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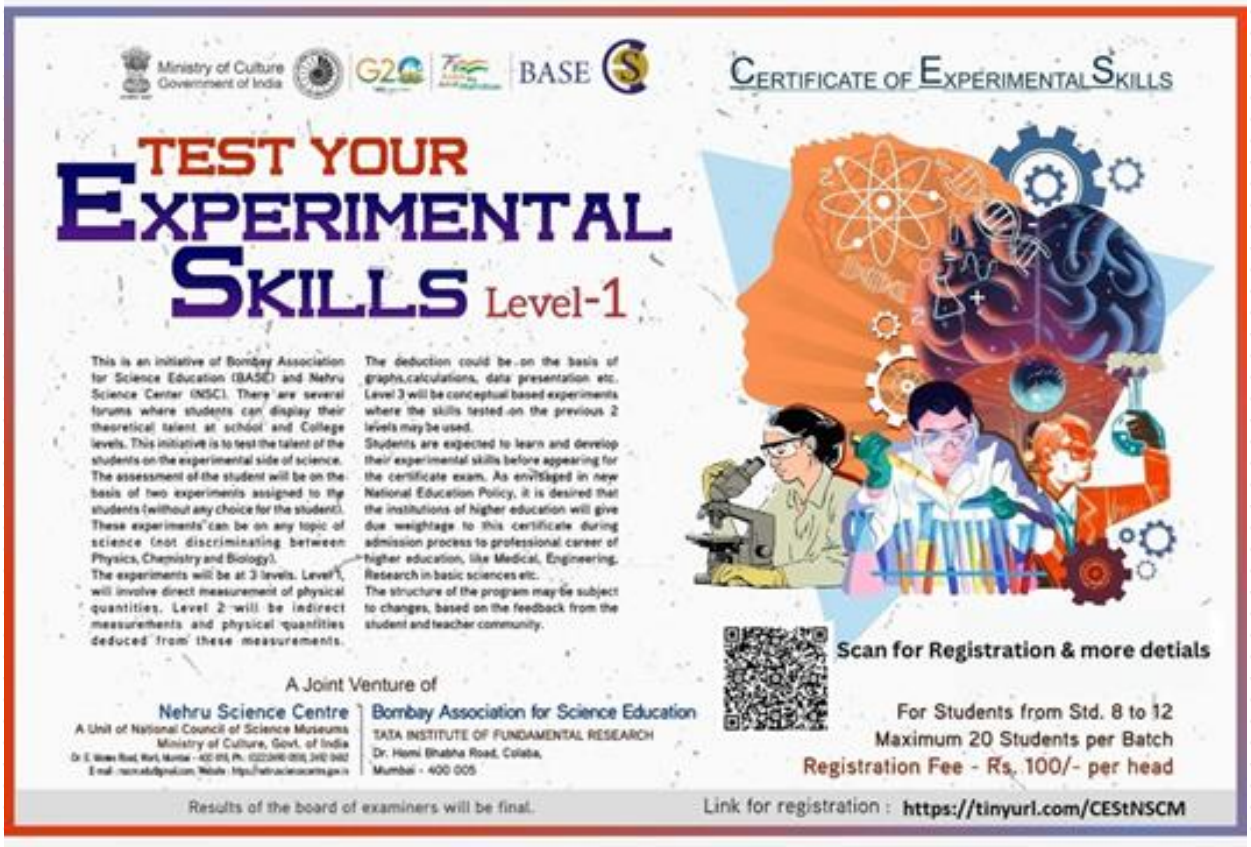
CES- An Assessment Of Experimental Skills



Navi Mumbai Science Foundation

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This is a quarterly e-magazine published by Navi Mumbai Science Foundation, a society engaged in spreading science education and scientific temperament among students of Navi Mumbai region for the last one decade. The magazine will mainly cover activities and articles on science education useful to students, teachers & society at large.

Contents .....

Views expressed in the magazine are from authors and editor may not agree

To receive the copy of E-magazine, send your mail id to edureka.nmsf@gmail.com or follow the EduReka Channel on Whatsapp.

From Editor's Desk!!....

Dear Readers,

Welcome to the latest edition of Edureka, where we explore a variety of engaging topics to broaden your horizons. We are back after a long hiatus and therefore we bring a lot of interesting articles for you to make up for this.

In this issue, we start with a look at the Certificate of Experimental Skills (CES). Designed for students in grades 8-12, this exam evaluates practical abilities. Learn how the CES is reshaping education and encouraging hands-on learning. Next, we delve into biofilms, uncovering their social significance. Discover the fascinating interactions between bacteria and their environment within these complex structures. Our journey continues with a study of prism dispersion, explaining how prisms create rainbows and separate light into colors. colors. This separation is due to the different values of refractive indices. Can we measure refractive index in a simple way?

We then simplify the concept of DNA restriction enzymes, exploring how they regulate genetic material. Finally, we take a reflective journey to Meghalaya's sacred forests, appreciating their cultural and ecological importance.

We hope you find inspiration in these pages as we strive to promote learning and exploration.

CES-an assessment for experimental skills

P.K. Joshi

Certificate of Experimental Skills (CES), is an exam for testing the experimental skills of students of class 8-12, irrespective of the exam board they pursue.

There is no dispute or debate about the need of experiments at school level, in the country. Also, the textbooks do include several activities which are very well planned. Regular experiments too are listed out quite well, even though they could have been written differently. But then where is the problem?

Organizations like Bombay Association for Science Education (BASE), started by scientists of TIFR, have been focusing on teacher training programs, based purely on experiments of school level. Yet the deficiency of experiments at school level is also a reality. BASE has been working on the continuing education program teachers, by conducting workshops and symposia in different aspects of science education. In the last decade there is ever increasing emphasis on science experiments.

The members of BASE realized that one of the key component missing is the assessment on these experimental skills. In regular board exams, the seriousness of assessment is missing for reasons which is beyond the purview of this article. This lack of seriousness in assessment is the problem which allows putting the experimental training at school level on the “back-burner”.

Setting up of training programs in experiments and/or setting up of experimental exams is quite a challenging task. Even if the experimental procedure is well established, from exam to exam, the teacher has to be vigilant in change in answers. It is quite different from theoretical exams where the answer is fixed permanently for a given question, even if somewhat descriptive in nature. The answers do not change with time, geography and local environment. But experimental answers have many a parameter which keep changing from place to place and from time to time.

Setting up a laboratory session for training program or exam, requires a lot more planning and actual physical work as compared to a theoretical session. There are no assumptions and every component of experiment, no matter how small, is equally important. There are instances where unavailability of one component can actually change the procedure or the result of the experiment.

In my opinion, even many training programs stay away from experimental training, precisely for this reason. Many a times a middle path is taken, called the demonstration where the factor of involvement of teachers/participants is dropped, and the result is purely in the hands of the person demonstrating. For example, if I have to demonstrate thin-layer-chromatography experiment, I just need to rehearse it before the session and perform it without any “failure”. BUT, if I have to ask 30 teachers to perform, then I need that confidence in myself to give proper instructions (written or verbal) to the participants, ensure that I get correct results myself, then ensure that all of them

have the same experimental conditions and that they have understood the concept clearly. In spite of this we have had large number of “failures”, for reasons beyond the purview of this article and can be discussed at some other time.

The person(s) conducting these programs also have to have enough confidence in themselves to handle these “failures”. Let me give other examples to explain this situation.

Prof. V.G. Gambhir from HBCSE, conducts a very simple experiment to explain the (un)equal importance of 5 sense organs. It is dependent on rubbing his hand on the shoulder of the participant. He never fails. But once in front of me the experiment did not work. With his experience and confidence, he immediately started investigating and figured out that the experiment fails if a person is wearing shirt made of Terrilyn. But if the shirt is made of cotton (pure or partial) it works very well. So, he could even explain the “failure”.

In another example, a TLC experiment, where pigments of spinach are separated very clearly and easily, is a very common experiment, which works without “failure”. But on one occasion, there was no separation. Our team did not get disturbed by it in front of 200 students and did figure out the reason for “failure” which was use of water from bore-well. We have always used Municipal water which has very low salt content.

This confidence, in handling “failures” is a barrier, which not many trainers and teachers want to take on head-on and hence there is an approach to avoid the experiments, especially, those with assessment. It is also possibly the reason why there is a tendency to “refer to last year’s answers”.

In Banaras Hindu University, when I joined as a reader, the first experiment I encountered, had a similar story. The answer from the students was: Last year the students got the same answer. The faculty there too had allowed this explanation for several sessions! When I decided to do the experiment with proper understanding the source of error was detected in few minutes and the “expected” number was obtained.

At International Junior Science Olympiad (IJSO), for which I was the coordinator till the year 2018, there was a team of teachers/scientists who had this confidence, and many of them happened to be the members of BASE.

To take on this issue head-on, in December 2022, a proposal was made to Nehru Science Center (NSC), Mumbai to conduct an exam where students can be judged on their experimental skills. The science centre, which has many staff members who have this required level of confidence in experimental skills, accepted this proposal with great enthusiasm.

This collaboration between BASE and NSC gave birth to the new and fast spreading exam which tests the skills of school students and award certificates to students for their experimental skills. The assessment is conducted very strictly, looking for skills of observation, conducting experiment, using simple measuring tools for conducting simple school level experiments.

Readers are requested to visit the site of Nehru Science Center, for further details.

https://nehrusciencecentre.gov.in/educational-activities/other-events/#Skills

This exam is conducted every month and is already running at 3 centres in India, and expanding. So far 130 (Mumbai), 58 (Nagpur) and 13 (Dharampur) students have appeared for the skill test and 16, 5 and 2 students, from respective centers have received the certificate.

It is expected to start at some other centers very soon and the centers will be announced on these websites very soon. Currently it is the only experimental skill test being conducted in India. Please visit the https://www.tifr.res.in/~base/ces/index.html for more information about this program.

Biofilm: the social lives of bacteria

Amruta Rajarajan

Could you imagine living completely alone?

As human beings, we are highly social creatures: we live together with our families, several families make a neighbourhood, and several neighbourhoods together form a town, like Vashi. We not only live close to each other, but also *divide labour* as a society. Some of us are teachers, store owners, cooks or engineers. We divide labour in such a way that each individual member of society can enjoy otherwise unimaginable benefits. For example, each of us could buy and own beautiful clothes of our choice, without knowing how to weave cloth or stitch. We could ride a bus to school without knowing how to engineer buses ourselves, or drive. We could eat rice, *dal* and *roti* every day without knowing how to farm crops. Life can be better for everyone when we each contribute and share!

We are not the only ones who enjoy the benefits of social life - bacteria too are highly social beings. Bacteria are single-celled micro-organisms that live everywhere around us - in soil, water, food, air, as well as on plants, animals and in us humans. Just like us, bacteria do not live as isolated cells, but in specialised groups known as **biofilms.** In fact, bacteria exist primarily as members of biofilms on land, whereas 20-80% do so in aquatic environments. Biofilms may consist of one or more species of bacteria that are (a) adhered to a surface and (b) have a slimy "coat" known as Extracellular Polymeric Substance (EPS). Bacteria living in a biofilm 'town' can grow faster by exchanging essential nutrients with their neighbours that are unavailable to their planktonic (free-living) counterparts. They may even gain new abilities by exchanging bits of their DNA. Finally, the slimy coat (EPS) on a biofilm can form a protective shield against harsh environmental conditions. In fact, many human infections e.g. those causing Pneumonia and periodontal disease are difficult to treat because pathogenic bacteria form biofilms, and can shield themselves from antibiotics. But bacteria are single-celled creatures that cannot see or hear each other: **how do they form biofilms**?

First, planktonic cells arrive as **primary colonisers** and sit on a surface. The cells are held to the surface through weak van der Waals attraction. They then attach to the surface using microscopic hair-like structures on the cell known as **pili** (singular: pilus). Once attached, they use available nutrients to grow and proliferate. The newly emerged cluster of cells **co-adhere** to each other as well as the surface. At this point, more bacterial cells may arrive and aggregate with the cluster. Cells may also attach to each other before they reach a surface. A biofilm is now forming! But how do cells know that they are around other bacterial cells? They do so using a mechanism known as **quorum sensing**. Each bacterial cell releases chemical molecules, or signals, that can be sensed by other cells. The concentration of these signalling molecules increases with the density of bacterial cells. When cells sense a particular concentration of quorum-sensing molecules, they begin to secrete different proteins, lipids and polysaccharides, forming the EPS - similar to how we change into a raincoat and carry an umbrella when we notice dark clouds and thunder outside.

Bacterial cells within a biofilm can exchange nutrients and **facilitate** the growth of other cells. They may also **compete** with other cells for nutrients, depending on what kind of a surface they are attached to and which nutrients are available. Finally, once there is a severe shortage of nutrients, cells may begin **detaching** from the biofilm.

The social lives of bacteria can be just as complicated as ours. During a regular day, we may ask ourselves: should I do homework or play outside? Should I meet a friend or help my parents at home? A bacterium may ask itself: should I attach to a surface or another bacterial cell? Should I secrete an EPS or not? Knowing that pathogenic bacteria form biofilms and cause infections, how should we treat them?

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Alternative relationship in prism dispersion

P.K. Joshi

The standard representation between angle of refraction and angle of incidence in the text book is in terms of minimum deviation between the incident and emergent rays. However, it is worthwhile to understand the phenomenon at other angles. This work deals with the other angles which broadens the perception of student at the angle of incidence other than that which represents the phenomenon of minimum deviation.

Introduction:

The standard equation [1] given in the text book $\mu = \frac{\sin[(A+D_m)/2]}{A/2}$ on the basis of the Figure 1

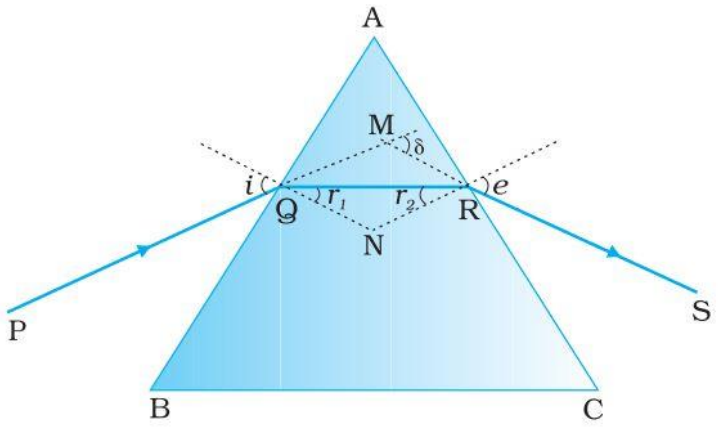

Figure 1. A text book ray diagram for a prism [1]. Not to scale.

From figure 1, angle d is the deviation between incident and the emergent ray. When this angle is minimum it is D_m and the equation of refractive index is defined on the basis of the angle of minimum deviation.

However, it has been observed that at other angle of incidences too the phenomenon of refraction is possible, but students tend to confuse between the two phenomena, not realizing that the angle of minimum deviation is just a special case of all the general cases. Misconception stretches to the level that discussing about calculation of m at other angles is unacceptable.

This work deals with the general case.

Theory:

Consider the sketch in Figure 2. For simplicity, let us redefine the angles as defined in Figure 2.

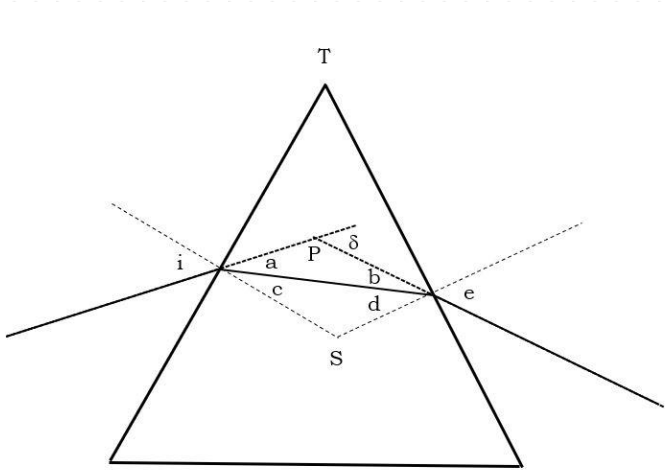

Figure 2. Ray diagram of the optics of prism, defining several angles for the purpose of calculations (Not to scale).

Let the prism be an isosceles prism with two equal sides having the common angle T. The normal to these sides, where the incident beam and emergent beam make angle *i* and *e*, meet in angle S.

Let μ be the refractive index of the optically dense medium which can be glass or water or any transparent liquid in a transparent container of the shape given in Figure 2.

Then

$$\mu \sin(c\,) = \sin(i)$$

$$\mu \sin(d) = \sin(e)$$

$$T + S + 90 + 90 = 360$$

$$S = 180 - T$$

$$c + d = 180 - S = T$$

$$\sin(e) = \mu \sin(d) = \mu \sin(180 - S - c)$$

$$= \mu \sin(T - c)$$

$$= \mu \left(\sin(T)\cos(c) - \cos(T)\sin(c)\right)$$

$$= \mu \left[\sin(T)\sqrt{1 - \frac{sin^2(i)}{\mu^2}} - \frac{\cos(T)\sin(i)}{\mu}\right]$$

$$\sin(e) = \sin(T)\sqrt{\mu^2 - sin^2(i)} - \cos(T)\sin(i) \quad \text{.....(1)}$$

For I = 40, T=60 and μ= 1.5 we have

$\sin(i) = 0.643$ $\sin^2(i) = 0.413$, $\sin(T) = 0.866$ $\cos(T) = 0.5$

$$\sin(e) = 0.866 \times \left(\sqrt{2.25 - 0.413}\right) - 0.5 \times 0.643 = 0.8519$$

Angle of emergence = 58.5 degrees.

Equation (1) leads to not so trivial expression for μ, given by

$$\mu^2 = sin^2(i) + \left\{\frac{\sin(e)}{\sin(T)} + \frac{\sin(i)}{\tan(T)}\right\}^2 \text{.....(2)}$$

This equation connects e to i in terms of angle of prism and . And the identity

$$\delta = i + e - T \text{.....(3)}$$

Can be established by simple geometry.

For T=60°, the normal prism available in class rooms, m=1.5, for different values of incident angle i, values of e (the angle of emerging ray) and deviation angle d, between the incident and emergent beam are listed in Table 1. Using equation 1 and 3. It can be seen that the minimum angle of deviation is for i= 48°

Table 1. Values of angle of emergent ray (e) and angle of deviation d, for different values of incident angle (i), for T=60 and μ=1.5, using equation 1.

i	sin(i)	$sin^2(i)$	e	d
20	0.3421	0.1170	-	-
28	0.4695	0.2205	87.6	55.6
30	0.5001	0.2501	77.1	47.1
35	0.5736	0.3291	66.0	41.0
40	0.6429	0.4133	58.5	38.5
45	0.7072	0.5001	52.4	37.4
47	0.7314	0.5350	50.2	37.2
48	0.7432	0.5524	49.2	37.2
50	0.7661	0.5869	47.2	37.2
55	0.8192	0.6711	42.7	37.7
60	0.8661	0.7501	38.9	38.9
65	0.9064	0.8215	35.6	40.6
70	0.9397	0.8831	32.9	42.9
75	0.9660	0.9331	30.7	45.7
80	0.9848	0.9699	29.2	49.2
85	0.9962	0.9924	28.2	53.2
89.8	1.0000	1.0000	27.9	57.7

It can also be seen that for T=90°, cos(T)=0 and the equation 1 and 2 can be modified to

$$sin^2(i) + sin^2(e) = \mu^2$$

Which has been discussed in an earlier work [2].

However, this equation, and the experimental measurements are possible for $\mu \leq 1.44$. For case where water (in a transparent thin container) is the medium, experimental measurements for i and e are possible, for values of $i \geq 65°$.

For glass prism, $\mu = 1.5$, at T=90° only total internal reflection is possible from the second surface. No refraction phenomena, as shown in Figure 1, can be observed.

For all values of μ, given the angle of prism T, there is a lower limit on the angle of incidence for which phenomenon of refraction, as shown in Figure 1, is possible.

Table 2. For different values of m there is a lower limit of i, for a given T, where the phenomenon of refraction, as shown in Figure 1, can be observed.

μ	1.33		1.5
T	Minimum Angle of Incidence	T	Minimum Angle of Incidence
90°	≥65°	90°	No angle
80°	≥45°	80°	≥70
70°	≥30°	60°	≥30
56°	≥10°	48°	≥10
49°	All	42°	All

How does it compare with the experiment?

Experiment.

With the easy availability of laser beams easily, it would be desirable to use these beams for studying dispersion. However, measuring angles becomes much complex process, as compared to age-old textbook procedure of placing the prism on a piece of paper and using pins.

A line is drawn which passes through two paper pins and the prism was placed in a way that the incident light is at desired angle of incidence. Then observing two pins after dispersion, forming a straight line, are placed on the paper.

The line representing the emergent ray making an angle ‘e’ with the normal to the emerging surface, is drawn. A line perpendicular to the surface of the prism can be drawn in a way such that angle i and e can be measured using trigonometric principles. Angle measured using trigonometry has higher precision as compared to school level angle measuring instrument, protractor.

The experiment was conducted using 2 different prisms (different μ values). The results can be seen in Table 2.

Table 3. Refractive index calculated for different values of i. Using equation 2.

Incident angle	Emergence angle measured	μ
34.6	75.12	1.549993
44.59	55.98	1.550034
46.32	53.13	1.550004
49.1	53.25	1.549963
54.95	44.57	1.549968
61.93	39.81	1.550025
67.31	37.75	1.550044
75.26	33.12	1.549996

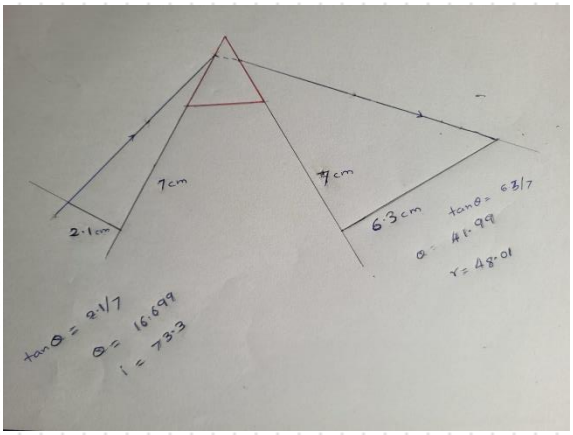

Figure 3. Example of how the angle of incidence and emergence.

A photograph of the measurement (for i=73.3°) is shown in Figure 3. A prism was laid on a piece of paper (outline in red) and the ray of light is drawn in blue. A normal is not shown, but using trigonometry angle q is calculated, where q = 90-i. Similarly, angle 'e' is calculated using trigonometry.

In listing the value of refractive index, large number of digits was to show the accuracy with which value of μ was obtained. The average value of μ was 1.54± 0.01

Similar results were obtained for prism with higher refractive index.

Table 4. Refractive index calculated for different values of i. using equation 2.

Incident angle	Emergence angle	μ
	measured	
50.8	67.58	1.701478
56.18	61.5	1.709768
59.04	62.53	1.744792
73.3	48.01	1.705508
61.9	54.37	1.695334
65.77	53.13	1.713055

Here the average value of μ obtained was 1.71 ± .02. The larger uncertainty here was due to different deviations which are observed on the emergent side, depending on the wavelength of the light.

CONCLUSION: It is possible to calculate the value of m for different values of angle of incidence on the prism, using the equation mentioned above. The value of m can be measured with good precision if repeated for large number of values of angle of incidence.

This experiment does not require any costly equipment like spectrometer and can be carried out on simple piece of paper.

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1 . Chapter 9.6 and Figure 9.23 RAY OPTICS AND OPTICAL INSTRUMENTS NCERT text book of class XII)

2 . P.K. Joshi, Refractive Index – using adjacent sides, GPG Journal of Science Education (2020) Vol 1(1) p14-16

Decoding DNA: A Simple Guide to How Scientists Cut and Paste Genes

Rashmi Priya

History of Restriction Digestion:

Let's travel back to the 1970s, when Werner Arber made a remarkable discovery – he found restriction endonucleases in bacteria. These enzymes, like tiny molecular scissors, played a crucial role in protecting bacterial cells from invading viral DNA. Arber's work shed light on the intricate defense mechanisms within bacteria.

Around the same time, Daniel Nathans independently grasped the potential of these remarkable enzymes. Recognizing their ability to cut DNA at specific points, Nathans saw beyond their role in bacterial defense. Instead, he envisioned these molecular scissors as powerful tools for manipulating DNA in a laboratory setting

Hamilton Smith's ground-breaking contribution solidified the field. In 1970, he isolated the first restriction enzyme, Hind II, from the bacterium *Haemophilus influenzae*. This landmark discovery marked the inception of a transformative era in molecular biology, providing scientists with the means to precisely cut and splice DNA.

How Restriction Enzymes Work at the Molecular Level:

Imagine our DNA as a string of beads, and the restriction enzyme as a pair of scissors.

1. Recognition and Binding:

Restriction enzymes showcase an incredible talent for identifying specific DNA sequences, termed recognition sites. These sites often possess a symmetrical structure known as palindromic sequences, resembling a genetic mirror image

Picture the enzyme as a molecular detective, skillfully navigating the intricate DNA strands until it pinpoints its designated recognition site. This recognition is like finding a specific address in a huge city of genetic information.

2. Cleavage and Scission:

Once the restriction enzyme finds the recognition site, it performs a surgical cut, precisely cleaving the DNA at specific phosphodiester bonds. This is similar to the molecular scissors making an exact cut at predetermined points in the DNA ladder. The outcome is distinct DNA fragments, each with its own unique sequence. Depending on the nature of the cut, these fragments may possess overhangs, called sticky ends, or have a flush ending, further diversifying the genetic toolkit generated through this process.

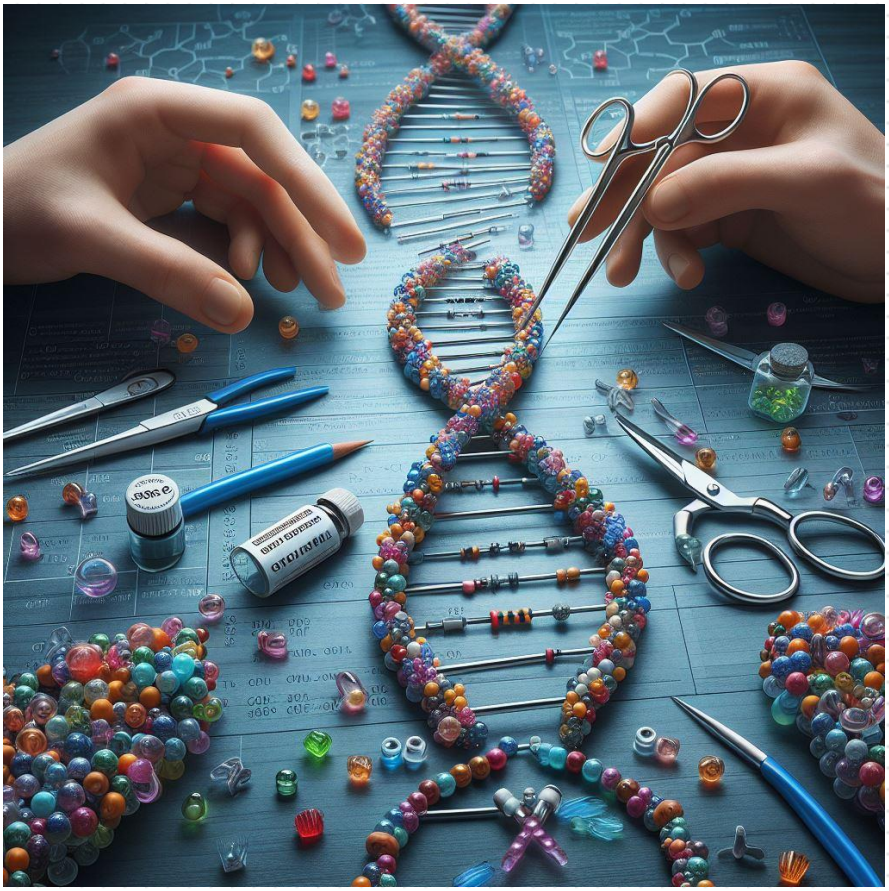

Image 1 – A imagination of restriction Enzyme working as scissors on DNA (Image generated using Microsoft Designer)

3. Facilitation of Genetic Manipulation:

The DNA fragments act like pieces of a genetic puzzle, serving as essential tools for scientists in genetic manipulation. Their distinctive patterns and ends enable easy insertion into vectors or other DNA molecules. This ability is crucial for groundbreaking advances like gene cloning, genetic engineering, and making recombinant DNA. By strategically manipulating these fragments, scientists open up new possibilities, creating fresh genetic combinations and contributing to transformative developments across scientific fields.

Major Implications and Scientific Advancements:

This discovery isn't just about fancy science terms. It's about unlocking the secrets of our genes and using that knowledge to make incredible advancements.

The way scientists cut DNA, called restriction digestion, has led to many important discoveries. It helped create maps of genes, showing where they are on chromosomes. This cutting method also helped find changes in genes that cause different diseases, especially in medical research.

Not just that, this cutting process played a big role in making genetically modified organisms (GMOs). These are organisms whose genes have been changed for different uses, like in farming, medicine, or industry.

In simple words, by using restriction digestion, scientists have learned a lot about genes and made things like gene maps, found disease causes, and even changed genes to make useful things in different areas of science.

Conclusion

Exploring the history and details of restriction digestion, it's clear that this technique goes beyond unraveling DNA secrets. It stands as a crucial foundation for groundbreaking scientific achievements. From Arber's discovery of bacterial defense mechanisms to Smith isolating Hind II, these milestones have significantly impacted molecular biology, shaping how we inquire and innovate in the realm of science.

"Mawphlang" a Sacred Grove of Meghalaya

Chaitali Dixit

Sacred groves, an ancient art of in-situ conservation of local forest patches, the practice of preparing and preserving forested areas for future generations' benefit and sustainability. Sacred groves also known as sacred Woods are a tract of virgin forest that is protected traditionally by the local communities as a whole and a harbor rich in biodiversity.

Sacred grove is called "virgin" because they are untouched by human activities remaining in their natural state without any significant human interaction or exploitation. They are considered pristine and hold immense ecological and cultural values. Hunting and logging is completely restricted in a sacred grove. In the ancient era, local community used to protect environment to balance ecological system of the area by protecting forest considered as a sacred grove. The locations of sacred groves were mainly dependent on the types of deities. Sacred stone found in most of the sacred groves located in hills, are worshipped in the name of their deities. It is believed that deities preside on the sacred trees therefore, it is worshipped, protected and no one is permitted to cut down trees.

One such famous sacred grove is the sacred grove of Meghalaya, "The mawphlang sacred grove". It is located at mawphlang village,24 km away from Shillong, the capital city of Meghalaya. It covers an area of 76.8 hectares, a primordial forest aged more than 700 years, standing aloft through the test of time and conserved by the local khasi tribe community through social fencing.

Mawphlang sacred forest was originally home to the blah community. Mawphlang means "grassy stone", and is one of many settlements in the Khasi hills named after monoliths. According to locals a story about Mawphlang sacred grove says that, A clan war ensued and the Hima Mawphlang won. following which a search for leader began. The clan settled upon a woman who was revard and said to possess even supernatural gifts. However, she refused and instead promised to make her son the leader provided God gave her a sign. She planted some saplings inside the forest with a belief that if saplings survive for 3 years, her son was meant to be their leader. The saplings planted by her flourished and her son took on the title.

The local khasi tribe holds the pride to take care of sacred grove with a distinct entity. The local khasi guides narrate the story of the sacred groove to visitors, as per one guide, "the local deity is called 'labasa', who is called by local priests and worshipped at the time of any severe Mishap and illness". The local people strongly believe that, the deities appear with routine sacrifices performed on monoliths of sacred groves, bless and save them from any such misshappenings. An amazing aura, the Godly presence, the solemnly environment is felt by the visitors which takes sacred grove to a spiritual level. According to the local Khasis,"what stays in the forest must stay in the forest". No one can take even a leaf outside the forest else, it can cause any miss happening to the person and the family.

The Mawphlang sacred grove is rich in biodiversity. The dense deciduous trees form a netting of verdant ceiling and the silence echos powerfully. Many endemic medicinal plant species and spiritual plants contribute to a divine supernatural power to the forest that is felt by the locals and visitors of the sacred grove.

The sacred grove is classified as a subtropical broad leaf type, although Pinus kesiya (Pine trees) dominates the surrounding areas. The main flowering trees and shrubs are: *Laeocarpus ganitrus* (Rudraksha), *Rhododendron formosum* (Lali gurans),*Rhododendron arboreum* (burans/gurans), *Pyrus pashia* (Wild Himalayan pear), *Quercus griffithii* (Species of oak), *Daphne cannabina* (Satpura), *Symplocos chinensis* (family of sapphire berry), and above 450 species of trees, herbs and wildlife including clouded leopard, monkeys deers and frogs of the genus Rana. Visitors are allowed only to a restricted patch of the forest along with a guide where wild animals are not seen but sacred monoliths and stones are shown by the guide.

Visiting the mawphlang sacred grove is a worth visit to witness the divine power of the forest, to witness many medicinal plants which are claimed to treat tuberculosis and breast cancer, and to feel the divine presence of Brahma, Vishnu, and Mahesh under the rudraksha trees of the sacred grove.

Forthcoming event of NMSF

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Homi Bhabha Bal Vaigyanik Competition-2024" Guidance Sessions, Starting from 16th June, 2024. Open lecture for all on 9th June 2024. For further details, visit NMSF website

http://www.navimumbaisciencefoundation.org

DON'T MISS IT

Coming up in Next issue (April-June 2024)

1. More about experiments
2. Student's corner
3. Teacher's page
4. Activity question AND MUCH MORE……

DO YOU HAVE ANY INTERESTING EDUCATIONAL STORY TO TELL? JUST SEND YOUR STORY TO US AT edureka.nmsf@gmail.com
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