.

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OBSERVATION SCHEDULE FOR ASSESSING PEDAGOGICAL COMPETENCY OF SCIENCE TEACHERS AT SECONDARY LEVEL

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Pedagogical competency of science teachers determines how far he/she is able to teach science effectively and achieve the objectives of science education. In this context, constructing a tool to assess and map the pedagogical competency of science teacher has recently been felt for conducting research in the field of science education. Pedagogical competency of teacher means ability and capacity to apply as well as use knowledge, skills, attitude effectively by adopting new circumstances for correct instructive strategies in science in a real teaching learning situation. One way to assess pedagogical competency is using Observation Schedule. This tool is based on five criteria having 36 indicators such as i) attitude while teaching in the classroom ii) scientific approach to teach science iii) content knowledge iv) knowledge of teaching methods v) skills of teaching science. Each criterion has many indicators, which will help observer in observation. The tool is of five point scale such Very poor, Poor, Good, Very Good and Excellent (1.2.3.4.5). The tool is standardised on science teachers teaching at secondary level, Odisha. It can be administered by the person having sufficient knowledge and understanding on science teaching at secondary level. The face and content validity is ensured by taking expert comments into consideration at time of preparing final draft of the schedule. The reliability of the observation schedule was estimated by using test-retest method by giving seven days gap. It was found to be 0.824. The tool is prepared for assessing pedagogical competency of science teachers at secondary level.

The main purpose of this paper is to develop observation schedule to assess pedagogical competency of science teacher at secondary level.

Introduction

Now a days, Science in school education has attained a significant and compulsory place because of its wide application in daily life as well as for providing vast scope at vocational field. Science is an active, energetic, broad field of knowledge and experience that made people to acquire suitable skills and competencies to adopt the changing world and to change the world in a favourable direction. Not only the individual, but also the whole nation and human civilisation have been taking advantages of Science for personal and collective growth and development. Teaching Science is one of the challenging tasks undertaken by the science teacher. With this respect the role of science teacher in the society is crucial as they have the great responsibility to teach science in an effective way so that nation can get competent man power in the field of Science

and Technology. To accomplish this challenging task, science teachers not only need to develop and implement appropriate Science pedagogy but also to demonstrate successful pedagogical competency in classrooms. Pedagogical competency of Science teachers determines how far he/she is able to teach science and achieve the objectives of science education. In this context the demand of constructing a tool to assess and map the pedagogical competency of science teacher has recently been felt for conducting research in the field of science teacher education.

Conceptualisation of Pedagogical Competency

According to Wikipedia, Pedagogy is the study of being a teacher or the process of teaching. Dictionary of Instructional Technology (1986) compiled by Henry Elington and Duncan Harries states that the word 'Pedagogy' is "re-emerging in educational circles as a term of educational science ,i.e. the study of classroom methodology and teaching techniques". The Encyclopedia of Britanicca explain the meaning of pedagogy as "The science of teaching involving the study of human learning processes and the application of learning principles to the development of educational goals and curricular and to the teaching situations. It covers (i) Various components of teaching and schooling (ii) Major theories of learning. The International Encyclopedia of Teaching and Teacher Education (1978) edited by Michael J. Dunkin equates 'Pedagogy with 'Instruction.' The term generally refers to strategies of instruction, or a style of instruction. The dictionary meaning of pedagogy is the study of teaching methods (Oxford). Pedagogy is an art, practice or profession of teaching: systematised learning or instruction concerning principles and method of teaching. (Webster). The term generally refers to strategies of instruction, or a style of instruction. Pedagogy is also occasionally referred to as the correct use of instructive strategies. Pedagogy is the art and science of teaching (Dictionary of Education, 1977). Science pedagogy refers to of how to teach science, approaches and strategies to teaching learning science, methods adopted, effective utilisation of learning resources and teaching aids, the way the content delivered, what students learn as a result of pedagogical designing.

Competency is the ability to do or take responsibility (Race 2005). Competencies are, in essence, definitions of expected performance that, taken as a whole, should provide users with complete picture of the most valuable behaviours, values and tasks required for their organisation's success (Rankin 2004). The competency is a statement which describes the integrated demonstration of a cluster of related knowledge, skills and attitudes that are observable and measurable, necessary to perform a job independently at a prescribed proficiency level (Earnest 2001). According to Terrence Hoffmann (1999) the term "competency" has not been clearly defined in the literature. Two main meanings of the term have been identified, one referring to the outputs, or results of training – that is, competent performance. The other definition referring to the inputs, or underlying attributes, required of a person to achieve competent performance. Each definition has been used to describe both individual and organisational competencies."A competency is an underlying characteristic of a

person which enables them to deliver superior performance in a given job, role or situation (Marshall, 1996). Competence means a skill and standard of performance whilst competency refers to behaviour by which it was achieved. It means that competence describes what people do and competency describes how people do it. (Rowe, 1995). Essentially, competencies underlie the behaviours thought necessary to achieve a desired outcome. A competency is something you can demonstrate.(Weightman,1994). It is considered as a generic knowledge, motive, trait, social role or skill of a person linked to superior performance on the job (Hayes 1979). Competency is the ability to transfer skills and knowledge to the new situation within the occupational area.

A competency is a set of defined behaviours that provide a structured guide enabling the identification, evaluation and development of the behaviours in individual employees. It encompasses organising and planning of work, innovating and coping with non-routine work/ activities. Any individual's technical, behavioural or managerial tasks can be measured or counted relatively and that can be shown to differentiate between an effective and ineffective performer(s). Any personal trait, characteristic or skill which can be shown to be directly linked to effective or outstanding performance. A competency, then, refers to the way that a state of competence can be demonstrated to the relevant community. Thus the notion of competency is confined to the ability to perform a discrete task or "discrete workplace requirement". The notion that tasks and workplace requirements can be discrete from knowledge, skills, values, attitudes and context, is problematic. A parallel evolution of a more complex view of competency from many researchers in the last decade recognises a concept which incorporates "the ability to transfer skills and knowledge to new situations and environments" as well as the performance of tasks expected in the workplace. This "broader" concept can include among others: the performance of tasks, the management of a series of tasks, the ability to respond to irregularities and contingencies, the capacity to deal with the complexities of the workplace including taking responsibility and working with others, the ability to put one's knowledge, skills and attitudes to new tasks and to new situations, not putting aside respect of other human beings or tolerance of other values (Naumesc, 2008).

Pedagogical competency can be described as the ability and the will to regularly apply the attitude, knowledge and skills that promote the learning of the teacher's students. This shall take place in accordance with the goals that are being aimed at and the existing framework and presupposes continuous development of the teacher's own competence and course design (Ryegard, A., Orisson ,T.,Apelgren, K., Eriksson, R. (2010). Internationally teaching excellence is often used to describe what we call pedagogical competence (Skelton 2007, Kreber 2002). Therefore, pedagogical competency of the science teacher is based on his/her behaviour while implementing science pedagogy and it describes the attributes of him/her. It consists mainly of underlying characteristics of a science teacher which result in effective and/ or superior performance in teaching. These competencies are transferable from one sphere to another. It can be measured in terms of science teacher's behaviour in teaching learning situation. This pedagogical competency

is result oriented in terms of effective teaching and learning.

Thus, it is clear that Pedagogical competency of science teacher means ability and capacity to apply as well as use knowledge, skills, attitude effectively by adopting new circumstances for correct instructive strategies in science in a genuine teaching learning situation with perseverance .

Pedagogical Competency Not Merely the Ability to Perform Sum of Skills of Teaching

Pedagogical competency of science teacher should not be considered as only the ability to perform skills in class. It is broader terms which not only include several teaching skills required for a science teacher but also some other factors constitute this wide field.

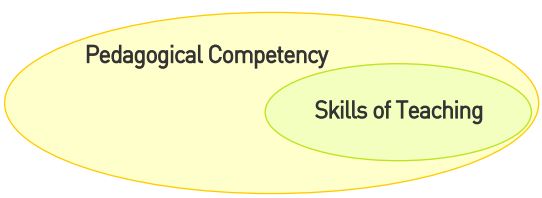

Fig. 1 Pedagogical competency is not only the sum of teaching skills

The pedagogical competency of science teacher cannot be assessed only on the ground of how far the teacher is able to apply different skills or whether he/she is using those skills or not. It is crucial to find whether those skills are applied appropriately within a selected method of teaching by means of contribution of convenient knowledge in science subject in association with expression of best attitude promoting learning inside classroom, through adequate scientific approach. Thus pedagogical competency of science teacher can be mapped on the basis of indicators of these individual aspects as well as the analysis of situation arising due to interrelation between each factor with other factor (s).

Assessing Pedagogical Competency

Many researchers have tried to construct tools for assessing teaching Competency and Pedagogical Competency of teachers. But researcher is unable to find tool prepared specially for assessing pedagogical competency of science teachers. Some of the researchers have considered only application of skills in the classroom for assessing pedagogical competency. On the other hand some of them have extended pedagogical competency outside the classroom and included criteria such as attitude that furthers students' learning, scientific approach, broad and appropriate subject knowledge, knowledge about how students learn, knowledge regarding teaching, knowledge about educational goals and organisation, holistic view, applied teaching skills, striving for continued growth, leadership and organisational ability, collaboration with others and external contact (Assessing Teaching Skills, UPI, Uppsala University 2010). Some of the researches have conducted studies at different stages of education and developed criteria for assessing pedagogical competency and constructed tools such as check list, rating scale, observation schedule, portfolio to assess the pedagogical competency. According to some researchers a tool that is used more and more frequently for compiling material to be used for

the assessment of pedagogical competence is the pedagogical competences portfolio (Apelgren and Giertz 2001, Winka 2009).

In order to develop a systematic and methodical assessment of pedagogical competency of science teachers requires relevant criteria upon which the assessment is based, documentation that demonstrates that the criteria have been fulfilled and clear descriptions of the levels that are to be achieved in order to fulfill the different criteria. (Ramsden and Martin, 1996; Chism, 2006; Elton, 1998; Trigwell, 2001). But very few of them have developed appropriate tool for assessing pedagogical competency of science teacher. In India NCF (2005) has also emphasised implementation of critical pedagogy in science classroom by developing appropriate competencies among teachers to understand learning situations. In this context, it is urgent to construct a tool that can be easily implemented and give appropriate data for assessing pedagogical competency of science teacher. Therefore, the authors have attempted to develop an Observation Schedule for assessing pedagogical competency of science teacher.

Different Aspects of Pedagogical Competency of Science Teaching

The authors have developed this Observation Schedule for assessing pedagogical competency of science teacher at secondary level. This tool is based on five criteria such as i) attitude while teaching in the classroom ii) scientific approach to teach science iii) content knowledge iv) knowledge of teaching methods v) skills of teaching science. Again the author also listed indicators for each criterion for easy observation and recording.

1. Attitude while Teaching in Classroom

Positive and desired attitude contribute significantly for pedagogical competency inside the classroom. The attitude of science teacher towards the subject, pupil, own responsibility can be observed minutely, when a teacher teaches in classroom. The fundamental scientific pedagogical outlook and ability to put in practice is an important aspect of pedagogical competency of a science teacher.

2. Scientific Approach to Teach Science

It is important for a teacher to follow planned, systematic, logical step to make students understand each and every teaching points. Any concept cannot be accepted blindly. Teacher need to formulate hypothesis and help the students to reach to the facts through relevant evidence, illustration for testing hypothesis. It can be observed that whether the teacher is able to create such a scientific environment inside the classroom by adopting scientific approach or accepting everything written in the textbook only. Thus observable scientific approach inside the classroom would predict the relevant pedagogical competency of science teacher.

3. Content Knowledge

A science teacher should have depth knowledge of the scientific concept, principle, law , generalisation and its application so that he/she can make learner understand and can give additional knowledge in the particular context. In addition to this the science teacher must be able to apply this knowledge in relation to other aspects of pedagogical competency at proper

time through relevant insight. Content knowledge of science teacher can also be observed in the classroom situation.

4. Knowledge of Teaching Methods

Pedagogical competency of science teacher is dependent on ability to use certain specific teaching methods for certain concepts, laws, principles in science. Different methods are used in science teaching such as lecture cum discussion, problem solving, enquiry, discussion, cooperative and collaborative learning, project method, demonstration method. One can observe how effectively the teacher uses relevant teaching methods while teaching.

5. Skills of Teaching Science

Teaching skills are the pillars of the pedagogical competency. Every aspect of the pedagogical competencies needs their delivery to the learners through teaching skills. The teaching skills are all art and behaviour of teacher that maximises pupil's learning as well as makes communication between the teacher and pupils efficient. Skills such as skill of introducing a lesson, explaining, probing question, illustration, using teaching aids, reinforcement, using blackboard, stimulus variation, managing student, evaluation are crucial for performance of adequate pedagogical competency of science teacher. Each criterion is based on number of indicators, which will help the observer for better observation. The details of criterion along with its indicators are given in Table-1

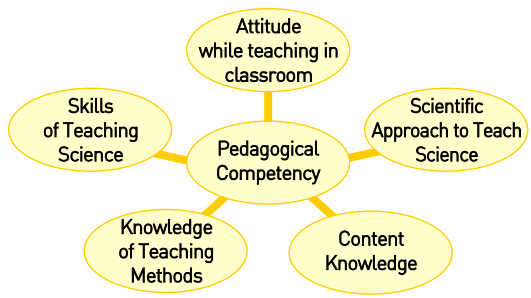

Fig. 2 Different elements of pedagogical competency of science teaching

Table 1: Details of criteria and indicators of observation schedule

Criteria	Indicators	Scale Value
1. Attitude while teaching in classroom	1. Exhibits the roles and responsibilities of science teacher and emit the same from students 2. Keeps eye-contact with all students in classroom 3. Creates a suitable teaching-learning climate 4. Plans teaching with student as starting point 5. Stimulates students to be active learners 6. Listens to students without bias and prejudice	1. 2. 3. 4. 5.
2. Scientific approach to teach science	7. Plans teaching in accordance with latest pedagogy 8. Relate teaching to latest research findings on subject 9. Apply an objective and reflective approach	

	10. Helps students to develop problem solving and scientific attitude 11. Formulate hypotheses and test it through relevant evidences 12. Uses student's response for further improvement of teaching and learnings.	
3. Content knowledge	13. Sound knowledge of science content 14. Gives latest knowledge in science 15. Refers to latest publications, and other learning resources 16. Resolves the doubts and queries of students correctly 17. Sound knowledge of scientific experimentation and demonstration	
4. Knowledge of teaching methods	18. Familiar with different teaching methods of science 19. Good knowledge of different parts of the teaching-learning process 20. Uses suitable method of teaching for topic 21. Familiar with a variety of mode of assessment 22. Uses teaching methods appropriate for going beyond textbook 23. Sound knowledge in conducting practical activities 24. Uses low cost and no cost locally available teaching aids	
5. Skills of teaching science	25. Uses relevant introduction strategy for introducing topic 26. Makes structured, organised and clear oral presentation 27. Puts questions with proper speed, pause and voice 28. Manages students response by using different techniques 29. Uses simple, relevant and interesting examples 30. Uses relevant teaching aid during teaching 31. Handles/manages apparatus, chemicals/other teaching aids 32. Uses blackboard appropriately 33. Manages student behaviour by using verbal and non verbal techniques in laboratory and science class 34. Provides suitable reinforcement to students 35. Reviews the lesson at end of class 36. Gives well thought home assignment	1. 2. 3. 4. 5.

Reliability and Validity of Observation Schedule

The tool is standardised on science teachers (both rural and urban) teaching at secondary level, Odisha. The reliability of the observation tool was estimated by using test-retest method by giving seven days gap. It was found to be 0.824. Similarly, for getting validity the tool was distributed to ten Science teacher educators who have validated it through their significant suggestions and recommendations. Thus the face and content validity is ensured.

Administration and Scoring of Observation Schedule

The observation schedule is useful for assessing pedagogical competency of science teacher. The person having knowledge and understanding on science teaching can use it for recording pedagogical competency. One needs to observe the total period and record observation by this schedule by marking on scale points. It's a five point scale stated as 1, 2, 3, 4, 5 corresponding to Very Poor, Poor, Good, Very Good and Excellent. The observation schedule can be scored by adding scale value on different indicator. The Table-2 presents details of scoring of tool.

Table 2: Maximum score against each criteria of observation schedule

Sl. No	Criteria	No. of Indicators	Minimum Score	Maximum Scores
1.	Attitude while teaching science in classroom	6	6	30
2.	Scientific approach to teach science	6	6	30
3.	Content knowledge	5	5	25
4.	Knowledge of teaching methods	7	7	35
5.	Skills of teaching science	12	12	60
	Total	36	36	180

Interpretation of Observation Schedule

The observation schedule can be interpreted on the basis of percentage of score obtained by the teachers. The Table-3 gives detail idea about process of interpretation.

Table 3 Score range and level of pedagogical competency

Percentage of score	Score range	Level of pedagogical competency
Less than 20	Less than 36	Very poor
20-39	36-70.2	Poor
40-59	72-106.2	Good
60-89	108-160.2	Very good
90 & above	Above 162	Excellent

Conclusion

Assessing pedagogical competency is essential for enhancing quality of science teaching and learning. The most important task in this context is to map pedagogical competency of science teacher which is very critical as it requires keen observation capacity and understanding on the part of the observer. Each and every indicators of the ability to apply knowledge, attitude, method, approach, skill of the science teacher has to be observed and assessed to evaluate the pedagogical competency of the science teacher. This Observation Schedule can be used for assessing pedagogical competency of secondary school science teachers. So this tool will be very useful for researchers, educationists, teacher educators as well as educational administrators.

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ASSESSMENT CONCEPT AND STRATEGIES

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Assessment is one of the best tools to know our students/learner. Teacher recognises that it helps to improve their teaching and they may be able to know where students stand. In this paper we would like to improve of assessment in day-to-day teaching and learning in the classroom and its board spectrum in the society at large. It helps to know learning pattern of students in general.

Introduction

The word assessment is derived from the Latin word "Assidere" which means to sit besides. Therefore assessment in the present context carries significant relationship to its etymological meaning. In the school education, assessment holds a significant place in trying to find out or apprise our self about the child performance. Educational assessment is a term having wide range of implications that includes all the process and the product that describes the nature and extent of a child's learning.

Purpose of Assessment

The scope of assessment depends upon the purposes of educational assessment. It may either be used to screen the group of students whether they conform or do not conform to given standards or it may be used to evaluate educational programme and teaching methodologies. Culture has pervasive effects on determining the ways in which assessment are done. Therefore, cultural considerations play a significant role in distinguishing parameters of assessment across nation. Authors such as Mercer (1973) and Satter (1982) argued that many formal tests are biased against students from minority culture. This bias may take many forms. Two common examples are text questions that hold little relevance to the minority group. Such omissions and commissions in terms of assessment have not been found in Indian context. More so because the assessment modalities are governed by centralised bodies such as CBSE, ICSE and State Boards. In such a situation, individual school and teacher do not have a say on the assessment structure. There are more takers of pre-designed system.

Type of Assessment

Assessment can be divided into two types – formal assessment and informal assessment. Formal assessment proposes standards that compare the individual in performance with the peer group. Formal tests in evaluation processes are best used for classification of students on the basis of intellectual, sensory and academic ability

in order to determine a student's eligibility performance. With this the purpose of testing often is completed in several sessions and the results are evaluated by the team of professionals. Formal test can also be used to evaluate the measure of an educational programme. A great deal of caution needs to be exercised in evaluating student as well as school programme. A slightest degree of error may lead to determination of wrong judgment. A lot is based on formal assessment in considering a course on future for the child as a useful educational programme. Parallel with the formal assessment, informal assessment can also be administered. The informal assessment consists of those processes of evaluation that indicates skills and behaviour relevant to the curriculum with the used teacher made devices. Informal assessment may constitute of test rating devices, checklist and observational system. Many of the items in the informal devices selected from instructional material like worksheets, games, flash cards etc. While giving informal test, the investigator should carefully observe and take note regarding the student's responses patterns depending upon the requirement of assessment information. The type of assessment whether formal or informal needs to be decided.

Assessment for Determining 'How to Teach'

The distinct requirement of instructions to a particular student depends upon the assessment result. Experts had given specific guideline for determining how to teach. Research supporting the use of direct instruction has been performed. States investigating the effectiveness of direct instructions for teaching academic skills have reported positive results.(Carnine and Silbert, 1979; Chadwick and Day,1970; Hartman,1974; Lovaas, 1968; Simth and Lovitt, 1973; Stephens, 1977, Hartman and Cooper, 1973).

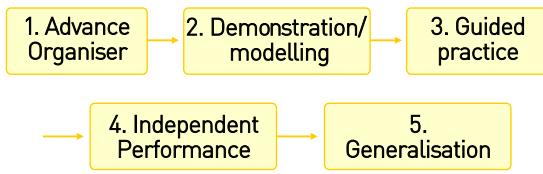

Fig. 1 *Direct Instruction Sequence*

The sequence in Figure 1 presents the basic steps of direct instruction. Learning Progress is assessed at each stage of the direct instruction sequence to determine if teaching is effective.

Advance Organisers

Advance organisers are used to improve the students content (Lenz, 1982) and develop the instructional process. If students are provided the steps of instruction it help them how to follow the content area. Mercer and Mercer (1985) has suggested the following as an advance organiser :

- provide background information
- motivate students to learn
- identify topics and/or tasks
- provide a structural framework for the class period
- clarify required activity
- introduce vocabulary
- state concepts to be learned
- state expected outcome

Demonstration/Modelling

This stage helps the students to learn about the new skills in particular concept and it gives them opportunity to ask more questions and learn the topic in better way. Teacher demonstrates in front of the students and that is why their ideas get clear and they can also learn and do themselves.

Guided Principle

In this stage students practice new skill with the help of teacher. They can learn with the help of peer and by doing repeatedly their errors get cleared. In this stage they get feedback from the teacher and feedback helps them to learn more. Students get verbal praise in this stage from the teacher.

Independent Performance

In this stage students start performing independently. If they are not able to perform they repeatedly start doing it by following the teachers' guidance, and sooner or later they become independent learner.

Generalisation

The generalisation skills occur when the student masters the skill and apply his mastery to solve problems. For example, if a child masters in properties of triangle then the child is able to solve the problems related to triangle.

Summary of Direct Instruction

All the above components of instruction are for effective transaction in the classroom. Their success have been documented through commercially produced programmes such as Distar reading (Engelmann and Berner, 1974), Corrective reading programme (Engelmann et.al.., 1978), and Corrective Spelling through Morphographs (Dixon and Engelmann, 1979). These components help the student with knowledge , motivation, and practice to various learning situations(Alley and Deshler, 1979; Shumaker , Deshler , Alley and Warner, 1983; Warner, Schumakar, Alley, and Deshler, 1980). Direct instruction includes the continuous assessment it helps the child to get feedback as per his/her need from the teachers.

Assessment of Mathematics Education

Learning of mathematics follows consequence that includes two basic concepts along with developments of computational skills. Many researchers claim that evaluating to understand the basic concept of mathematics leads to learning problem in the later year. Mathematics assessment revolves around the fundamental of computations.

The Nature of Mathematics

The Mathematics is a sequential concept. If child learns addition and master it then he can learn subtraction. The content of mathematics has logical structure. The content has to design from simple to complex relationship. Researchers (Sibert, Carnine, and Stein, 1981; Underhill, Uprichard, and Heddens, 1980) report that optimal learning occurs when instruction follows a hierarchy of math skills. Mastery of lower skills is required to develop higher skills in mathematics.

Level of Learning

Level of learning plays very important role in mathematics teaching. Underhill, Uprichd, and Heddens(1980) report several basic levels of learning in mathematical learning experiences. These levels are concrete, semi concrete, and abstract. Concrete level helps to develop manipulative skills. Semiconcrete level involves working illustrations of items to perform math task. The helping items include dots, tallies, pictures. The abstract levels mean to use numerals and student have to solve problem with the help of numerals. Student with difficulty in maths needs much experience with concrete and semi concrete experience before they start numerals. Traditionally assessment is conducted at abstract level only. But, authorities in mathematics education(Denmark, 1976; Engelhardt,1976; Reisman, 1982; Underhill,1976) said that assessment should not be limited to abstract level only. Traditional achievement helps to determine the achievement level of children and general area of weakness. Once the problem area is identified, the teacher may use informal assessment techniques at the concrete level to determine the necessary instruction for teaching specific concepts and skills.

Sequencing of Mathematics Instruction

To ensure efficient learning of essential math skills has to design programme and held the levels of learning, sufficient practice activities, and coverage of concepts, computation, and skill application. The following figure shows how the numerous components of math programme can be integrated (Susan, S.,et.al.1986). There are two strands.

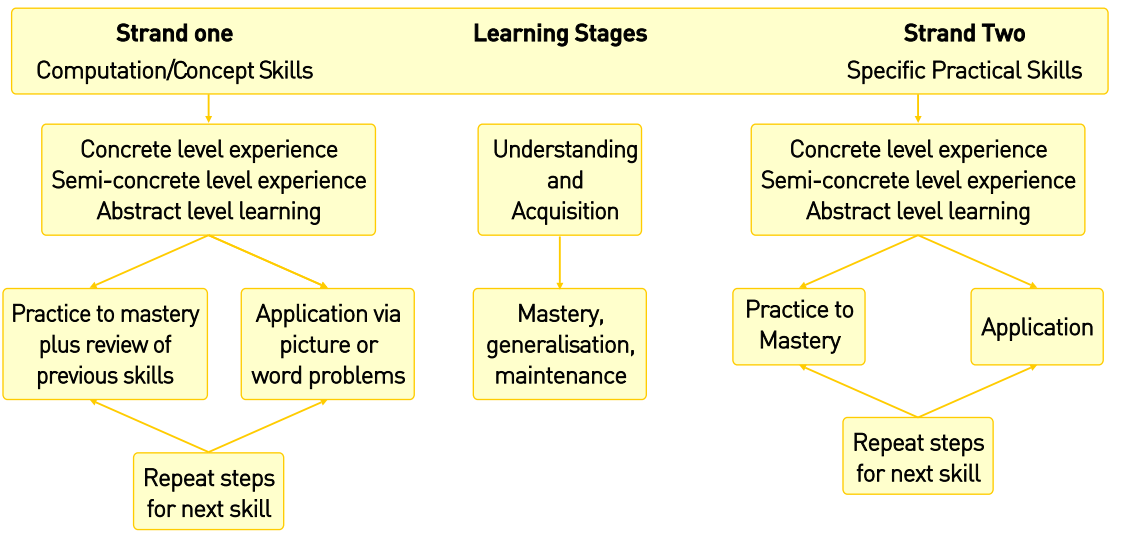

Fig. 2 *Mathematics Teaching Sequence*

Mastery of Skills

The assessment process helps to find out which skills is mastered by the child and in which skills the child is lacking mastery. The determination of skill mastery may be done by using percent correct and rate correct and incorrect. If an untimed criterion approach is used, it is good practice to include three items for each skill and 67 per cent or 100 per cent as criterion for mastery (Underhill, Uprichd, and Heddens,1980)

Conclusion

Assessment is one of the important tool by which we able to know the progress of the student. For overall development of the child in particular subject the informal assessment is also required which help the instructor to know the level of each child and accordingly the treatment may be provided to the child. This may help the child to achieve the mastery level in the subject which is utmost requirement for the progress of the child in the present time.

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ENVIRONMENT FRIENDLY AND COST-EFFECTIVE USE OF AQUEOUS HYDROGEN SULPHIDE FOR IDENTIFICATION OF CATIONS

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Qualitative analysis of inorganic salts is an integral or part of laboratory curriculum at higher secondary, under graduate and post graduate stages all over the world. Hydrogen sulphide is an analytical reagent used in qualitative analysis for the identification and confirmation of various cations. Hydrogen sulphide is a very poisonous gas with the characteristic foul odour of rotten eggs which also pollutes the environment. Increasing awareness about healthy laboratory environment has prompted to search greener and safer way to detect the cations as sulphides. Present paper describes the preparation of non-toxic aqueous hydrogen sulphide reagent which can be used in place of hydrogen sulphide gas.

Keywords:

Green Chemistry, Aqueous hydrogen sulphide reagent, Greener sulphide reagent, detection of group II and IV cations

Introduction

Hydrogen sulphide gas is a very important reagent used for the identification of cations of Group II (Hg^{2+}, Pb^{2+}, Bi^{3+}, Cu^{2+}, Cd^{2+}, As^{3+}, Sn^{2+}, Sb^{3+}, Sn^{4+}) and Group IV (Zn^{2+}, Mn^{2+}, Co^{2+}, Ni^{2+}) in a given salt mixture. These cations occupy more than 50 per cent portion of all the cations from group 0 to VI. Hydrogen sulphide has a great pedagogical importance as it gives detailed understanding of ionic equilibria, Le Chatelier's Principle, common ion effect and the solubility product. These concepts may be best understood in the laboratory by performing cation identification tests through hydrogen sulphide gas. It is inexpensive, can be prepared easily. It is prepared by the reaction of ferrous sulphide with concentrated strong acids like hydrochloric acid or sulphuric acid in a Kipps apparatus. Generally, hydrogen sulphide gas is used in 12 to 15 practical sessions for each academic year for qualitative analysis of cations. Hydrogen sulphide gas is a great health hazard. Teachers, laboratory staff and students are exposed to this gas number of times in a session.

Some workers (Johri 1971, Sidhwani and Choudhary, 2008) proposed alternative scheme of identification of cations without using hydrogen

sulphide gas. In one of the schemes, in place of hydrogen sulphide gas, potassium trithio carbonate (PTC) reagent is used (Johri, 1971). But preparation of PTC is not very easy and also requires hydrogen sulphide gas. These schemes have different classification system for cations into various groups. Majority of laboratory instructors do not have an idea about these classifications. In most of the universities, colleges and schools, the century-old classical method of analysis involving use of hydrogen sulphide gas is still in practice. Most of the books and available literature on analytical chemistry prescribe the classification and scheme of identification of cations using hydrogen sulphide gas (Vogel,1996).

Ill Effects of Hydrogen Sulphide Gas

In the laboratory, inhalation is the major cause of hydrogen sulphide exposure. It is rapidly absorbed through lungs. It is also absorbed through the gastrointestinal tract (ATSDR, 1999). The distribution of inhaled hydrogen sulphide is rapid and widespread. The storage of hydrogen sulphide in the body fluid is governed by its metabolism and excretion (Nagata et. al, 1990). The concentration of hydrogen sulphide in heart, brain, liver, kidneys and spleen is different for the same exposure of hydrogen sulphide (WHO 2003). Hydrogen sulphide is metabolised through oxidation, methylation and reactions with disulfide containing proteins (Beauchamp et al., 1984). The major metabolic pathway for detoxification of hydrogen sulphide is oxidation in liver; the major oxidation product of sulphide is thiosulfate, which is then converted to sulphate and subsequently execreted in urine (Bartholomew et al., 1980).

Preparation of Aqueous Hydrogen Sulphide Reagent:

Initially, hydrogen sulphide gas is prepared by the reaction of ferrous sulphide with concentration hydrochloric or sulphuric acid in Kipps apparatus:

$$Fe\ S + H_2SO_4 \rightarrow Fe\ SO_4 + H_2S$$

The evolved gas is passed through cold pre-boiled distilled water. It is a colourless gas with a characteristic odour of rotten eggs. It is soluble in water. The solubility of hydrogen sulphide in water is 4.12 g/L at 20^0C. Running of one time Kipps apparatus with about 50g ferrous sulphide is sufficient to make 1 litre of aqueous hydrogen sulphide reagent. This reagent is initially clear but over the time on exposure to air it turns cloudy. This is due to the slow reaction of hydrogen sulphide with oxygen dissolved in water, producing elemental sulphur, which makes solution cloudy. To increase the life span of the

Table 1 : Human Health Effects at Various Hydrogen Sulphide Concentrations (WHO, 2003)

Exposure (mg/m^3)	Effect/Observation	Reference
0.011	Odour threshold	Amoore and Hautala, 1983
2.8	Bronchial construction in asthmatic individuals	Jappinen et al., 1990
5.0	Increased eye complaints	Vanholorne et al., 1995
7 or 14	Increased blood lactate concentration, decreased skeletal muscle citrate synthase activity, decreased oxygen uptake	Bhambhani and Singh, 1991; Bhambhani et al., 1996b, 1997

5 – 29	Eye irritation	IPCS, 1981
28	Fatigue, loss of appetite, headache, irritability, poor memory, dizziness	Ahlhorg, 1951
→140	Olfactory paralysis	Hirsch and Zavala, 1999
→560	Respiratory distress	Spolyar, 1951
[3]700	Death	Beauchamp et al., 1984

reagent cold de-aired pre-boiled distilled water is used for the preparation of this reagent.

Hydrogen sulphide on dissolving in water enters into a series of chemical reactions. The chemical reactions include the dissociation of the molecular hydrogen sulphide into hydrogen sulphide ion,

$$H_2S_{(aq)} = H^+_{(aq)} + HS^-_{(aq)}$$

The dissociation of hydrogen sulphide ion into sulphide ion,

$$HS^-_{(aq)} = H^+_{(aq)} + S^{2-}_{(aq)}$$

And self ionisation of water,

$$H_2O = H^+_{(aq)} + OH^-_{(aq)}$$

Each of these reactions has an associated equilibrium relation. In pure water the hydrogen sulphide solution has a pH of about 4.

Cost-Effectiveness and Advantages of Using Aqueous Hydrogen Sulphide

There are about 800 universities and approximately 8000 colleges in India offering chemistry and chemistry-related subjects as a discipline. In addition there are millions of higher secondary schools, where chemistry is taught as a subject. In all cases, qualitative inorganic analysis is carried out. A science student of higher secondary stage has chemistry laboratory for two years in which hydrogen sulphide gas is handled. A maximum of ten such classes for two hours duration is allotted for quantitative analysis. The average number of students doing qualitative analysis in schools and colleges are about 50 and 150 respectively. For a batch of 20 students working about 3 hours almost 20 dm^3 of H_2S is generated using a Kipps apparatus. Some H_2S escapes to the atmosphere, causing air pollution, while the rest pollutes water. Running a Kipps apparatus onetime requires about 50g of ferrous sulphide and about 500 mL of 6N sulphuric acid. It is estimated that about 100 to 125 test trials are made with H_2S gas by a batch of 20 students. While only 8 to 10 drops of aqueous H_2S reagent is sufficient for single test, hence 1 Litre of reagent is able to perform 2000 – 2500 test trials for cations [1mL = 20 drops]. It is clear from the estimation that with the same amount of chemicals, 20 times more number of tests can be performed by using aqueous H_2S reagent. Moreover, teachers, students and laboratory staff are saved from the multiple exposure of deadly hydrogen sulphide gas. This results in 95% saving of materials (chemicals) and great saving from ill effects of hydrogen sulphide gas.

Using Kipps apparatus has disadvantage of contamination of other metal sulphides as the

same delivery tube of the apparatus is used by the number of students for identification of various cations. This disadvantage can also be overcome by the use of aqueous hydrogen sulphide reagent.

The author has prepared the reagent and successfully used it for several years during the practical sessions of pre-service science teachers at Regional Institute of Education at Ajmer (Rajasthan) and Bhubaneswar (Orissa), India.

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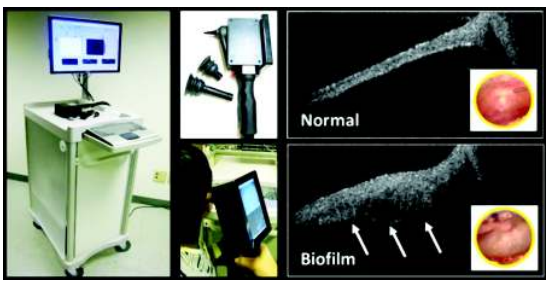
SCIENCE NEWS

Nowhere to Hide: New Device Sees Bacteria Behind the Eardrum

Doctors can now get a peek behind the eardrum to better diagnose and treat chronic ear infections, thanks to a new medical imaging device invented by University of Illinois researchers. The device could usher in a new suite of non-invasive, 3-D diagnostic imaging tools for primary-care physicians.



University of Illinois researchers tested a prototype of a new device that can see biofilms behind the eardrum to better diagnose and treat chronic ear infections. (Credit: Graphic by Stephen Boppart)

The research team, led by University of Illinois electrical and computer engineering professor Stephen Boppart, will publish their advance in the online Early Edition of the journal Proceedings of the National Academy of Sciences the week of May 28.

Ear infections are the most common conditions that pediatricians treat. Chronic ear infections can damage hearing and often require surgery to place drainage tubes in the eardrum, and problems can persist into adulthood.

Studies have found that patients who suffer from chronic ear infections may have a film of bacteria or other microorganisms that builds up behind the eardrum, very similar to dental plaque on unbrushed teeth. Finding and monitoring these so-called biofilms are important for successfully identifying and treating chronic ear infections.

"We know that antibiotics don't always work well if you have a biofilm, because the bacteria protect themselves and become resistant," Boppart said.

"In the presence of a chronic ear infection that has a biofilm, the bacteria may not respond to the usual antibiotics, and you need to stop them. But without being able to detect the biofilm, we have no idea whether or not it is responding to treatment."

However, middle-ear biofilms are difficult to diagnose. A doctor looking through a standard otoscope sees only the eardrum's surface, not the bacteria-seeded biofilm lurking behind it waiting to bloom into infection. Invasive tests can provide evidence of a biofilm, but are unpleasant for the patient and cannot be used routinely.

The new device is an application of a technique called optical coherence tomography (OCT), a non-invasive imaging system devised by Boppart's group. It uses beams of light to collect high-resolution, three-dimensional tissue images, scanning through the eardrum to the biofilm behind it — much like ultrasound imaging, but using light.

"We send the light into the ear canal, and it scatters and reflects from the tympanic membrane and the biofilm behind it," said graduate student Cac Nguyen, the lead author of the paper. "We measure the reflection, and with the reference light we can get the structure in depth."

The single scan is performed in a fraction of a second — speed is a necessity for treating squirming tots — and images a few millimeters deep behind the eardrum. Thus, doctors can see not only the presence of a biofilm, but also how thick it is and its position against the eardrum.

The researchers hope to make their device — currently a hand-held prototype — even more compact, easy to use, and low-cost. The device company Welch Allyn, based in Skaneateles Falls, N.Y., is a collaborator in the project, which was funded by the National Institutes of Health.

Steel-Strength Plastics: Durable Plastic May Replace Metals

As landfills overflow with discarded plastics, scientists have been working to produce a biodegradable alternative that will reduce pollution. Now a Tel Aviv University researcher is giving the quest for environmentally friendly plastics an entirely new dimension — by making them tougher than ever before.

Prof. Moshe Kol of TAU's School of Chemistry is developing a super-strength polypropylene — one of the world's most commonly used plastics — that has the potential to replace steel and other materials used in everyday products. This could have a long-term impact on many industries, including car manufacturing, in which plastic parts could replace metallic car parts.

Durable plastics consume less energy during the production process, explains Prof. Kol. and there are additional benefits as well. If polypropylene car parts replaced traditional steel, cars would be lighter overall and consume less fuel, for example. And because the material is cheap, plastic could provide a much more affordable manufacturing alternative.

Although a promising field of research, biodegradable plastics have not yet been able to mimic the durability and resilience of common, non-biodegradable plastics like polypropylene. Prof. Kol believes that the answer could lie in the catalysts, the chemicals that enable their production.

Plastics consist of very long chains called polymers, made of simple building blocks assembled in a repeating pattern. Polymerisation

catalysts are responsible for connecting these building blocks and create a polymer chain. The better the catalyst, the more orderly and well-defined the chain — leading to a plastic with a higher melting point and greater strength and durability. This is why the catalyst is a crucial part of the plastic production process.

Prof. Kol and his team of researchers have succeeded in developing a new catalyst for the polypropylene production process, ultimately producing the strongest version of the plastic that has been created to date. "Everyone is using the same building blocks, so the key is to use different machinery," he explains. With their catalyst, the researchers have produced the most accurate or "regular" polypropylene ever made, reaching the highest melting point to date.

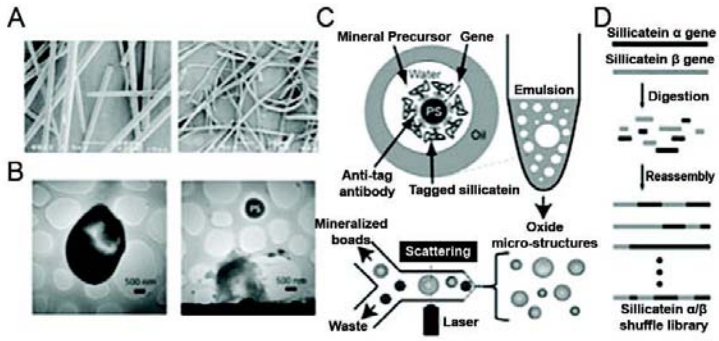
Prof. Kol's polypropylene is good news for green manufacturing and could revolutionise the industry. The durability of the plastic results in products that require less maintenance — and a much longer life for parts made from the plastic.

Beyond car parts, Prof. Kol envisions a number of uses for this and related plastics, including water pipes, which he says could ultimately conserve water use. Drinking water for the home has been traditionally carried by steel and cement pipes. These pipes are susceptible to leakage, leading to waste and therefore, higher water bills. But they are also very heavy, so replacing them can be a major, expensive operation.

"Plastic pipes require far fewer raw materials, weighing ten times less than steel and a hundred times less than cement. Reduced leaking means more efficient water use and better water quality," Prof. Kol explains. The replacement of steel water pipes by those made of plastic is becoming more common, and the production of plastics with even greater strength and durability will make this transition even more environment-friendly.

Scientists Synthesise First Genetically Evolved Semiconductor Material

In the not-too-distant future, scientists may be able to use DNA to grow their own specialised materials, thanks to the concept of directed evolution. UC Santa Barbara scientists have, for the first time, used genetic engineering and molecular evolution to develop the enzymatic synthesis of a semiconductor.



This image shows the process of synthesising silica through directed evolution of silicatein proteins. (Credit: Published with permission from PNAS Plus - Biological Sciences - Biochemistry: Lukmaan A. Bawazer, Michi Izumi, Dmitriy Kolodin, James R. Neilson, Birgit Schwenzer, and Daniel E. Morse PNAS Plus: Evolutionary selection of enzymatically synthesised semiconductors from biomimetic mineralisation vesicles PNAS 2012 ; published ahead of print June 7, 2012, doi:10.1073/pnas.1116958109)

"In the realm of human technologies it would be a new method, but it is an ancient approach in

nature," said Lukmaan Bawazer, first author of the paper, "Evolutionary selection of enzymatically synthesised semiconductors from biomimetic mineralisation vesicles," published in the Proceedings of the National Academy of Sciences. Bawazer, who was a Ph.D. student at the time, wrote the paper with co-authors at UCSB's Interdepartmental Graduate Programme in Biomolecular Science and Engineering; Institute for Collaborative Biotechnologies; California NanoSystems Institute and Materials Research Laboratory; and Department of Molecular, Cellular and Developmental Biology. Daniel Morse, UCSB professor emeritus of biochemistry of molecular genetics, directed the research.

Using silicateins, proteins responsible for the formation of silica skeletons in marine sponges, the researchers were able to generate new mineral architectures by directing the evolution of these enzymes. Silicateins, which are genetically encoded, serve as templates for the silica skeletons and control their mineralisation, thus participating in similar types of processes by which animal and human bones are formed. Silica, also known as silicon, is the primary material in most commercially manufactured semiconductors.

In this study, polystyrene microbeads coated with specific silicateins were put through a mineralisation reaction by incubating the beads in a water-in-oil emulsion that contained chemical precursors for mineralisation: metals of either silicon or titanium dissolved in the oil or water phase of the emulsion. As the silicateins reacted with the dissolved metals, they precipitated them, integrating the metals into the resulting structure and forming nanoparticles of silicon dioxide or titanium dioxide.

With the creation of a silicatein gene pool, through what Bawazer only somewhat euphemistically calls "molecular sex" — the combination and recombination of various silicatein genetic materials — the scientists were able to create a multitude of silicateins, and then select for the ones with desired properties.

"This genetic population was exposed to two environmental pressures that shaped the selected minerals: The silicateins needed to make (that is, mineralise) materials directly on the surface of the beads, and then the mineral structures needed to be amenable to physical disruption to expose the encoding genes," said Bawazer. The beads that exhibited mineralisation were sorted from the ones that didn't, and then fractured to release the genetic information they contained, which could either be studied, or evolved further.

The process yielded forms of silicatein not available in nature, that behaved differently in the formation of mineral structures. For example, some silicateins self-assembled into sheets and made dispersed mineral nanoparticles, as opposed to more typical agglomerated particles formed by natural silicateins. In some cases, crystalline materials were also formed, demonstrating a crystal-forming ability that was acquired through directed evolution, said Bawazer.

Because silicateins are enzymes, said Bawazer, with relatively long amino acid chains that can fold into precise shapes, there is the potential for more functionality than would be possible using shorter biopolymers or more traditional synthetic approaches. In addition, the process could potentially work with a variety of metals, to evolve different types of materials. By changing the laboratory-controlled environments in which

directed evolution occurs, it will be possible to evolve materials with specific capacities, like high performance in an evolved solar cell, for example.

"Here we have demonstrated the evolution of material structure; I'd like to take it a step further and evolve material performance in a functional device," said Bawazer.

Research for this paper was supported by the U.S. Department of Energy.

Lichen can Survive in Space: Space Station Research Sheds Light on Origin of Life; Potential for Better Sunscreens

You can freeze it, thaw it, vacuum dry it and expose it to radiation, but still life survives. ESA's research on the International Space Station is giving credibility to theories that life came from outer space — as well as helping to create better sunscreens.

In 2008, scientists sent the suitcase-sized Expose-E experiment package to the Space Station filled with organic compounds and living organisms to test their reaction to outer space. When astronauts venture on a spacewalk, hours are spent preparing protective suits to survive the hostile conditions. No effort was made to protect the bacteria, seeds, lichen and algae attached to the outside of the Space Station, however.

"We are exploring the limits of life," explains ESA's René Demets. Our atmosphere does a wonderful job of protecting life on Earth by absorbing harmful UV rays and keeping temperatures relatively stable.

In contrast, the space samples endured the full power of the Sun's rays. The samples were insulated somewhat by the Space Station but still had to cope with temperatures changing from -12ºC to +40ºC over 200 times as they orbited Earth.The samples returned to Earth in 2009 and the results have now been published in a special issue of the journal *Astrobiology*.

Lichen have proven to be tough cookies — back on Earth, some species continue to grow normally. René explains, "These organisms go into a dormant state waiting for better conditions to arrive."The lichen have attracted interest from cosmetic companies. They can survive the full power of the Sun for 18 months, so knowing more could lead to new ingredients for sunscreen.

Living organisms surviving in open space supports the idea of 'panspermia' — life spreading from one planet to another, or even between solar systems. It seems possible that organisms could colonise planets by hitching rides on asteroids. ESA is probing this intriguing theory further on future Station missions with different samples.

Lab-Engineered Kidney Project Reaches Early Milestone

Regenerative medicine researchers at Wake Forest Baptist Medical Center have reached an early milestone in a long-term project that aims to build replacement kidneys in the lab to help solve the shortage of donor organs.

In proof-of-concept research published online ahead of print in *Annals of Surgery*, the team

successfully used pig kidneys to make "scaffolds" or support structures that could potentially one day be used to build new kidneys for human patients. The idea is to remove all animal cells — leaving only the organ structure or "skeleton." A patient's own cells would then be placed on the scaffold, making an organ that the patient theoretically would not reject.

While this is one of the first studies to assess the possibility of using whole pig kidneys to engineer replacement organs, the idea of using organ structures from pigs to help human patients is not new. Pig heart valves — removed of cells — have been used for more than three decades to provide heart valve replacements in human patients.

"It is important to identify new sources of transplantable organs because of the critical shortage of donour organs," said lead author Giuseppe Orlando, M.D., an instructor in surgery and regenerative medicine at Wake Forest Baptist. "These kidneys maintain their innate three-dimensional architecture, as well as their vascular system, and may represent the ideal platform for kidney engineering."

For the research, pig kidneys were soaked in a detergent to remove all cells, leaving behind the organ's "skeleton," including its system of blood vessels. In addition, the structure of the nephron — the kidney's functional unit — was maintained. The scaffolds were implanted in animals, where they were re-filled with blood and were able to maintain normal blood pressure, proving that the process of removing cells doesn't affect the mechanical strength of the vessels.

"There are many challenges to be met before this system could be used to engineer replacement kidneys, including problems with blood clots forming in the vessels," said Anthony Atala, M.D., co-author and director of the Wake Forest Institute for Regenerative Medicine. "The kidney is a very complex organ with at least 22 different cell types."

But, the fact that nephron structure is maintained suggests the potential to re-populate the kidney with cells, according to the scientists. They speculate that new cells introduced into the scaffold would recognise their natural niche through physical or chemical signals of the scaffold.

While the project is in its infancy, the idea represents a potential solution to the extreme shortage of donor kidneys. According to the authors, the probability in the U.S. of receiving a kidney transplant within five years of being added to the waiting list is less than 35 percent. As of late August 2011, nearly 90,000 patients in the U.S. were waiting for kidney transplants.

The science of regenerative medicine has already had success engineering skin, cartilage, bladders, urine tubes, trachea and blood vessels in the lab that were successfully implanted in patients. These structures were able to receive oxygen and nutrients from nearby vascularised tissues until they developed their own blood vessel supply.

However, the "holy grail" of regenerative medicine is to engineer more complex organs such as the kidney, liver, heart and pancreas. These organs are very dense with cells and must have their own oxygen supply to survive. This need for a scaffold with a full vasculature is why scientists are exploring the possibility of removing cells from donor organs and replacing them with a patient's own cells.

Scientists have already used scaffolds from rodents or pigs to engineer heart, liver, lung and intestinal scaffolds. When re-populated with organ-specific cells, these "organoids" were able to produce some of the functions of native organs in the lab. The goal of the current study is to produce kidney scaffolds from the pig because of similarities to humans in terms of organ structure and size.

The research was supported by the Telemedicine and Advanced Technology Research Center.

Novel Vaccine for Strain of Foot-And-Mouth Disease

One of the most economically devastating diseases in the world for those who raise cows, sheep, pigs, goats, deer and other cloven-hoofed animals is foot and mouth Disease (FMD). This incredibly contagious and fast-spreading disease causes fever, blisters on the feet and mouth (hence the name), loss of appetite, drooling, and lameness. Most herds affected are culled, as in the case of the 2001 outbreak in Great Britain when over 10 million animals had to be destroyed.

Traditional vaccines for FMD typically have three problems: *first*, there are so many different strains of the FMD virus that you must have a very well-matched vaccine to have any effect; *second*, traditional vaccines contain live FMD virus so they cannot be produced in the United States, and; *third*, depending on a vaccine's quality, it can be nearly impossible to determine whether an animal is actually infected, or has simply been exposed to the vaccine. Unless one can differentiate between vaccinated and infected animals, those animals vaccinated outside the U.S. with the traditional vaccine would be prohibited from entering any country that is designated FMD free. The United States has been FMD-free since 1929, but this is no guarantee that the disease will not strike again, as the UK learned in 2001 after being FMD-free for 34 years.

Now, at the Department of Homeland Security Science and Technology Directorate's high-containment Plum Island Animal Disease Center (PIADC), located off the tip of Long Island, scientists have produced a molecular vaccine against one strain of FMD, that 1) does not use a live FMD virus for vaccine manufacture, and; 2) can be used to differentiate an infected from inoculated animal using common diagnostic tests.

"This is the biggest news in FMD research in the last 50 years," says PIADC Director Dr. Larry Barrett. "It is the first licensed FMD vaccine that can be manufactured on the U.S. mainland, and it supports a vaccinate-to-live strategy in FMD outbreak response."

The new FMD vaccine, originally discovered by Dr. Marvin Grubman in the USDA Agricultural Research Service at PIADC, took seven years to develop and license. Dr. Bruce Harper, Director of Science at PIADC and the manager over PIADC's Targeted Advanced Development Branch, led the development team, who worked with industry partners GenVec Inc., a biopharmaceutical company in Gaithersburg, Maryland, and Antelope Valley Biologics, a Benchmark Biolabs affiliate in Lincoln, Nebraska.

The FMD viral structure includes genetic material surrounded by a coat of proteins called a capsid. The new vaccine produces only the virus coat particles, which form empty viral capsids, and not

the entire genome of the virus; thus it lacks the infectious viral nucleic acids. When the vaccine is injected into the animal the resulting empty viral capsids trigger a protective immune response.

"The absence of the nucleic acids of the real virus allows us to differentiate between vaccinated and infected animals," said Grubman. "This is critical when determining that an animal is free of infection after an FMD outbreak. Now it will no longer be necessary to destroy all the animals in a herd when just a few become infected."

The development of the vaccine was a team effort that required new scientific discoveries in order to work properly. Dr. John Neilan, the Branch Chief of the DHS Targeted Advanced Development Branch at PIADC, developed a way to address the immune response to the vaccine, which made it possible to achieve the level of effectiveness required for a USDA license. The vaccine has been granted conditional license for use in cattle by the USDA Animal and Plant Health Inspection Service's Center for Veterinary Biologics. Under the conditional license, the product may be distributed should the need for it arise, as authorised by federal emergency management officials within USDA. APHIS issued the conditional license to Antelope Valley Bios, Inc., who manufactured the vaccine under a contract from GenVec.

The FMD virus, noted since at least the 16th century, survives in lymph nodes and bone marrow. Large amounts of the virus are found in all body secretions and excretions and every time an infected animal breathes out it releases large amounts of infectious virus, exposing other animals. FMD virus can survive on the ground for extended periods, and can be carried in contaminated feed, manure, on the tires of vehicles and on the shoes and clothes of people. It has been documented to spread by being carried with the wind over long distances. The most common route of introduction of FMD into a country has been through feeding contaminated meat product scraps to pigs, as was the case in the devastating 2001 outbreak in the United Kingdom.

There are seven known serotypes and more than 60 subtypes of the FMD virus, and there is no universal vaccine against the disease. Potential cost of an FMD outbreak in United States could exceed $50 billion. FMD is present July 3 in Africa, the Middle East, Asia, and parts of South America.

"Our work isn't over yet," says S&T's Agricultural Defense Branch Chief Michelle Colby. "This vaccine protects against just one strain of FMD, so this is just the tip of a growing iceberg. DHS has several vaccines for other FMD serotypes ready to enter the licensure process."

Big Step Taken to Develop Nuclear Fusion Power

UT researchers have successfully developed a key technology in developing an experimental reactor that can demonstrate the feasibility of fusion energy for the power grid. Nuclear fusion promises to supply more energy than the nuclear fission used today but with far fewer risks.

Researchers and staff at UT's Magnet Development Laboratory prepare the central solenoid mockup for the vacuum pressure impregnation process. (Credit: University of Tennessee, Knoxville)

Mechanical, aerospace and biomedical engineering professors David Irick, Madhu Madhukar and Masood Parang are engaged in a project involving the United States, five other nations, and the European Union, known as ITER. UT researchers completed a critical step this week for the project by successfully testing their technology this week that will insulate and stabilise the central solenoid — the reactor's backbone.

ITER is building a fusion reactor that aims to produce 10 times the amount of energy that it uses. The facility is now under construction near Cadarache, France, and will begin operations in 2020."The goal of ITER is to help bring fusion power to the commercial market," Madhukar said. "Fusion power is safer and more efficient than nuclear fission power. There is no danger of runaway reactions like what happened in nuclear fission reactions in Japan and Chernobyl, and there is little radioactive waste." Unlike today's nuclear fission reactors, fusion uses a similar process as that which powers the sun.

Since 2008, UT engineering professors and about 15 students have worked inside UT's Magnet Development Laboratory (MDL) located off of Pellissippi Parkway to develop technology that serves to insulate and provide structural integrity to the more than 1,000 ton central solenoid.

A tokamak reactor uses magnetic fields to confine the plasma — a hot, electrically charged gas that serves as the reactor fuel — into the shape of a torus. The central solenoid, which consists of six giant coils stacked on top of one another, plays the starring role by both igniting and steering the plasma current.

The key to unlocking the technology was finding the right material — a glass fiber and epoxy chemical mixture that is liquid at high temperatures and turns hard when cured — and the right process of inserting this material into all of the necessary spaces inside the central solenoid. The special mixture provides electrical insulation and strength to the heavy structure. The impregnation process moves the material at the right pace, factoring in temperature, pressure, vacuum and the material's flow rate.

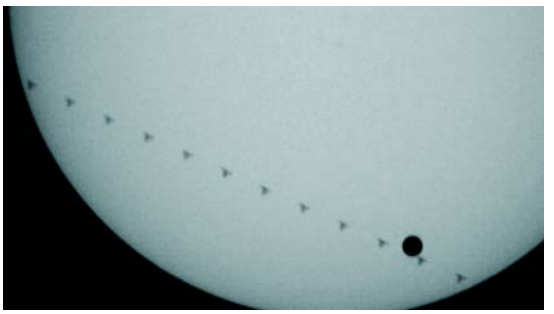
This week, the UT team tested the technology inside its mockup of the central solenoid conductor.It took two years to develop the technology, more than two days to impregnate the central solenoid mockup and multiple pairs of watchful eyes to ensure everything went according to plan.

This summer, the team's technology will be transferred to US ITER industry partner General Atomics in San Diego, which will build the central solenoid and ship it to France.

ITER — designed to demonstrate the scientific and technological feasibility of fusion power — will be the world's largest tokamak. As an ITER member, the US receives full access to all ITER-developed technology and scientific data, but bears less than 10 percent of the construction cost, which is shared among partner nations. US ITER is a Department of Energy Office of Science project managed by Oak Ridge National Laboratory.

Venus Transit: June 5-6, 2012

On June 5th, 2012, Venus has passed across the face of the sun, producing a silhouette that no one alive today will likely see again.



A double transit: the International Space Station and Venus on June 8, 2004. (Credit: Photo courtesy of Tomas Maruska.)

Transits of Venus are very rare, coming in pairs separated by more than a hundred years. This June's transit, the bookend of a 2004-2012 pair, won't be repeated until the year 2117. Fortunately, the event is widely visible. Observers on seven continents, even a sliver of Antarctica, will be in position to observe it.

The nearly 7-hour transit begins at 3:09 pm Pacific Daylight Time (22:09 UT) on June 5th. The timing favours observers in the mid-Pacific where the sun is high overhead during the crossing. In the USA, the transit will be at its best around sunset. That's good, too. Creative photographers will have a field day imaging the swollen red sun "punctured" by the circular disk of Venus.

Transits of Venus first gained worldwide attention in the 18th century. In those days, the size of the solar system was one of the biggest mysteries of science. The relative spacing of planets was known, but not their absolute distances. How many miles would you have to travel to reach another world? The answer was as mysterious then as the nature of dark energy is now.

Venus was the key, according to astronomer Edmund Halley. He realised that by observing transits from widely-spaced locations on Earth it should be possible to triangulate the distance to Venus using the principles of parallax.The idea galvanised scientists who set off on expeditions around the world to view a pair of transits in the 1760s. The great explorer James Cook himself was dispatched to observe one from Tahiti, a place as alien to 18th-century Europeans as the Moon or Mars might seem to us now. Some historians have called the international effort "the Apollo programme of the 18th century."

This year's transit is the second of an 8-year pair. Anticipation was high in June 2004 as Venus approached the sun. No one alive at the time had seen a Transit of Venus with their own eyes, and the hand-drawn sketches and grainy photos of previous centuries scarcely prepared them for what was about to happen. Modern solar telescopes captured unprecedented view of Venus's atmosphere backlit by solar fire. They saw Venus transiting the sun's ghostly corona, and gliding past magnetic filaments big enough to swallow the planet whole.

Our Microbes, Ourselves: Billions of Bacteria Within, Essential for Immune Function, Are Ours Alone

Gut bacteria's key role in immunity is tuned to the host species, researchers have found, suggesting that the superabundant microbes lining our digestive tract evolved with us — a tantalising clue in the mysterious recent spike in human autoimmune disorders.

A new study reports that the superabundance of microbial life lining our GI tracts has coevolved with us. These internal bacteria, which are essential for a healthy immune system, are ultimately our evolutionary partners. In other words, humans may have co-evolved with gut bacteria unique to humans, which are not immunologically functional in other mammals.

This study, the first to demonstrate that microbes are specific to their host species, also sheds light on what's called 'the hygiene hypothesis.' According to this idea, living in increasingly hyper-hygienic environments might contribute to recent spikes in childhood allergies, as these beneficial host-specific microbes are hindered by the plethora of antibacterial home products and cleaning chemicals.

"For every cell in your body that is you, that contains your specific genetic information, there are approximately nine foreign bacterial cells, primarily in your digestive tract and even on your skin," said Dennis Kasper, HMS professor of microbiology and immunobiology and senior author on the paper. "From the viewpoint of cell count, every human being is ninety percent microbial. Now we've found that these bacteria, which we need for optimal health, are species specific."

That 500 to 1,000 microbial species inhabit mammals has long been documented. Researchers have suggested that when it comes to digestion and other metabolic activities, the particular species of bacteria may not be significant provided the bacteria contain specific, helpful genes. In other words, a bacterium that breaks down food in the mouse gut can probably do the same in the human.

But the microbes that fortify our immune system have not been studied in this regard. Are they functionally unique, or would any species suffice?

To address this question, Hachung Chung, a postdoctoral researcher in Kasper's lab, studied two groups of mice, both of which had been bred to lack microbial flora. For one group, she introduced microbial species that are natural to mice, and to the second, she introduced human microbes. For both groups of mice, an equal quantity of microbes, and an equal diversity of species, soon flourished in their digestive tracts.But despite this apparent similarity, when Chung examined the intestinal tissue, including intestinal lymph nodes, of mice from each of the two groups, she discovered that the mice with humanised microbes had surprisingly low levels of immune cells, levels equivalent to mice who lacked intestinal bacteria all together."Despite the abundant and complex community of bacteria that were in the human flora mice, it seemed like the mouse host did not recognise the bacteria, as if the mice were germ-free," said Chung.

Chung repeated the experiment, only this time populating a third group of mice with microbes

common to rats. This new group showed the same immune system deficiency as the humanised mice. "I was very surprised to see that," Chung said. "Naturally, I would have expected more of a half-way response."

In a third experiment, Chung infected all the mice with salmonella. Almost from day one, the mice with human flora showed significantly higher levels of salmonella in their system than the mice with normal flora. The immune systems of the mice with human flora were effectively incapable of fending off the pathogenic bacteria.

"This raises serious questions regarding our current overuse of antibiotics, as well as ultra-hygienic environments that many of us live in," said Kasper. "If the bacteria within us are specific to us and necessary for normal immune system function, then it is important to know if we are in fact losing these vital bacteria. Are we losing the bacteria we have coevolved with? If that is the case, then this is yet further evidence supporting the idea that the loss of good bacteria is partly to blame for the increased rates of autoimmunity that we are now seeing."

Infection Biology: The Elusive Third Factor

LMU researchers have identified an enzyme that is involved in a modification pathway that is essential for bacterial pathogenicity. Because it shows no similarity to other known proteins, it may be an ideal target for development of novel antimicrobial drugs.

Studies on a number of pathogenic bacteria have shown that these strains become pathogenic only when an enzyme called elongation factor P (EF-P) is chemically modified on a conserved lysine residue. EF-P is a universally conserved translation factor, which is involved in protein synthesis. Two enzymes are known to be involved in modifying the conserved lysine of EF-P, however these enzymes cannot fully account for the pattern of modification seen on EF-P in living cells.

Thus, at least one other protein must be involved in the modification process — however to date it has proved to be particularly elusive. Now a research team led by LMU biochemist Daniel Wilson, who is also affiliated with the Center for Integrated Protein Science Munich (CIPSM), a Cluster of Excellence at LMU, has succeeded in identifying the mystery protein as the enzyme YfcM and showing that it displays hydroxylase activity. Strikingly, YfcM shows no sequence similarity to any other known protein and therefore, may have a unique structure.

This is not the only reason why discovery of YfcM will arouse great interest. "YfcM may turn out to be an ideal target for the development of new — and urgently needed — antibiotics, however, more insight will be needed to ascertain the role of the YfcM mediated hydroxylation of EF-P," says Wilson.

Source: Science Daily online

BioChip May Make Diagnosis of Leukemia and HIV Faster, Cheaper

Inexpensive, portable devices that can rapidly screen cells for leukemia or HIV may soon be possible, thanks to a chip that can produce three-dimensional focusing of a stream of cells, according to researchers.

"HIV is diagnosed based on counting CD4 cells," said Tony Jun Huang, associate professor of engineering science and mechanics at Penn State. "Ninety percent of the diagnoses are done using flow cytometry."

Huang and his colleagues designed a mass-producible device that can focus particles or cells in a single stream and performs three different optical assessments for each cell. They believe the device represents a major step toward low-cost flow cytometry chips for clinical diagnosis in hospitals, clinics and in the field.

"The full potential of flow cytometry as a clinical diagnostic tool has yet to be realised and is still in a process of continuous and rapid development," the team said in a recent issue of Biomicrofluidics. "Its current high cost, bulky size, mechanical complexity and need for highly trained personnel have limited the utility of this technique."

Flow cytometry typically looks at cells in three ways using optical sensors. Flow cytometers use a tightly focused laser light to illuminate focused cells and to produce three optical signals from each cell. These signals are fluorescence from antibodies bound to cells, which reveals the biochemical characteristics of cells; forward scattering, which provides the cell size and its refractive index; and side scattering, which provides cellular granularity. Processing these signals allows diagnosticians to identify individual cells in a mixed cell population, identify fluorescent markers and count cells and other analysis to diagnose and track the progression of HIV, cancer and other diseases.

"Current machines are very expensive, costing $100,000," said Huang. "Using our innovations, we can develop a small one that could cost about $1,000."

One reason the current machines are so large and expensive is the method used to channel cells into single file and the necessary alignment of lasers and multiple sensors with the single-file cell stream. Currently, cells are guided into single file using a delicate three-dimensional flow cell that is difficult to manufacture. More problematic is that these current machines need multiple lenses and mirrors for optical alignment.

"Our approach needs only a simple one-layer, two-dimensional flow cell and no optical alignment is required," said Huang.

Huang and his team used a proprietary technology named microfluidic drifting to create a focused stream of particles. Using a curved microchannel, the researchers took advantage of the same forces that try to move passengers in a car to the outside of a curve when driving. The microfluidic chip's channel begins as a main channel that contains the flow of carrier liquid and a second channel that comes in perpendicularly that carries the particles or cells. Immediately after these two channels join, the channel curves 90 degrees, which moves all the cells into a horizontal line. After the curve, liquid comes into the channel on both sides, forcing the horizontal line of cells into single file. The cells then pass through a microlaser beam. An advantage of this microfluidic flow cytometry chip is that it can be mass-produced by molding and standard lithographic processes. The fibers for the optical-fiber delivered laser beams and optical signals already exist.

"The optical fibers are automatically aligned once inserted into the chip, therefore, requiring no

bulky lenses and mirrors for optical alignment," said Huang. "Our machine is small enough it can be operated by battery, which makes it usable in Africa and other remote locations."

The researchers tested the device using commercially available, cell-sized fluorescent beads. They are now testing the device with actual cells.

Toward Super-Size Wind Turbines: Bigger Wind Turbines Do Make Greener Electricity

In a study that could solidify the trend toward construction of gigantic windmills, scientists have concluded that the larger the wind turbine, the greener the electricity it produces. Their report appears in ACS' journal *Environmental Science and Technology*.

Marloes Caduff and colleagues point out that wind power is an increasingly popular source of electricity. It provides almost 2 per cent of global electricity worldwide, a figure expected to approach 10 per cent by 2020. The size of the turbines also is increasing. One study shows that the average size of commercial turbines has grown 10-fold in the last 30 years, from diameters of 50 feet in 1980 to nearly 500 feet today. On the horizon: super-giant turbines approaching 1,000 feet in diameter. The authors wanted to determine whether building larger turbines makes wind energy more or less environmentally friendly.

Their study showed that bigger turbines do produce greener electricity — for two main reasons. First, manufacturers now have the knowledge, experience and technology to build big wind turbines with great efficiency. Second, advanced materials and designs permit the efficient construction of large turbine blades that harness more wind without proportional increases in their mass or the masses of the tower and the nacelle that houses the generator. That means more clean power without large increases in the amount of material needed for construction or fuel needed for transportation.

Early Human Ancestor, Australopithecus Sediba, Fossils Discovered in Rock

Scientists from the Wits Institute for Human Evolution based at the University of the Witwatersrand in Johannesburg have just announced the discovery of a large rock containing significant parts of a skeleton of an early human ancestor. The skeleton is believed to be the remains of 'Karabo', the type skeleton of*Australopithecus sediba*, discovered at the Malapa Site in the Cradle of Humankind in 2009.

Professor Lee Berger, a Reader in Palaeoanthropology and the Public Understanding of Science at the Wits Institute for Human Evolution, will make the announcement at the Shanghai Science and Technology Museum in Shanghai, China, on 13 July 2012.

"We have discovered parts of a jaw and critical aspects of the body including what appear to be a complete femur (thigh bone), ribs, vertebrae and other important limb elements, some never before seen in such completeness in the human fossil record," says Berger. "This discovery will almost certainly make Karabo the most complete early human ancestor skeleton ever discovered.

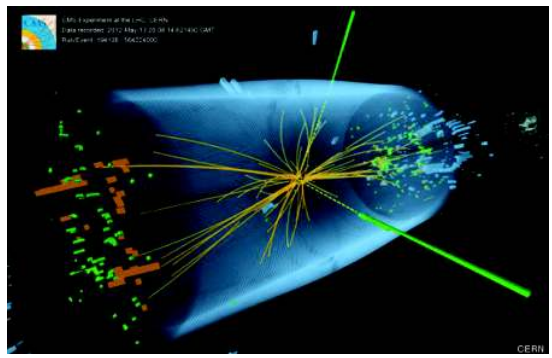
We are obviously quite excited as it appears that we now have some of the most critical and complete remains of the skeleton, albeit encased in solid rock. It is a big day for us as a team and for our field as a whole."

The remains are invisible to the casual observer and are entrenched in a large rock about one metre in diameter. It was discovered almost three years ago, but lay unnoticed in the Wits laboratories until early last month. Prof. Berger and his wife Jackie Smilg, a radiologist at the Charlotte Maxeke Hospital, who is conducting her PhD on the CT scanning of fossil material embedded in rock, scanned the large rock in a state of the art CT scanner.

Berger added that negotiations had begun with the Shanghai Science and Technology Museum, the Natural History Museum in the United Kingdom and the Smithsonian in Washington. "We have already donated casts of*Australopithecus sediba* to these three institutions, amongst others," says Berger.

CERN Experiments Observe Particle Consistent With Long-Sought Higgs Boson

At a seminar held at CERN today (July 4) as a curtain raiser to the year's major particle physics conference, ICHEP2012 in Melbourne, the ATLAS and CMS experiments presented their latest preliminary results in the search for the long sought Higgs particle. Both experiments observe a new particle in the mass region around 125-126 GeV.



Finally found – Higgs Boson Particle

"We observe in our data clear signs of a new particle, at the level of 5 sigma, in the mass region around 126 GeV. The outstanding performance of the LHC and ATLAS and the huge efforts of many people have brought us to this exciting stage," said ATLAS experiment spokesperson Fabiola Gianotti, "but a little more time is needed to prepare these results for publication."

"The results are preliminary but the 5 sigma signal at around 125 GeV we are seeing is dramatic. This is indeed a new particle. We know it must be a boson and it is the heaviest boson ever found," said CMS experiment spokesperson Joe Incandela. "The implications are very significant and it is precisely for this reason that we must be extremely diligent in all of our studies and cross-checks."

"It is hard not to get excited by these results," said CERN Research Director Sergio Bertolucci. " We stated last year that in 2012 we would either find a new Higgs-like particle or exclude the existence of the Standard Model Higgs. With all the necessary caution, it looks to me that we are at a branching

point: the observation of this new particle indicates the path for the future towards a more detailed understanding of what we're seeing in the data."

The results presented today are labelled preliminary. They are based on data collected in 2011 and 2012, with the 2012 data still under analysis. Publication of the analyses shown today is expected around the end of July. A more complete picture of today's observations will emerge later this year after the LHC provides the experiments with more data.

The next step will be to determine the precise nature of the particle and its significance for our understanding of the universe. Are its properties as expected for the long-sought Higgs boson, the final missing ingredient in the Standard Model of particle physics? Or is it something more exotic? The Standard Model describes the fundamental particles from which we, and every visible thing in the universe, are made, and the forces acting between them. All the matter that we can see, however, appears to be no more than about 4 per cent of the total. A more exotic version of the Higgs particle could be a bridge to understanding the 96 per cent of the universe that remains obscure.

"We have reached a milestone in our understanding of nature," said CERN Director General Rolf Heuer. "The discovery of a particle consistent with the Higgs boson opens the way to more detailed studies, requiring larger statistics, which will pin down the new particle's properties, and is likely to shed light on other mysteries of our universe."

Positive identification of the new particle's characteristics will take considerable time and data. But whatever form the Higgs particle takes, our knowledge of the fundamental structure of matter is about to take a major step forward.

CERN, the European Organisation for Nuclear Research, is the world's leading laboratory for particle physics. It has its headquarters in Geneva. At present, its Member States are Austria, Belgium, Bulgaria, the Czech Republic, Denmark, Finland, France, Germany, Greece, Hungary, Italy, the Netherlands, Norway, Poland, Portugal, Slovakia, Spain, Sweden, Switzerland and the United Kingdom. Romania is a candidate for accession. Israel and Serbia are Associate Members in the pre-stage to Membership. India, Japan, the Russian Federation, the United States of America, Turkey, the European Commission and UNESCO have Observer status.

Solar System Ice: Source of Earth's Water

Scientists have long believed that comets and, or a type of very primitive meteorite called carbonaceous chondrites were the sources of early Earth's volatile elements — which include hydrogen, nitrogen, and carbon — and possibly organic material, too. Understanding where these volatiles came from is crucial for determining the origins of both water and life on the planet. New research led by Carnegie's Conel Alexander focuses on frozen water that was distributed throughout much of the early Solar System, but probably not in the materials that aggregated to initially form Earth.

The evidence for this ice is now preserved in objects like comets and water-bearing carbonaceous chondrites. The team's findings contradict prevailing theories about the

relationship between these two types of bodies and suggest that meteorites, and their parent asteroids, are the most-likely sources of Earth's water. Their work was published on July 2012 by *Science Express*.

Looking at the ratio of hydrogen to its heavy isotope deuterium in frozen water (H_2O), scientists can get an idea of the relative distance from the Sun at which objects containing the water were formed. Objects that formed farther out should generally have higher deuterium content in their ice than objects that formed closer to the Sun, and objects that formed in the same regions should have similar hydrogen isotopic compositions. Therefore, by comparing the deuterium content of water in carbonaceous chondrites to the deuterium content of comets, it is possible to tell if they formed in similar reaches of the Solar System.

It has been suggested that both comets and carbonaceous chondrites formed beyond the orbit of Jupiter, perhaps even at the edges of our Solar System, and then moved inward, eventually bringing their bounty of volatiles and organic material to Earth. If this were true, then the ice found in comets and the remnants of ice preserved in carbonaceous chondrites in the form of hydrated silicates, such as clays, would have similar isotopic compositions.

Alexander's team included Carnegie's Larry Nitler, Marilyn Fogel, and Roxane Bowden, as well as Kieren Howard from the Natural History Museum in London and Kingsborough Community College of the City University of New York and Christopher Herd of the University of Alberta. They analysed samples from form in the same regions of the Solar System as comets because they have much lower deuterium content. If so, this result directly contradicts the two most-prominent models for how the Solar System developed its current architecture.

The team suggests that carbonaceous chondrites formed instead in the asteroid belt that exists between the orbits of Mars and Jupiter. What's more, they propose that most of the volatile elements on Earth arrived from a variety of chondrites, not from comets.

"Our results provide important new constraints for the origin of volatiles in the inner Solar System, including the Earth," Alexander said. "And they have important implications for the current models of the formation and orbital evolution of the planets and smaller objects in our Solar System."

New Biofuel Process Dramatically Improves Energy Recovery, and Uses Agricultural Waste

A new biofuel production process created by Michigan State University researchers produces energy more than 20 times higher than existing methods.

The results, published in the current issue of Environmental Science and Technology, showcase a novel way to use microbes to produce biofuel and hydrogen, all while consuming agricultural wastes.

Gemma Reguera, MSU microbiologist, has developed bioelectrochemical systems known as microbial electrolysis cells, or MECs, using bacteria to breakdown and ferment agricultural waste into ethanol. Reguera's platform is unique

because it employs a second bacterium, which, when added to the mix, removes all the waste fermentation byproducts or non-ethanol materials while generating electricity.

Similar microbial fuel cells have been investigated before. However, maximum energy recoveries from corn stover, a common feedstock for biofuels, hover around 3.5 per cent. Reguera's platform, despite the energy invested in chemical pretreatment of the corn stover, averaged 35 to 40 per cent energy recovery just from the fermentation process, said Reguera, an AgBioResearch scientist who co-authored the paper with Allison Spears, MSU graduate student.

"This is because the fermentative bacterium was carefully selected to degrade and ferment agricultural wastes into ethanol efficiently and to produce byproducts that could be metabolized by the electricity-producing bacterium," Reguera said. "By removing the waste products of fermentation, the growth and metabolism of the fermentative bacterium also was stimulated. Basically, each step we take is custom-designed to be optimal."

The second bacterium, *Geobacter sulfurreducens*, generates electricity. The electricity, however, is not harvested as an output. It is used to generate hydrogen in the MEC to increase the energy recovery process even more, Reguera said.

"When the MEC generates hydrogen, it actually doubles the energy recoveries," she said. "We increased energy recovery to 73 per cent. So the potential is definitely there to make this platform attractive for processing agricultural wastes."

Reguera's fuel cells use corn stover treated by the ammonia fiber expansion process, an advanced pretreatment technology pioneered at MSU. AFEX is an already proven method that was developed by Bruce Dale, MSU professor of chemical engineering and materials science.

Dale is currently working to make AFEX viable on a commercial scale.

In a similar vein, Reguera is continuing to optimise her MECs so they, too, can be scaled up on a commercial basis. Her goal is to develop decentralised systems that can help process agricultural wastes. Decentralised systems could be customised at small to medium scales (scales such as compost bins and small silages, for example) to provide an attractive method to recycle the wastes while generating fuel for farms.

New Toilet Turns Human Waste into Electricity and Fertiliser

Scientists from Nanyang Technological University (NTU) have invented a new toilet system that will turn human waste into electricity and fertilisers and also reduce the amount of water needed for flushing by up to 90 per cent compared to current toilet systems in Singapore.

Dubbed the No-Mix Vacuum Toilet, it has two chambers that separate the liquid and solid wastes. Using vacuum suction technology, such as those used in aircraft lavatories, flushing liquids would now take only 0.2 litres of water while flushing solids require just one litre.

The existing conventional water closet uses about 4 to 6 litres of water per flush. If installed in a public restroom flushed 100 times a day, this next generation toilet system, will save about 160,000

litres in a year — enough to fill a small pool 10 x 8 metres x 2m.

The NTU scientists are now looking to carry out trials by installing the toilet prototypes in two NTU restrooms. If all goes well, the world can expect to see and even sit on the new toilet in the next three years.

Associate Professor Wang Jing-Yuan, Director of the Residues and Resource Reclamation Centre (R3C) at NTU who is leading the research project, said that their ultimate aim is not only for the new toilet system to save water, but to have a complete recovery of resources so that none will be wasted in resource-scarce Singapore.

"Having the human waste separated at source and processed on-site would lower costs needed in recovering resources, as treating mixed waste is energy intensive and not cost-effective," Prof Wang said. "With our innovative toilet system, we can use simpler and cheaper methods of harvesting the useful chemicals and even produce fuel and energy from waste."

Aiming to convert all waste to resource, the new toilet system which is part of a project that has received $10 million from Singapore's National Research Foundation's Competitive Research Programme in 2010, will be useful for new housing estates, hotels, resorts, and especially communities not linked to the main sewerage system and so require their own sewerage facilities.

How it works

The No-Mix Vacuum Toilet will divert the liquid waste to a processing facility where components used for fertilisers such as nitrogen, phosphorus and potassium can be recovered.

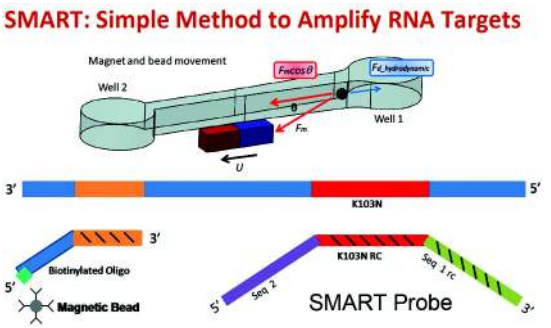
At the same time, the solid waste will be sent to a bioreactor where it will be digested to release biogas which contains methane. Methane is odourless and can be used to replace natural gas used in stoves for cooking. Methane can also be converted to electricity if used to fuel power plants or fuel cells.

'Grey water' (used water from the laundry, shower and kitchen sink) can be released back into the drainage systems without further need for complex waste water treatment, while leftover food wastes can be sent either to the bioreactors or turned into compost and mixed with soil, resulting in a complete recovery of resources.

Assisting Assoc Prof Wang in the project are four other NTU researchers — Asst Prof Chang Wei-Chung, Dr Chen Chia-Lung, Dr Apostolos Giannis and Dr Rajinikanth Rajagopal. This next-generation toilet and resource recovery system took the team one and a half years to develop and will be showcased to the industry at the upcoming WasteMET Asia 2012, held from the 1st to 4th July this year at Marina Bay Sands' Sands Expo and Convention Center.

A SMART(er) Way to Track Influenza

Brown University researchers have created a reliable and fast flu-detection test that can be carried in a first-aid kit. The novel prototype device isolates influenza RNA using a combination of magnetics and microfluidics, then amplifies and detects probes bound to the RNA. The technology could lead to real-time tracking of influenza.



Brown University researchers have created a reliable and fast flu-detection test that can be carried in a first-aid kit. The novel prototype device isolates influenza RNA using a combination of magnetics and microfluidics, then amplifies and detects probes bound to the RNA. (Credit: Image courtesy of Brown University).

In April 2009, the world took notice as reports surfaced of a virus in Mexico that had mutated from pigs and was being passed from human to human. The H1N1 "swine flu," as the virus was named, circulated worldwide, killing more than 18,000 people, according to the World Health Organization. The Centers for Disease Control and Prevention in the United States said it was the first global pandemic in more than four decades.

Swine flu will not be the last viral mutation to cause a worldwide stir. One way to contain the next outbreak is by administering tests at the infection's source, pinpointing and tracking the pathogen's spread in real time. But such efforts have been stymied by devices that are costly, unwieldy and unreliable. Now, biomedical engineers at Brown University and Memorial Hospital in Rhode Island have developed a biochip that can detect the presence of influenza by zeroing in on the specific RNA sequence and then using tiny magnets in a tube to separate the flu-ridden sequence from the rest of the RNA strand. The result: A reliable, fast prototype of a flu-detection test that potentially can be carried in a first-aid kit and used as easily as an iPhone.

"We wanted to make something simple," said Anubhav Tripathi, associate professor of engineering at Brown and the corresponding author on the paper, published in the *Journal of Molecular Diagnostics*. "It is a low-cost device for active, on-site detection, whether it is influenza, HIV, or TB (tuberculosis)."

The Brown assay is called SMART, which stands for "A Simple Method for Amplifying RNA Targets." Physically, it is essentially a series of tubes, with bulbs on the ends of each, etched like channels into the biochip.

There are other pathogen-diagnostic detectors, notably the Polymerase Chain Reaction device (which targets DNA) and the Nucleic Acid Sequence Based Amplification (which also targets RNA). The SMART detector is unique in that the engineers use a DNA probe with base letters that match the code in the targeted sequence. This ensures the probe will latch on only to the specific RNA strand being assayed. The team inundates the sample with probes, to ensure that all RNA molecules bind to a probe.

"The device allows us to design probes that are both sensitive and specific," Tripathi said.

This approach creates excess — that is, probes with no RNA partners. That's OK, because the Brown-led team then attached the probes to 2.8 micron magnetic beads that carry the genetic sequence for the influenza RNA sequence. The engineers then use a magnet to slowly drag the RNA-probe pairs collected in the bulb through a tube that narrows to 50 microns and then deposit the probes at a bulb at the other end. This

convergence of magnetism (the magnetised probes and the dragging magnets) and microfluidics (the probes' movement through the narrowing channel and the bulbs) serves to separate the RNA-probe pairs from the surrounding biological debris, allowing clinicians to isolate the influenza strains readily and rapidly for analysis. The team reports that it tracks the RNA-probe beads flawlessly at speeds up to 0.75 millimeters per second.

"When we amplify the probes, we have disease detection," Tripathi said. "If there is no influenza, there will be no probes (at the end bulb). This separation part is crucial."

Once separated, or amplified, the RNA can be analysed using conventional techniques, such as nucleic acid sequence-based amplification (NASBA).

The chips created in Tripathi's lab are less than two inches across and can fit four tube-and-bulb channels. Tripathi said the chips could be commercially manufactured and made so more channels could be etched on each.

The team is working on separate technologies for biohazard detection.

Stephanie McCalla, who earned her doctorate at Brown last year and is now at the California Institute of Technology, is the first author on the paper. Brown professors of medicine Steven Opal and Andrew Artenstein, with Carmichael Ong and Aartik Sarma, who earned their undergraduate degrees at Brown, are contributing authors.

The U.S. National Institutes of Health and the National Science Foundation funded the research.

New Properties of Carbon Material Graphene Discovered

Graphene has caused a lot of excitement among scientists since the extremely strong and thin carbon material was discovered in 2004. Just one atom thick, the honeycomb-shaped material has several remarkable properties combining mechanical toughness with superior electrical and thermal conductivity.

Now a group of scientists at Lowa State University, led by physicist Jigang Wang, has shown that graphene has two other properties that could have applications in high-speed telecommunications devices and laser technology — population inversion of electrons and broadband optical gain.

Wang is an assistant professor in the Department of Physics and Astronomy in the College of Liberal Arts and Sciences at Lowa State University. He also is an associate scientist with the Department of Energy's Ames Laboratory.

Wang's team flashed extremely short laser pulses on graphene. The researchers immediately discovered a new photo-excited graphene state characterised by a broadband population inversion of electrons. Under normal conditions, most electrons would occupy low-energy states and just a few would populate higher-energy states. In population-inverted states, this situation is reversed: more electrons populate higher, rather than lower, energy states. Such population inversions are very rare in nature and can have highly unusual properties. In graphene, the new state produces an optical gain from the infrared to the visible.

Simply stated, optical gain means more visible light comes out than goes in. This can only happen when the gain medium is externally pumped and then stimulated with light (stimulated emission). Wang's discovery could open doors for efficient amplifiers in the telecommunication industry and extremely fast opto-electronics devices.

Graphene as a gain medium for light amplification

"It's very exciting," Wang said. "It opens the possibility of using graphene as a gain medium for light amplification. It could be used in making broadband optical amplifiers or high-speed modulators for telecommunications. It even provides implications for development of graphene-based lasers."

Wang's team unveiled its findings in the journal *Physical Review Letters* on April 16. In addition to Wang, the paper's other authors are Tianq Li, Liang Luo and Junhua Zhang, Lowa State physics graduate students; Miron Hupalo, Ames Laboratory scientist; and Michael Tringides and Jörg Schmalian, Lowa State physics professors and Ames Laboratory scientists.

Wang is a member of the Condensed Matter Physics program at Lowa State and the Ames Laboratory. He and his team conduct optical experiments using laser spectroscopy techniques, from the visible to the mid-infrared and far-infrared spectrum. They use ultrashort laser pulses down to 10 quadrillionths of a second to study the world of nanoscience and correlated electron materials.

In 2004, United Kingdom researchers Andre Geim and Konstantin Novoselov discovered graphene, which led to their winning the 2010 Nobel Prize in Physics. Graphene is a two-dimensional (height and width) material with a growing list of known unique properties. It is a single layer of carbon only one atom thick. The carbon atoms are connected in a hexagonal lattice that looks like a honeycomb. Despite a lack of bulk, graphene is stronger than steel, it conducts electricity as well as copper and conducts heat even better. It is also flexible and nearly transparent.

An understanding gap existed, Wang explained, between the two scientific communities that studied the electronic and photonic properties of graphene. He believed his group could help bridge the gap by elaborating the non-linear optical properties of graphene and understanding the non-equilibrium electronic state. Wang explained that linear optical properties only transmit light — one light signal comes into a material and one comes out. "The non-linear property can change and modulate the signal, not just transmit it, producing functionality for novel device applications."

Graphene in a highly non-linear state

Wang said other scientists have studied graphene's optical properties, but primarily in the linear regime. His team hypothesised they could generate a new "very unconventional state" of graphene resulting in population inversion and optical gain.

"We were the first group to break new ground, to start looking at it in a highly excited state consisting of extremely dense electrons — a highly non-linear state. In such a state, graphene has unique properties."

Wang's group started with high-quality graphene monolayers grown by Hupalo and Tringides in the

Ames Laboratory. The researchers used an ultrafast laser to "excite" the material's electrons with short pulses of light just 35 femtoseconds long (35 quadrillionths of a second). Through measurements of the photo-induced electronic states, Wang's team found that optical conductivity (or absorption) of the graphene layers changed from positive to negative — resulting in the optical gain — when the pump pulse energy was increased above a threshold.

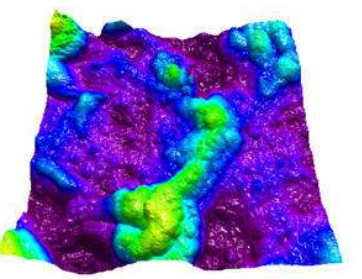
The results indicated that the population inverted state in photoexcited graphene emitted more light than it absorbed. "The absorption was negative. It meant that population inversion is indeed established in the excited graphene and more light came out of the inverted medium than what entered, which is optical gain," Wang said. "The light emitted shows gain of about one percent for a layer a mere one atom thick, a figure on the same order to what is seen in conventional semiconductor optical amplifiers hundreds of times thicker."

The key to the experiments, of course, was creating the highly non-linear state, something "that does not normally exist in thermal equilibrium," Wang said. "You cannot simply put graphene under the light and study it. You have to really excite the electrons with the ultrafast laser pulse and have the knowledge on the threshold behaviours to arrive at such a state."

Wang said a great deal more engineering and materials perfection lies ahead before graphene's full potential for lasers and optical telecommunications is ever realised. "The research clearly shows, though, that lighting up graphenes may produce brighter emissions as well as a bright future," he said.

New Technique to Give Us Better Understanding of Human Tissues

Research from North Carolina State University demonstrates that a relatively new microscopy technique can be used to improve our understanding of human tissues and other biomedical materials. The study focused specifically on eye tissues, which are damaged by scarring in diabetic patients.



High resolution atomic force microscopy image of inner limiting membrane extracted from a human eye. (Credit: Image courtesy of North Carolina State University)

"Our findings are a proof of concept, showing that this technique is extremely effective at giving us the data we need on these tissues," says Dr. Albena Ivanisevic, co-author of a paper describing the research. "Specifically, it gives a great deal of information on the composition of these tissues, as well as the tissue's topography, or surface characteristics." Ivanisevic is an associate professor of materials science and engineering at NC State and associate professor of the joint biomedical engineering program at NC State and the University of North Carolina at Chapel Hill.

The study is one of the first to explore how this technology, called bimodal dual AC mode microscopy, can improve our understanding of human tissues and biomaterials.

The research team, which included researchers from Purdue University and the University of Louisville School of Medicine, examined two types of eye tissue from diabetic patients. Specifically, they looked at the inner limiting membrane (ILM), which is the surface layer of the retina, and so-called epiretinal membranes. Epiretinal membranes are scar tissues that form on the ILM in diabetics. Scar tissue can cause significant damage to the retina and, if untreated, may lead to blindness.

There are multiple treatments for this scarring. In the United States, a common technique is for a surgeon to peel off the ILM, removing the scar tissue with it. In many other parts of the world, surgeons inject dye into the eye to better distinguish the parts of the eye they will operate on. This process is not currently allowed in the United States, due to concerns about the dye's toxicity.

The researchers launched this project, in part, to determine if bimodal dual AC mode microscopy could be used to provide a better understanding of the topographical properties of the ILM. Further, the researchers wanted to use the technology to see if it offered insight into how — or whether — various dyes affect the topographical characteristics of the ILM. "All of this information could be used to improve surgical outcomes and to foster research into additional treatments for the condition," Ivanisevic says.

The researchers found that bimodal dual AC mode microscopy, an atomic force imaging technique, captured the properties of the tissue in exceptional detail. Atomic force imaging effectively runs a probe over the surface of a material to collect data on its topography, similar to the way in which a record player's needle runs over the surface of an album.

"The next step would be to use this technology to assess the utility — and potential risk — of various dyes," Ivanisevic says. "If we can find a dye that is extremely effective and poses little risk, it may be approved for use in future surgeries."

Nano-Pesticides: Solution or Threat for a Cleaner and Greener Agriculture?

Research is urgently needed to evaluate the risks and benefits of nano-pesticides to human and environmental health. Melanie Kah and Thilo Hofmann from the Department of Environmental Geosciences of the University of Vienna recently performed an extensive analysis of this emerging field of research.

The results were published on June 6th in the journal *Critical Reviews in Environmental Science and Technology*. The study presents the current scientific state of art on nano-pesticides and identifies direction priorities for future research.

Nanotechnology has developed tremendously in the past decade and was able to create many new materials with a vast range of potential applications. Some of those innovative materials are promising to reduce environmental pollution. For instance, carbon nanotubes and metal nano-particles are great candidate materials for cleaning polluted water and soils.

However, the risk that nano-particles may pose to human and environment health is not yet fully understood. The precautionary principle, therefore, suggests keeping environmental

release of nano-particles minimal until their fate and toxicity is better understood. "A good understanding of nano-materials is essential to evaluate whether the benefits overcome potential new risks," explains Thilo Hofmann, dean elected at the Faculty of Geosciences, Geography and Astronomy of the University of Vienna.

Among numerous proposed applications, nanotechnology has the potential to revolutionise agricultural practices and food systems. Research has been extremely active over the past few years to develop new pesticides products based on nanotechnology. "Nano-pesticide research is emerging at high speed at the agrochemical labs, however, this topic has not reached public awareness or state authorities so far, nor are any products available at the marked. Since those nano-pesticides have new or enhanced properties, this will change in near future and will inevitably result in both new risks and new benefits to human and environmental health," states Thilo Hofmann.

Nano-pesticides encompass a great variety of products, some of which are already on the market. The application of nano-pesticides would be the only intentional diffuse input of large quantities of engineered nano-particles into the environment. Innovation always results in both drawbacks and benefits for human and environmental health. Nano-pesticides may reduce environmental contamination through the reduction in pesticide application rates and reduced losses. However, nano-pesticides may also create new kinds of contamination of soils and waterways due to enhanced transport, longer persistence and higher toxicity.

The current level of knowledge does not allow a fair assessment of the advantages and disadvantages that will result from the use of nano-pesticides. As a prerequisite for such assessment, a better understanding of the fate and effect of nano-pesticides after their application is required. The suitability of current regulations should also be analysed so that refinements can be implemented if needed. Research on nano-pesticides is, therefore, a priority for preserving the quality of both the food chain and the environment.

WEB WATCH

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

- www.readbookonline.net

  This site contains about two thousand books from hundreds of authors. The collections of these books are under the following categories: fictions/novels, short stories, poems, essays, plays, non-fictions.

- www.readanybook.com

  This is the largest online library. Best fiction books are always available here. Search for your favourite book on this site and read them free.

- www.pagebypagebooks.com

  This site contains hundreds of classic books, all in convenient page by page format. From Aesop to H. G. Wells and everything in between.

- www.readcentral.com

  Over 5000 free online books and several thousand quotes and poems are available on this site. There is no downloading or subscription, you can just read the books online for free.

- www.publicbookshelf.com

  Read free online romance novels, romance e-books and other full books online including biographies and memory books, mystery and suspense books, poetry books, horror books and other non-fiction books.

- www.wegivebooks.org

  This site is a collection of free online books for children. Read a special collection of free childrens' books on your iPad, mobile device or computer. All the books available are appropriate for children through age ten.

- www.bookrix.com

  On this site you can create, publish and sell your own e-books online. There are a lot of books to read under the categories like fiction, fantasy, poetry, religion, drama, music, humour, science fiction, biography and auto-biography etc.

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YOU HAVE ASKED

Ques.- Have you seen clothes made up of coconut fibres? What are other uses of these fibres?

Neha and Monica
Class VI
C-8/6, Patel Nagar, Bikaner, Rajasthan

Ans.- In Japan, some fabric manufacturing companies are trying to make dress material from coconut fibres. As these fibres are very hard, only a small percentage of coconut fibres is mixed with other fibers in making fabrics. Attempts are being made to increase the percentage of usage of coconut fibres in future as researches have shown that the clothes made up of it may protect us from ultra-violet rays.

The other uses of coconut fibres are :

- Coconut fibres are used for making ropes, broom-sticks, brushes etc.
- They are also used in boats and for making nets used for catching fishes.
- They are also used for making door-mats and for stuffing quilts, mattresses and pillows.
- The coconut fibres have higher water absorbing capacity and thus increase the growth of plants. You would have seen money-plants ascending on rods wrapped with coconut fibres at your home.

Ques.- What would happen if a magnet is made to come in contact with a compass?

Neha and Monica
Class VI
C-8/6, Patel Nagar, Bikaner, Rajasthan

Ans.- A magnetic compass needle responds to the magnetic field by aligning itself into a north south direction, pointing to the place on the earth's surface known as the magnetic north pole.
When a magnet is made to come in contact with a compass, the compass starts working in the magnetic field of the magnet. The south pole of the needle is attracted towards the north pole of the magnet and the north pole of needle is attracted towards the south pole of the magnet.

Ques.- Amongst herbivorous, carnivorous and omnivorous, humans will be put in which category?

Lakhan Singh Bairwa
P.O. Baldrakha, Mandal Garh

Ans.- Human are omnivorous. Evidence of Humans as Omnivores are discussed below-

Archeological Record - As far back as it can be traced, clearly the archeological record indicates an omnivorous diet for humans that included meat. Our ancestry is among the hunter/gatherers from the beginning. Once domestication of food sources began, it included both animals and plants.

Cell Types - Relative number and distribution of cell types, as well as structural specialisations, are more important than overall length of the intestine to determining a typical diet. Dogs are typical carnivores, but their intestinal characteristics have more in common with omnivores. Wolves eat quite a lot of plant material.

Fermenting Vats - Nearly all plant eaters have fermenting vats (enlarged chambers where foods sits and microbes attack it). Ruminants like cattle and deer have forward sacs derived from remodeled esophagus and stomach. Horses, rhinos, and colobine monkeys have posterior, hindgut sacs. Humans have no such specialisations.

Jaws - Although evidence on the structure and function of human hands and jaws, behaviour, and evolutionary history also either support an omnivorous diet or fail to support strict vegetarianism, the best evidence comes from our teeth.

The short canines in humans are a functional consequence of the enlarged cranium and associated reduction of the size of the jaws. In primates, canines function as both defense weapons and visual threat devices. Interestingly, the primates with the largest canines (gorillas and gelada baboons) both have basically vegetarian diets. In archeological sites, broken human molars are most often confused with broken premolars and molars of pigs, a classic omnivore. On the other hand, some herbivores have well-developed incisors that are often mistaken for those of human teeth when found in archeological excavations.

Salivary Glands - These indicate we could be omnivores. Saliva and urine data vary, depending on diet, not taxonomic group.

Intestines - Intestinal absorption is a surface area, not linear problem. Dogs (which are carnivores) have intestinal specialisations more characteristic of omnivores than carnivores such as cats. The relative number of crypts and cell types is a better indication of diet than simple length. We are intermediate between the two groups.

Conclusion - Humans are classic examples of omnivores in all relevant anatomical traits.

Ques.- Is Vitamin-D manufactured in the presence of sunlight?

Lakhan Singh Bairwa
P.O. Baldrakha, Mandal Garh

Ans.- Yes, Vitamin-D is manufactured in our body in the presence of sunlight. **Vitamin D** is a group of fat-soluble secosteroides. In humans, body can also synthesize it from cholesterol when sun exposure is adequate.

Vitamin D_3 (cholecalciferol) is produced by ultraviolet irradiation (UV) of its precursor 7-dehydrocholesterol. This molecule occurs naturally in the skin of animals and in milk. Vitamin D_3 can be made by exposure of the skin to UV, or by exposing milk directly to UV (one commercial method).

In the liver vitamin D is converted to calcidiol, which is also known as Calcifediol (INN), 25-hydroxycholecalciferol, or 25-hydroxyvitamin D—abbreviated 25(OH). Part of the calcidiol is converted by the kidneys to calcitriol, the biologically active form of vitamin D. Calcitriol circulates as a hormone in the blood, regulating the concentration of calcium and phosphate in the bloodstream and promoting the healthy growth and remodeling of bone.

Ques.- The odour of burning paper is same to the odour which comes out when we burn cotton threads. So, can we predict that paper and cotton both are made-up of plants?

Satyanarayan Teli
P.O. Baldrakha, Bhilvada

Ans.- Yes, paper and cotton both are made from plants. **Paper** is a thin material mainly used for writing upon, printing upon, drawing or for packaging. It is produced by pressing together moist fibres, typically cellulose pulp derived from wood, rags or grasses, and drying them into flexible sheets. **Cotton** is a soft, fluffy staple fibre that grows in a ball, or protective capsule, around the seeds of cotton plants of the genus *Gossypium*. The fiber is almost pure cellulose.

Ques.- We have seen attires in the museums, which the warriors used to wear. Are they all made up of any kind of fibre?

Satyanarayan Teli
P.O. Baldrakha, Bhilvada

Ans.- Yes, the attires worn by the warriors are made up of fibres known as synthetic fibres. Fibres are of two types. The fibres like cotton, silk, jute, wool which are obtained from plants and animals are known as natural fibres. The other kind of fibre is synthetic fibre which is synthesized by chemicals. Some examples are nylon, polyester, acrylic, rayon etc. Synthetic fibres are being synthesized since last hundred years and the dresses of warriors were made from these fibres in order to keep them safe.

By

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THE CONSTITUTION OF INDIA

PREAMBLE

WE, THE PEOPLE OF INDIA, having solemnly resolved to constitute India into a **SOVEREIGN SOCIALIST SECULAR DEMOCRATIC REPUBLIC** and to secure to all its citizens :

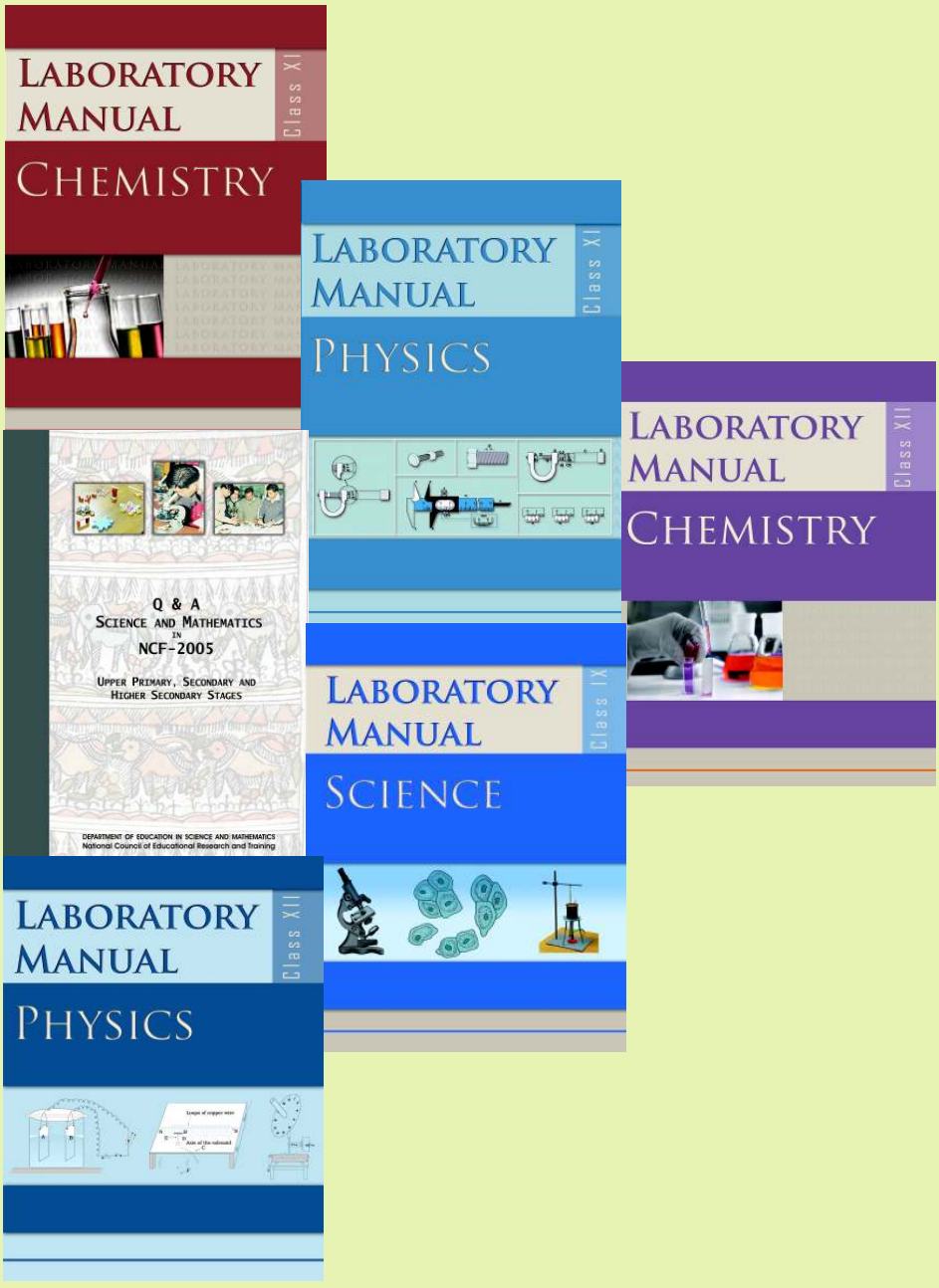
JUSTICE, social, economic and political;

LIBERTY of thought, expression, belief, faith and worship;

EQUALITY of status and of opportunity; and to promote among them all

FRATERNITY assuring the dignity of the individual and the unity and integrity of the Nation;

IN OUR CONSTITUENT ASSEMBLY this twenty-sixth day of November, 1949, do **HEREBY ADOPT, ENACT AND GIVE TO OURSELVES THIS CONSTITUTION.**



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(National Council of Educational Research and Training)
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NATIONAL SEMINAR
ON
'NEW PERSPECTIVES OF HEALTH AND PHYSICAL EDUCATION IN SCHOOL'

CALL FOR PAPERS FOR PARTICIPATION

A national seminar on **'New Perspectives of Health and Physical Education in School'** is being organised by North East Regional Institute of Education, National Council of Educational Research and Training, Umiam-793103, Meghalaya for two days from 19-20 February 2014. Interested participants are requested to send their abstracts (500 words) and full papers (5000 words) to the Coordinator. The abstracts and full papers, that are to be sent in both hard and soft copies, should be related to the subthemes and will be published as books of seminar proceedings. On request from the presenting author, local free hospitality with TA will be provided. No registration fee is required. Last dates for —

- **Abstract submission: 15 November 2013**
- **Full paper submission: 24 December 2013**
- **Participation confirmation: 31 December 2013.**

For further details, please see websites
www.nerie.nic.in and www.ncert.nic.in