



# IEC INTERNATIONAL JOURNAL OF TECHNOLOGY AND MANAGEMENT

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## Great Newton's story of passion, curiosity, and concentration

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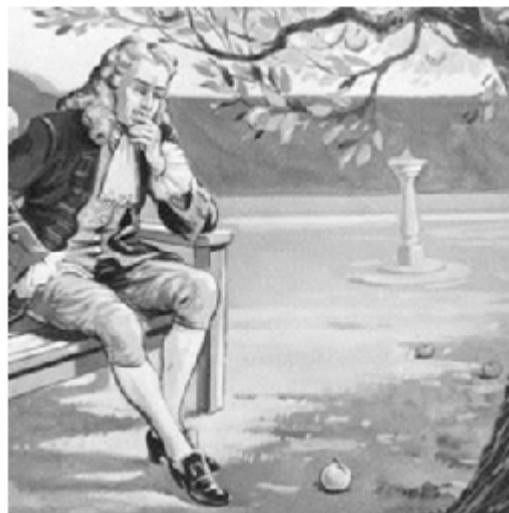
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### 1. Introduction

Whenever the name Newton comes up, a figure of the divine being emerges which can be compared to a deity. It seems that the person had divine vision from birth, which led to his many scientific achievements. When someone asked him how he formulated the theory of universal gravitation, his answer was, "Thinking about it constantly, and waiting for that moment until slowly all things became clear." It is difficult to imagine from this response of Newton that a person can read and think, becoming an idol of concentration to satisfy his curiosity. In this article, we are going to look at an aspect of the life of Newton where there is dissatisfaction with the difficult circumstances of childhood, there is the great passion to satisfy his curiosity from adolescence to adulthood, and from time to time angel-like persons come to help him to reach the top of his scientific achievements.

### Introverted childhood

In England of the 17th century, according to the Julian calendar Isaac Newton was born on Christmas in the full moon night of 24-25 about two hours after midnight in Woolsthorpe Manor of village Colsterworth in Lincolnshire. Newton's village is located 60 miles north-west of the famous Cambridge University. In October, three months before his birth, his father (also named Isaac Newton) had died. Boy Isaac was born prematurely and was so weak that there was no chance of surviving even a day. With the grace of God, Newton lived a healthy life of 84 years. Leaving him with his maternal grandmother at the age of three, in 1646, his mother Hana Ayscoughs remarried Barnabas Smith. The 60-year-old Smith from the neighboring village, North Witham, was a wealthy man and financially



helped the grandmother, Mary Ayscoughsof, for the maintenance of Woolsthorpe Manor. Newton could not recover from the shock of separation from his mother, for the rest of his life and it made him of irritable and rebellious nature. He loved his mother very much, for whom he had no hatred in his heart, but there was such a pain of separation at an early age that, from time to time, it erupted in uncontrollable anger. The effects of the absence of father from his birth and separation from mother in his early childhood made Newton an introverted child. He would sit alone for hours looking at the stars in the distant sky and speculate about them.

Smith and Hana became parents of a girl Mary born in 1647, a boy Benjamin in 1651 and another girl Hana in 1652. But after Smith's death in 1653, Newton's mother took everyone back to Woolsthorpe Manor. By the time he was ten years old, Newton had lost his sense of affection for those close to him. He did not feel any

attachment to his maternal grandparents, nor to his mother or step-father nor the half siblings. To outsiders, Newton was a calm, gentle and reflective child, but at times his temper flared up. In an enraged situation he once threatened his mother and stepfather to burn inside the house. In the religious environment of the house, Newton became theistic and throughout his life took help of the Bible to solve any problem. Due to his religious ideology, he felt that God had created the universe for a specific purpose and it was necessary for Newton to know about the universe.

### **Schoolboy Life and Two-and-a-half-penny's Notebook**

At the age of twelve, Newton began his student life at the Grammar School in Grantham, which was 7-8 miles from his village. For this he had to live as a tenant in the house of the owner of a drug store, named Clark. There were many books in Clark's house and the child Newton became fond of reading books. At that time, the school taught mainly Latin and Greek languages and very little mathematics was taught. The calm and sensitive child Newton, was not interested in schooling and soon he was counted among the weakest students in the class.

Newton himself admitted that his dormant intellectual stage came to an end on the day he was kicked in the stomach by the most notorious boy in the school. In a fit of rage, he challenged his stronger comrade to fight in the church grounds. According to John Conduit, who first wrote his biography, Newton was physically weaker than his rival but his passion and determination was so high that he kept hitting the notorious boy until he accepted defeat. Even after this, Newton's anger did not subside and he grabbed the boy's ear and started rubbing his nose against the wall of the church. It was not enough to prove physical superiority over his rival, and soon Newton went far ahead intellectually as well. In Newton's life such angry and retaliatory incidents continued coming many times, which first showed up in school.



**Figure 1. A penny coin in seventeenth century England**

After the above incident, once Newton's mental ability was awakened, there was no stopping. Adolescent Isaac exhibited all those qualities which are signs of extraordinary ability. He made models of windmills, designed noise making kites in the wind, made water clocks, paper lanterns and many types of toys to surprise people. He used to tell the time by looking at the shadows in the sunlight and used to draw various types of pictures and write down the details of the events in a notebook. Fortunately, this notebook of his is available in the Pierpont Morgan Library in New York. On the back of the front cover of this notebook, Newton wrote that it was bought for two and half penny in 1659. It contains details of some strange types of people living in Grantham, details of astrological predictions of solar eclipses and lunar eclipses, and has expressed curiosity about some problems. It has a diagram of Copernicus's solar system and the detailed description of constructing a sun clock. From the look of this notebook, it seems that Newton's intellectual fervor went far beyond the limits of what was taught in the school of that time. His interest in science was greatly increased and he wanted to know how things worked. Newton's mother asked him to return back home to look after their farm, the same year he had bought the two-and-a-half penny notebook.

Seventeen-year-old Newton proved utterly useless as a farmer. When he took the pigs and the sheep for grazing in the farm, he would take a book and sit under a tree and engage in reading. In the meantime, his domestic animals used to break the fence on the border to ruin the maize crop in the neighbor's field. The fence of his farm had become dilapidated and he received a legal notice and had to pay a fine of four shillings and four pennies. Thus, instead of a school certificate, his first qualification was recorded as a criminal. These events proved one thing that his passion for science had grown into an addiction and this tide continued for the next 37 years without turning down. Newton continued his work of reading, conducting scientific experiments and recording his knowledge in his notebooks.

Fortunately, two men played a key role in getting Newton out of his farming responsibilities. Newton's uncle William Ayscough was a pastor in the adjoining village and had graduated from Trinity College, Cambridge. John Stokes was the master of the Grantham School and was aware of Newton's genius. Together, they persuaded Newton's mother to send him back to

Grantham School, where Stokes would prepare him for admission to Trinity College. Newton once again became engrossed in his studies by living as a tenant at Clark's house.

### Entering in Cambridge University

June 1661, at the age of eighteen, Newton attended Trinity College, where he was two years older than his classmates. He was poorer than his classmates and was enrolled as a scholarship student and had to work as a servant to his tutor. Fortunately, Newton's tutor stayed at Trinity College for five weeks in a year so he had plenty of time to study.

The 17th century was a time of an intellectual revolution in England in which many eminent people raised the country's prestige. Harvey started the modern era in medical science with the discovery of blood circulation in the human body, while Halley made a splash with the discovery of the tail star, which was named later Haley Comet. Boyle was laying the foundations of chemistry, Hobbes was counted among the most experienced political experts of the time, while John Locke as a philosopher, was one of the first defenders of modern empiricism. It was on the basis of Locke's ideas that the Constitution of the United States of America was created. Despite the above awakening in England, the standard of education in the English universities was pathetic since it was based on the medieval Aristotelian. It was still believed that Earth was at the center of the universe and that everything was created from the four elements - earth, air, fire, and water.

The first step towards the end of Aristotelian assumption was taken by the Polish priest Copernicus, who propounded the notion of a heliocentric solar system in the early 17th century, and working on this basis the German astronomer Kepler, in Prague, formulated the three laws of planetary motion. Italian physicist Galileo created new mechanics based on his scientific experiments, which he had to give up under the pressure of the Catholic Church. In the meantime, Rene Descartes had shown, through tests of analysis and experience, that there were many shortcomings in scientific education.

The presence of Europe's first inventors was also giving impetus to the intellectual revolution in England, which was directly affecting young Newton. To understand new scientific discoveries, they started learning

wholeheartedly about the changes in the field of mathematics, because future scientific discoveries were going to be based on these. It was also a time of revolution in mathematics, which was constantly running parallel to the new discoveries in science. In the mid 17th century, three great mathematicians- Descartes, Fermat and Pascal- were at the top of their intellectual abilities. During his bachelor's degree education, Newton had assimilated the Cartesian System invented by Descartes. In this system of three mutually perpendicular axes, precise measurement of any point in space could be done whether the point was located on any line, curve or surface. In addition to algebra, analytical geometry could be used to represent any curve as an equation in terms of Cartesian coordinates. For example, a parabola with an axis Y can be represented by the x and y coordinates as  $y = x^2$

Newton's habit of writing of his activities, which had begun in school, continued at the university. His new notebook was titled: "Certain Philosophical Questions" in which further wrote: "My best friend is truth". Thus we see that Newton had accepted the concept of Descartes that everything that is observed in the real world is due to the motion of particles of matter and the root cause of all natural phenomena is the interaction between these particles. Newton's notebooks also show that he was aware of the latest research of Robert Boyle in chemistry, where information about the basic chemical elements had begun to emerge.

By the time he completed three years in Cambridge, Newton started making important contributions in the field of mathematics. He formulated the binomial theorem for fractions by means of which we can write the following infinite series:

$$(1+x)^{-1} = 1 + (1/2)x - (1/8)x^2 + (1/16)x^3 - (5/128)x^4 + \dots (1)$$

Working on this type of infinite series was Newton's first step in the field of calculus for Newton which was an all time great achievement. He passed his BA in June 1665.



Figure 2. Two identical looking balls of different mass thrown together by Galileo from the roof of the Tower of Pisa, while

traveling on two different parabolic trajectories, fell to the ground at the same time.

### Creation of Calculus

Newton had used geometric mathematics to establish calculus, which is quite complicated. We will use a modern and simple style here. In his experiment of dropping identical balls of different material from the top of the leaning tower of Pisa, Galileo had used the following equation to represent their trajectory:

$$s = gt^2 \quad (2)$$

where  $t$  denotes time,  $s$  is the distance covered by the ball from top of the tower, and  $g$  is the acceleration produced by the gravitational force. Representing  $s$  on the Y axis of the Cartesian system and  $t$  on the X axis in Equation (2) gives rise to the parabola trajectory of Newton as shown in *Figure 2*.

Newton found a wonderful way of expressing the concept of mechanics through calculus. The differential equation to express any speed  $v$  is as follows:

$$v = (ds/dt) \quad (3)$$

If the speed  $v$  is changing with time, then it is expressed by the derivative of speed ( $dv/dt$ ). Thus, acceleration  $a$  will be represented by the following differential equation:

$$a = (dv/dt) \quad (4)$$

When the ball is in free fall, the speed increases with time and it can be expressed as:

$$v = gt \quad (5)$$

Thus, we find that  $g$  represents the acceleration during free fall which is gravitationally generated acceleration.

Cambridge university was closed during 1665-67 due to bubonic plague, and Newton working alone in his village laid the foundation for the creation of calculus, and called it the Method of series and fluxions for mathematical calculations. Working on this basis, in the next twenty years, he did epoch-making research on the laws of motion, the moon and its effect on the earth, and the Universal Gravitational Constant. Talking to some people in later life, Newton described this time of one and a half years as the golden period of his research work.

### Prism, Spectrum, and Telescope

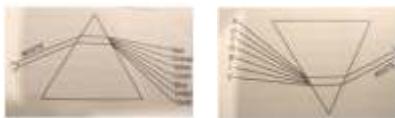


Fig. 3. A ray of sunlight after passing through a glass prism splits mainly into seven colors. When this colored light beam is thrown on another prism of the same type but inverted, the ray that comes out becomes white like the ray falling on the first prism. {Adopted from Ref. 2}

There were many misconceptions at the time Newton divided the white ray of the Sun into seven colors of the spectrum through a prism. Under the influence of Aristotle, it was recognized that different colors are produced by mixing light (white color) and darkness (blackcolor) in different proportions. Some people believed that rainwater colored the white light of the sun, which formed the rainbow. In the beginning of the 17th century, the pace of research was very rapid on the structure of the eye, color and vision. The German astrophysicist Kepler concluded on the basis of his experiments in 1604, that the most important organ for vision was not the eye lens which was a popular belief at the time. According to Kepler the lens produced an image on the inner layer of eye (retina) by focusing light, just as a small hole in a pinhole camera creates an image of external objects on a screen. Unfortunately René Descartes, the abstract thinker of that period, did not attach much importance to the Kepler's discovery. On the other hand he concluded in 1630 by experiments on animal eyes obtained from a slaughterhouse, that the physical effect of the eye was analyzed by the brain. Descartes, under the influence of Aristotle's ideology, was of the opinion that the basic color of light is white and that it becomes colored according to the nature of the medium through which it passes. The famous British physicist Robert Hooke, was also of the same opinion that pure light is white and it becomes colored due to distortion caused by objects.

Newton did not agree with the above Aristotle's ideology that colors are produced by mixing light and dark or by mixing white and black. This notion was not proved by experiments. Any page of a book printed with black ink contains both white and black colors, but seen from a distance the page does not look colored although it is a mixture of black and white and it looks gray. Living In his village away from Cambridge during the bubonic plague, Newton had bought glass prisms from the scrap market in 1666. The glass prism was considered a plaything, which people used to add colorful sparkles to their homes ceilings or walls by hanging. Newton did many experiments with the sun's ray and prism in the dark room of his village, in which white light after refraction was spread into colorful stripes on a screen on

the other side of the prism. Although these color bands were continuous with no clear boundaries between one color and another, Newton divided them into seven colors as red, orange, yellow, green, blue, dark blue (Indigo), and violet as shown in *Figure 3*. In fact, orange and dark blue (Indigo) are not visible in the color spectrum and Newton had named them on the lines of the seven music notes [sa, re, ga, ma, pa, dha, ni] which has remained till date. Does white light become colored as it passes inside a prism? To solve this problem, Newton passed the colored band through an inverted prism. After passing through this second prism of the same form, the dispersed colored band of light converges to a white beam as is shown in *Figure 3*.

Newton observed that the angle of refraction of each color had a different value, the largest for red and the smallest for violet. In a second arrangement similar to that shown in *Figure 3*, a black screen with a tiny hole was placed between the colored band of light and the inverted prism so that light of only one color fell on the prism. It was observed that there is no change in the color of the light even after passing through the second prism. In other experiments monochromatic light was allowed to fall on many types of objects, and it was found that the white or light-colored objects exhibit the same color as the monochromatic light that falls on them. On the basis of these experiments, Newton concluded that the white light of the Sun can be divided mainly into seven colors. Therefore, color is an intrinsic property of light and an object looks the same as the color of the light it reflects [1]. Newton named the process of division of white light into colors as 'color spectrum'. In later years an unprecedented advance was made in the fields of physics and chemistry by studies on the spectrum and this method of investigation came to be known as spectroscopy. Based on these important contributions Newton was made a Fellow of Trinity College in October 1667 and was awarded the MA degree in 1668. His mentor, Professor Isaac Barrow was very impressed with Newton's experimental work on light and his mathematical contributions to calculus, and he was instrumental in appointing Newton to the same position when he left his Lucasian professorship. Newton was elevated to the prestigious position of Lucasian Professor of Mathematics at Cambridge University on 19 October 1669.

There had been unprecedented progress in the field of

astronomy by the middle of the 17th century. Large telescopes were built to study distant stars and other celestial bodies, whose length was more than two hundred feet. The reason for this extraordinary increase in the length of telescopes was to increase their resolving power. This was necessary to see the separated images of two closely located stars, in a dense group of stars, formed by refraction through lenses of the telescope. The small length telescopes working on the principle of refraction were not capable of resolving the images of two closely located stars. In long-length telescopes, however, the images become blurred and colored at the edge, and it seemed that no increase in their resolving power was possible. In 1668, shortly before becoming a Lucasian professor, Newton's attention was focused on the problem of poor image formation in telescopes. According to his nature, he started thinking day and night about the solution of this problem. This relentless thinking came in the form of a solution, and it was so simple that Newton's genius spread far and wide. This simple and efficient design changed the technology of telescope making forever. Newton decided to collect the light coming from distant stars to form the image by using a parabolic mirror instead of a lens. In the process of image formation by the mirror, reflection takes place and the problem of light attenuation due to absorption in the lens is eliminated as shown in *Figure 4*. Based on his experience of creating a spectrum with a prism, Newton was aware of the fact that because of its shape, the difference in thickness of the lens near its edge and in the middle was responsible for coloring and blurring the image. Thus Newton's new design of the telescope based on image formation by reflection in the mirror, rather than refraction in the lens, solved the twin defects of blurr and and colored image formation.

Galileo had built a telescope for observing the planets with the help of a trained assistant, but Newton went a step further and decided to build his own telescope without anyone's help. He, himself, performed the casting of the mirror, molded the telescope tube and erected its entire structure. When fully built, this telescope of one inch diameter and six inches in length had a magnifying power of thirty, which was equivalent to a six feet long telescope equipped with a lens. It is pertinent to mention here that James Gregory, professor of mathematics at St. Andrews University, had come up with almost similar design for the telescope which could not be constructed due to the lack of competent

craftsmen [3]. On the suggestion of Professor Barrow, Newton constructed a second telescope, two inches in diameter and eight inch long (see Fig.6), which was demonstrated during the 1671 meeting of the Royal Society in London. There were great scholars of optics gathered in the meeting and Newton was immediately elected a Fellow of Royal Society .

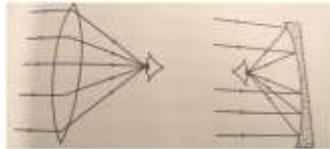


Fig.4. Light coming from distant celestial bodies, when focused by lens, gets attenuated due to refraction and becomes colored because of prism-like spread in the lens. When the same falls on a concave or parabolic mirror, focusing is due to reflection, and defects of the lens are removed making the image clear and bright. (Adopted from Ref. 2)

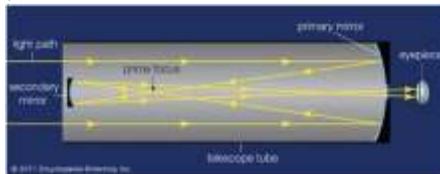


Figure 5. Reflecting Telescope Design has a large parabolic mirror, located at one end of the tube, with a small hole at the center. Light from the distant star enters from the other end of the tube which holds a small concave mirror that forms the image on exiting the hole in the center of the main mirror.



Fig. 6. Newton's Telescope (Adopted from Ref. 3)

## Apple falling from the tree & motion of the Moon

According to a famous story, when asked by a friend how he learned about gravity, Newton said that during bubonic plague he was sitting in the garden of his village and seeing an apple falling from the tree, he realized the force of gravity. It is to be noted here that for the next twenty years he did not tell anyone about it. As we have mentioned above, Newton used to think and read about any problem continuously until he came up with the way to solve the problem. In 1609 the German astronomer

Kepler had come to the conclusion that Mars moves in an elliptical orbit around the Sun. This had been possible by studying and analyzing the data collected by himself and by others, over a period of twenty years, on the motion of Mars in the sky. Later he gave three rules about the rotation of the planets in the orbit of the Sun which were based purely on observations. In addition to Kepler's work, Newton was aware of Galileo's experiment at the leaning tower of Pisa, which showed that a freely falling ball travels a distance of 16 feet in one second. Thus, Newton had the knowledge that the earth and other celestial bodies were capable of exerting a force of attraction. Newton was thinking deeply about two problems related to the force of attraction in celestial bodies and the earth. One of the problems was about the solution to the effect of distance on this force. The second problem was about the force of attraction of the earth on the moon: whether it is applied at the surface of the moon or at its center or at any point in between. In his attempt to find solutions to these problems, he always remembered the concept of Descartes that the root cause of any event in the universe is the mutual force between the particles of matter. Newton was also aware of Robert Boyle's research in chemistry, explaining chemical reactions at the molecule level.

In view of Newton's profound knowledge and his incomparable ability to think, it would not be wrong to speculate that at the time of the bubonic plague he must have found, all of a sudden, a way to solve the problems related to the gravitational force on which he continued to work for the next twenty years. Due to his habit of being alone since childhood, he did not share the findings of his research with anyone because he could not tolerate criticism of his work by others. Two examples would illustrate his habit of keeping the information hidden from others. The famous astronomer of the time, Halley, upon meeting him in Cambridge in 1684, asked about the shape of the orbit of a planet if the force of attraction between the planet and the sun was inversely proportional to the square of distance between them. In response, Newton vehemently said that the orbit of the planet would be elliptical, and in the light of *Figure 7* calculations indicate the Moon falling towards the Earth by 16 feet in one second. Thus, the gravitational force that makes the apple fruit fall on the earth, also forces the moon to revolve around the earth. It is to be noted here that till then the *Principia* was not published and no outsider was aware of the law of

gravitation propounded by Newton.

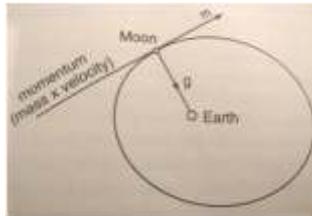


Fig. 7. According to Newton's first law of motion, free celestial bodies should move with a uniform speed in the silent space without any obstruction. On the basis of this fact, in the absence of gravitational force between the earth and the moon, the moon would move away from the earth at a constant velocity along the path 'm' shown by the arrow in a straight line. However, under the influence of gravitational force towards the earth's center, the moon experiences a constant acceleration in the same direction and starts falling towards earth in the same manner as an apple falls on the ground, leading to its elliptical path. (Adopted from Ref. 2)

## Kepler, Galileo and the Gravitational constant

Newton was constantly solidifying and refining his initial insights about gravity during his silence of twenty long years. Finally it was refined into a comprehensive system by him in his book, *Principia*, and presented to the scientific world. Newton went a step ahead of Kepler and Galileo and presented the three laws he had propounded, which replaced the conclusions of these two great mathematicians. Kepler had propounded three laws of planetary rotation around the Sun, which are clearly illustrated in *Figure 8*.

- #1 Planets revolve around the Sun in an elliptical orbit with the Sun at one focus.
- #2 The straight line connecting the planet to the Sun forms an equal triangular area in equal time during its motion around the sun. t
- #3 The square of the time taken by a planet to complete one revolution of its orbit is proportional to the cube of its average distance from the Sun ..

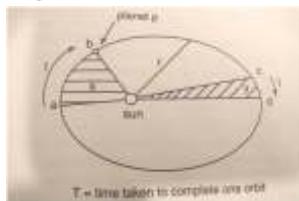


Fig. 8. The Sun is located at the focus of the planet's elliptical orbit. The planet moving in its orbit takes equal time in going from *a* to *b* and from *c* to *d* such that the triangular areas represented by X and

Y are equal. T is the time taken by planet *p* to complete one revolution in its orbit and its average distance from the Sun is *r*, so that  $T^2 = (\text{constant}) r^3$ . (Adopted from Ref. 2)

Galileo proved through his experiments from the Tower of Pisa that objects falling on the earth undergo a uniform acceleration and their path is a parabola. Both these facts are clarified through *Figure 2*.

In the light of Galileo's laws of motion of objects in the Earth's gravity, and Kepler's laws of planetary motion in the gravity of the Sun, Newton discovered the Universal Law of Gravitation which is a unique example of his stupendous genius. Kepler's laws had been in his mind since student life, so in the beginning he had obtained information about the inverse square law of force and the relation between Kepler's first and third laws. Seeing an apple fall from a tree in his village garden, Newton's idea of gravity was that of a force that held the moon in the orbit of the Earth, and the planets in the orbit of the Sun. The realization that the laws that apply to the Earth are also true for the universe could be possible due to Newton's remarkable insight. With this bold move of his, the understanding of man suddenly spread to the whole universe, and not just limited to the earth. Kepler's laws of motion had only revealed the motion of celestial bodies in the solar system. Newton's laws explained why the celestial bodies are moving through the universe.

Newton did not publish his discovery for twenty years. According to one view, he initially felt that gravity is limited only to the earth. Later, when he wanted to use this force on objects outside the earth, he had to spend a lot of time on the mathematical solution. How does Earth's gravitational force actually work? Does it attract the moon from its center or from its surface or some central part? He did not want to publish until he had refined the methods of calculus invented by him for these calculations. According to some others, this was not the only reason for his long silence. Newton could not tolerate even a friendly refutation of his belief by others. In such a situation, he used to suffer from uncontrollable anger. Therefore he used to confine his discoveries to himself instead of facing criticism from the scientists of his time.

**First of the three laws of motion propounded by Newton** is based on the principle of inertia, to maintain the same state. According to this, any object will remain stationary or will continue to move in a straight line with

a uniform speed unless there is an external force on it.

**Newton's second law of motion** defines force. According to this, the rate of change of momentum of a moving object is proportional to the force acting on it. This means that a constant force acting on an object moving with a constant or uniform motion produces acceleration. Galileo discovered this law by using the ball to drop it from the Tower of Pisa.

**Newton's third law of motion** states that if one object exerts a force on another, then the second also exerts a force equal to this force on the first object in the opposite direction.

Using these three basic laws, Newton succeeded in finding the value of the gravitational force between two bodies or two objects is proportional to product of the masses of two bodies and inversely proportional to the square of the distance between them:

$$F = G (m_1 m_2 / d^2) \quad (6)$$

where  $F$  is the force of gravity  $m_1$  and  $m_2$  are masses of the bodies and  $d$  is the distance between their centers.  $G$  is called the gravitational constant.

Newton did not get to know about the motion produced by gravity in a jiffy, but to solve this difficult problem, he had to evolve complicated mathematics to reach the ultimate goal. About a hundred years after Newton, an eccentric British physicist, Cavendish, was successful in finding the value of the gravitational constant  $G$  in the laboratory.

### Publications of Principia and Optics

Edmund Halley was born on 8 November 1656 in London and during his student days in Oxford, he had come in contact with John Flamsteed, the first Astronomer Royal of England. From 1676 to 1678, he lived on the island of Saint Helena, built an atlas of the stars of the southern hemisphere by telescope. He was elected a Royal Society Fellow, at the age of 22, for this important work. He made an in-depth study of the parabolic orbits of 24 tail stars (comets) observed by astronomers between 1337 and 1698 and found that there was only one tail star seen in 1531, 1607 and 1682, and predicted its return in 1758. Halley was appointed as the Astronomer Royal after the death of Flamsteed in

1729 and occupied this position till his death in 1742 but he did not see the arrival of the famous comet in 1758, that bears his name. The contribution of Halley in the publication of *Principia* is only slightly less than that of Newton.

Halley came to Cambridge to meet Newton for the first time in 1684 and tried his best to persuade Newton to write a book on his research of celestial mechanics. Accepting Halley's appeal, Newton started writing a three-part book called Mathematical Principles of Natural Philosophy. This book was given the abbreviation *Principia*. Newton, as was his nature, working passionately between August 1684 and April 1686, completed the writing of two parts of *Principia*. Halley, exercising his limited authority as a clerk in the Royal Society, worked tirelessly for the publication of *Principia*. Despite the opposition of Robert Hooke, members of the Royal Society granted permission for publication of *Principia*, with Halley in charge of its publication. At that time the financial condition of the Royal Society became so weak that in 1687 Halley had to put his own money into publishing *Principia* in addition to carrying out his editing responsibility. Finally, *Principia* was published on 5 July 1687, and its first edition quickly sold out, giving Halley his money back. The most proud and satisfying thing for Halley was Newton's display of gratitude to him. Newton wrote, "In the publication of this work the most acute and universally learned Mr Edmund Halley not only assisted me in correcting the errors of the press and preparing the geometrical figures, but it was through his solicitation that it came to be published "[3]. Halley, by persuading Newton, provided a masterpiece of scientific literature available to the public in the form of *Principia*. This book of about 500 pages contains 340 geometric drawings, some of which are very complicated.

Newton had many differences with Robert Hook on the theory of color and other aspects of optics. To get rid of the debate, Newton kept completely silent about his research work in optics for thirty years. *Optics* was published in 1704 after, main rival, Hook's death in 1703. There is a big difference between the presentation of Optics and *Principia*. *Optics* is written in English and lacks the cumbersome logic of mathematics, while *Principia* is full of Latin words and complicated mathematics. It seems that these two books have been written by two different people. It is important to

mention here that Newton was in Cambridge at the time of writing *Principia*, while writing *Optics* he was living in London. Perhaps the difference in presentation of two books was due to the difference in atmosphere of the two cities, which influenced Newton, living in the solitude of Cambridge, to become accustomed to the openness of London.

### Newton's well-wishers

There is immense literature available in books and articles on Sir Isaac Newton's life and work, from the observation of which one thing becomes clear that he was a believer in God. Be it equipment for scientific experiments, or calculus for mathematical analysis, he had made available the means he needed on his own. In spite of the self made great Newton, there were many such occasions in his life where if some people had not helped him, perhaps the world would have been deprived of his contribution to science and mathematics.

The first among those who helped Newton, was the medical store owner Clarke in Grantham. The bountiful stock of books in Clarke's house instilled in him the habit of reading books. After passing his BA at Trinity College, Humphrey Babington, a relative of Clarke, had also helped him in the election to be a fellow [3].

Newton's uncle William Ayscough and grammar school master John Stokes persuaded his mother for him to leave farming and go back to school. His mother wanted him to not be illiterate like his father and for this reason he was sent to a grammar school located in another village. But the mother had stopped his studies to take care of the farm spread over 100 acres. If his maternal uncle and the school teacher had not helped Newton would have spent the rest of his life as a farmer.

His Professor of Mathematics at Cambridge University, Isaac Barrow started treating him like their own son. Recognizing his unique talent and taking care of the loneliness that had arisen in his childhood, he saved him from situations that could drown Newton into darkness of despair. Prof Barrow played a crucial role to make Newton a Lucasian Professor and Fellow of Royal Society. Newton's Trinity College fellowship had a stipulation that he would always agree with the ideology of the Anglican Church and eventually become a pastor. Newton did not believe in the doctrine of the Trinity of

the Anglican Church, yet he somehow avoided expressing it. But in 1675, there was no way for Newton to escape the religious system of the church and he may have to leave the position of Lucasian professor. Professor Barrow, using his exclusive authority of the Royal Chaplain, freed the Lucasian Professor from this church sacrament, and Newton's life became happy [3].

It was not an easy task to persuade Newton to publish his research work on the force of gravity and the motion of the planets of the Solar System. Many eminent scientists had failed in this attempt, and even Professor Barron's request was politely rejected by Newton. Edmund Halley gracefully persuaded Newton to publish *Principia*, breaking the silence of twenty years on his research work. Halley knew that Newton did not like criticism of any kind. For this reason, in his first visit to Cambridge in 1684, he put a problem to Newton, because he knew that Newton would give his life to solve any problem. Talking about the difficulties he faced in his astronomical investigations, when Halley asked the shape of the orbit of a planet under the influence of the force following the inverse square law, Newton replied immediately that it was an ellipse. Expressing astonishment, when Halley asked how Newton came to know about this, he told that he had calculated it. When Halley expressed his desire to see the calculations, Newton could not find it in his papers immediately and promised to send them later. A few months later, when Halley read the article titled, "On the Motion of Bodies in Orbit" sent by Newton, he realized that Newton had invented a new system of celestial mechanics that provides a theoretical basis for Kepler's three laws. On his second visit to Cambridge, when Halley told Newton about the benefits of his work to future scientific research, Newton was impressed by his sincerity, and agreed to write *Principia*. Halley, regardless of his poverty, had his own money in the publication of the *Principia* (3). Thus we see that in the absence of the intelligence and sincerity with which Halley helped Newton, people would not have seen *Principia*.

### Newton's rivals

Among Newton's rivals, Robert Hooke in England, and Christian Huygens as well as Gottfried Leibniz in Europe were the most famous scientists of the time. Huygens was, in terms of scholarship, close to Newton and in addition to making significant contributions to

mathematics and mechanics, he did notable work in the manufacture of pendulum clocks, and significant changes in the design of microscopes and telescopes. Huygens too hesitated to publish the results of his research and worked almost alone because of the small number of his research students. Despite this similarity with Newton, Huygen's influence was limited only to the 17th century. According to Huygen, light propagates in the form of waves, which is the opposite of Newton's light propagation as particles. Huygen had negated Newton's gravitation, saying that it was pure mathematics and there was absolutely no mechanism in it.

Leibniz was primarily a mathematician and had two notable contributions. He, like Newton, composed the calculus independently. The operation symbols of his Calculus were more intuitive than Newton and are continued to be used till now. Unlike the scientists of that time, Leibniz was never associated with any educational institution. He displayed his versatility as a politician, a lawyer, a social reformer and a genealogy expert. In 1696, the Swiss mathematician Nicolas Fatio declared Leibniz's creation of the calculus to be a copy of Newton. Leibniz countered Fatio's objection in 1704, through an article in the journal *Acta Eruditorum*. Thus, anonymous counter charges were continued until the death of Leibniz and Newton.

Robert Hooke, was one of the founders of the Royal Society of London and on 12 November 1661, he was unanimously appointed as the Curator of the Society. His job was to present scientific experiments under the auspices of the Society. In March 1664 the City College of London appointed him to the prestigious position of Gresham Professor of Geometry, which he held for the rest of his life. As a scientist, he made significant research contributions in Optics, Mechanics and Geology. In 1660, during research on the ductility of a spring, he found that to some extent the change in its length is proportional to the stress exerted on it, and the law of elasticity is still famous by his name. The book, *Micrographia* based on the anatomy of microbes when viewed under a microscope, was published in 1665 which greatly enlightened the public about bacterial diseases. Despite their distinctive qualities Hooke and Newton were completely opposite to each other in nature. Unlike the introverted Newton sitting alone immersed in thought, the extrovert Hooke derived

pleasure in being surrounded by people. Where Newton hesitated to publish the notion he had propounded for years, Hooke immediately published whatever scientific possibility or idea he thought fit. The beginning of the dispute between the two was started with the publication of a research paper by Newton in the Royal Society in 1671, he had explained the theory related to the telescope constructed by him [4]. Hooke negated Newton's theory of particles of light and justified Huygen's wave theory of light. When Newton wrote in retribution that his theory was based on experiments, Hooke also included Huygen in the controversy and rejected the weight of experimental evidence produced by Newton. In 1686, after the publication of *Principia* Hooke claimed that he had suggested the inverse square law of force to Newton. continued until Newton outrightly rejected Hooke's claim, and the bitterness between the two continued until Hooke's death in 1703. It is also rumored that after being nominated as the President of the Royal Society, Newton got the only portrait of Robert Hooke removed from the Society's premises.

After Newton was elected President of the Royal Society in 1703, many reformist changes were made there. From the early 1690s the elected presidents were aristocrats who were only nominal presidents and the progress of the society was hindered. Newton quickly made major changes to the body of the society. He arranged for the exhibition of the latest research works in various fields of science - mathematics, mechanics, astronomy, optics, biology and chemistry during the meeting of the society. A new residence for the Royal Society was established and Halley was appointed Secretary of the Society. Thus the restoration of the rights of the Society revived it as a living institution.

### **Newton and Alchemy**

In Newton's biography written by Brewster in the 19th century, he mentions that the vast collection found by him included many books about alchemy, laboratory notebooks and manuscripts. The author wonders how Newton, a person with such a developed mind, could have coordinated with alchemy containing sorcery and magic descriptions like lore. By the time Brewster wrote his biography, alchemy had ended and modern chemistry had been fully developed, while at the time of Newton the rift between the two was only

beginning. Alchemists, like the present day chemists, were involved in deep investigations of converting one type of substance into another, and they used to discuss in detail the conditions the processes involved in these studies. The ultimate goal of an alchemist was to convert metals into gold.

Newton's curiosity in alchemy lasted for about thirty years. The furnace of his laboratory kept burning day and night, and Newton's engrossment seemed to suggest that his goal was to achieve something greater than human art and industry. Although Newton did not succeed in transformation of matter, he did come to realize that the forces of attraction and repulsion between the particles of matter were active. For Newton, the force active in a crucible between two particles was the same as the force of gravity. There is no evidence of this, but some commentators think that the similarity of these two different types of forces may have led to Newton's idea of universal gravitation and not the seeing of fruit falling from the apple tree.

### **Newton 's stay in London**

There are three distinct stages in the life of Newton: From childhood to 1660 in Lincolnshire in the rural setting, followed by 30 years of adulthood in the academic environment of Cambridge, and from adulthood until death in the socio-political environment of London. When he decided to leave Cambridge and to live in London at the age of 54, he may have realized that his great creative potential was on decline after reaching the climax and because of his rising popularity he needed a more comfortable life. In 1696, one of his former students, Charles Montague, now Chancellor of the Exchequer, nominated him Warden of the Mint of London. Montagu told Newton that in this position he was free to devote his free time to this work as he wished. But Newton was made of another clay and it was not in his character to do any work, whether large or small, in a superficial way.,

Newton bought books on economics, commerce and finance, asked sharp questions to the people of the mint and prepared thick notebooks. At that time the currency of England, as well as the treasury was going through a period of crisis. Two types of coins were in circulation at that time, one made by beating in a mold while the other was made by a milling machine. Beaten coins were

easily shredded to make counterfeit coins of lesser value than machine-made coins. Thus, the coins made by beating remained in circulation and hoarding of machine-made coins began to take place. To solve this dangerous problem, orders had already been given before the arrival of Newton. Although coinage was not the responsibility of the warden, Newton immediately started to solve this challenging problem and within a year the problem of counterfeit coins was brought under control. When the master of the mint died in 1699, Newton took his place and remained in the position until his death in 1727.

Newton was not very interested in politics, but he became a member of the British House of Commons twice for a short time due to the changing circumstances of the times. Whigs were a political party in the Parliament of England and contested against the Tories from 1680 to 1850. In contrast to the conservative Tories, the Whigs Party was against the monarchy's autocratic rule in England and was instrumental in the overthrow, without bloodshed, of the Roman Catholic monarchs in 1688. Newton was first elected Member of Parliament from Cambridge University on behalf of the Whigs Party in the election of 1689. Newton was accustomed to speaking less, always being thoughtful and outspoken about his point of view. These traits were not very good for a politician, yet on many occasions his intellectual power benefited his party. After remaining for one year in the House of Commons to rescue his party from the constitutional crisis Newton did not contest the 1690 re-election. In 1701, he contested the election for the second time and won against the strong candidate of Tories and was successful in getting a law enacted by bringing a bill against the making of counterfeit coins during the debate in Parliament. To enhance his political stature, Queen Ann of England decorated Newton with Knighthood in Trinity College on April 15, 1705, and now he became famous as Sir Isaac Newton.

Newton went to Woolsthorpe, the last time, in 1679 to serve his mother who died on 4 June. He stayed there for several months to settle family matters and divided his property among his relatives. Newton remained unmarried for the rest of his life. When he became Master of Mint, around 1700, his half sister Hannah Smith's 1679-born daughter Catherine Burton moved to London to live with him. In 1717, Catherine married

John Conduit, and on December 1, 1718, on Newton's recommendation, Codeau was elected a Fellow of Royal Society. Sir Isaac Newton moved to Cranbury with his niece Catherine and her husband. Just days after he made his last presidency at a meeting of the Royal Society on 19 February 1727, Newton became bedridden due to a bladder stone. He refused his last rites and died in his sleep on 20 March 1727. Newton had not left any will, due to which his ancestral property went to his uncle's great-grandson John Newton. About 32 thousand British pounds deposited by him in the bank was divided among the children of his half-brother and half-sisters, one of whom was also Catherine whose husband John Conduit appointed Master of Royal Mint after Newton. All of Newton's research papers were handed over to Catherine Burton and John Conduit. John Conduit was the first to write Newton's biography.

Newton was buried in Westminster Abbey in London. Elite persons from all walks of life, and politicians from all parties, present in his funeral, were lamenting the death of the greatest man of his time. The famous French writer and philosopher of the time, Voltaire, who was at that time in London and attended his funeral, said, " We have been told by the people and surgeons who looked after Newton, that free from the weaknesses of ordinary men, without any lust, he was a very great man." [5] Albert Einstein, who was of the same stature as Newton, had put up pictures of Michael Faraday and James Clerk Maxwell next to Newton on the wall of his study. There

is no doubt that no physicist has been as creative as Newton. Among the physicists at the pinnacle of excellence, Einstein, Maxwell, Boltzmann, Gibbs and Feynman, none is like Newton with the combined achievements of the theorist, experimentalist and mathematician.

### Acknowledgments

During the school-break just before Christmas of 2019, I went to the San Leandro Public Library with my grandchildren. I came across an excellent book by Paul Strathern, that I had not seen before. The presentation about Newton's life and work inspired me to write this article in Hindi for the benefit of school children in India. I dedicate it as my tribute to Sir Isaac Newton on the occasion of his 377th Birthday and as a mark of my affection to Leo and Mia.

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**Professor Surya N. Thakur** is an alumnus of the Banaras Hindu University. He passed MSc in 1964 and was recipient of the Chancellor's Gold Medal. He was an 1851 Exhibition scholar of the Royal Commission at the Reading University in England from 1970 to 1973. He has carried out research in the field of Molecular spectroscopy and Lasers with more than 130 publications in national and international journals. He was appointed Professor of Experimental spectroscopy in BHU in 1981 and retired from active service in 2005. He has guided 18 research scholars. He worked on lasers at the National Institute of Optics in Florence, Italy, during the summer of 1977 and on photoacoustic spectroscopy at University of Manchester Institute of Science and Technology during the summer of 1981. He worked as a Fulbright scholar at Rutgers University, New Jersey in 1982 and as a visiting professor in 1991-92. He was the Sectional President of Physics at the 78th Indian Science Congress in Indore. Professor Thakur is a Fellow of Laser and Spectroscopy Society of India and co-author of two books: Atom, Laser and Spectroscopy with Prof. DK Rai and Laser Induced Breakdown Spectroscopy with Prof. JP Singh. He has been spending part of his time with his children in California during the past 5 years and has written popular science articles in English as well as in Hindi.

## 5G Antenna with PBG Structure

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### Article Info

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**Abstract:** A new approach for designing a 5G antenna with photonic band gap structure (PBG) is proposed in this research article. Proposed antenna has the capabilities to work within both bands of 5G, lower (3.1 GHz to 3.5 GHz) and upper band (24 GHz to 27 GHz) as proposed by Telecom Regulatory Authority of India (TRAI). Two integrated antenna patches are used which radiate in different frequency bands. Small patch has

installed into the rectangular slot of large patch. Two PIN diodes have been used to excite both patches at different times. A PBG structure is introduced at the ground and the dimensions of this structure are optimized for desire bandwidth and gain. The results indicate that the antenna has higher gain and wider bandwidth than the conventional antenna without a PBG structure.

**Keywords:** Photonic band gap structure, PIN diode, EBN

### 1.Introduction

Wireless communication technology is evolving at a fast pace. 5G is a next-generation wireless communication technology that provides support for very high speed data transfer. This technology would enable IoT and robotics applications to work effectively [1,2]. With 5G, an integrated compact antenna is required that can transmit and receive the signal within the proposed lower and upper bands. Along with the conventional lower band, 5G technology also works in an upper band (millimeter wave) to achieve a larger bandwidth, higher data transfer rate and low latency. Many researchers have proposed 5G microstrip antennas for lower and upper bands separately [3-14]. Recently, Photonic Band Gap structures have attracted the attention of researchers in antenna design due to the property of lattice periodicity in space. It is because it can efficiently suppress the surface waves and higher order harmonics. The conventional microstrip antennas have the disadvantage of lower efficiency and narrow bandwidth due to the effect of surface waves [15-16]. PBG structures provide stop-bands, which eliminates the propagation of some frequencies, which affects radiation properties of antennas [17-28]. Zaidi et al.in

[17] have designed a microstrip patch antenna at millimetre wave frequencies using PBG cover and PBG substrate. They have reported gain improvement from 7.77 dB to 15.52 dB but their reflection coefficient ( $S_{11}$ ) has increased significantly from -31.24 dB to -17.26 dB. In [18], a design strategy using Photonic Band Gap (PBG) structure on ground plane is used to achieve wider bandwidth for patch antenna. The authors have reported an improvement in the impedance bandwidth from 3.72% to 31.9% at centre frequency 9 GHz after adding PBG on the ground plane. In [19,20], the work reported also shows enhancement in gain and bandwidth. The works attempted so far in the literature are either in the low-frequency band or in the upper frequency band. Recently, a new class of antennas using metamaterials has attracted the interest of many researchers. These artificial materials can enhance the characteristics of miniaturized antenna. A compact high gain rectangular dielectric resonator antenna using metamaterial as substrate for C band applications is proposed in [29]. Authors have reported the increases in the peak gain of the antenna by 86%. EBG antennas are also becoming a popular choice among researchers

because of its ability to offer unique solutions for effectively manipulating EM waves over a broad range of frequencies. In [30,31], a SRR based EBG structure and hemispherical Dielectric Resonator Antenna on an EBG Substrate respectively, are discussed for broadband and high gain systems. The works attempted so far in the literature are either in the low-frequency band or in the upper frequency band. In the proposed work, the antenna has been designed to work with the same structure in both bands of 5G technology.

## 2. Antenna Design Consideration

Proposed antenna is designed and simulated on HFSS software. A Rogers 5880, having a dielectric constant of 2.2, loss tangent of 0.0013 and standard height of 1 mm, is taken as a dielectric material for substrate. Dimensions of the patch for the proposed antenna are calculated using the well-known microstrip patch antenna formulas as stated below [32].

The dimensions of the ground and substrate are the same ( $L_g \times W_g$ ) that can be calculated by using the formula given in Equations 6 and 7 respectively. The selected dimensions of the radiating patch1 ( $L_{p1} \times W_{p1}$ ), patch 2 ( $L_{p2} \times W_{p2}$ ) and ground are given in Table 1. The top views of the radiating patch, bottom view of ground with and without the PBG structure are shown in Figure 1. To obtain the desired bandwidth and gain, a 2D PBG structure is formed by cutting the sixteen square blocks of size ( $a \times a$ ) at the ground plane as shown in Figure 1(c).

$$\text{Width of the patch- } W = \frac{c}{2f_0 \sqrt{\frac{\epsilon_r + 1}{2}}} \quad (1)$$

$$\text{Effective Dielectric Constant- } \epsilon_{eff} = \frac{(\epsilon_r + 1)}{2} + \frac{(\epsilon_r - 1)}{2} \left[ 1 + 12 \frac{h}{W} \right] \quad (2)$$

$$\text{Effective length- } L_{eff} = \frac{c}{2f_0 \sqrt{\epsilon_{eff}}} \quad (3)$$

$$\text{Length extension- } \Delta L = 0.412 h \frac{(\sqrt{\epsilon_{eff} + 0.3}) \left( \frac{W}{h} + 0.264 \right)}{(\sqrt{\epsilon_{eff} - 0.258}) \left( \frac{W}{h} + 0.8 \right)} \quad (4)$$

$$\text{The actual length of the patch- } L = L_{eff} - 2 \Delta L \quad (5)$$

$$\text{Length of Ground plane } L_g = L + 6h \quad (6)$$

$$\text{Width of Ground plane } W_g = W + 6h \quad (7)$$

### Where the following parameters are used-

- $f_0$  is the resonant frequency
- $W$  is the width of the patch
- $L$  is the length of the patch
- $h$  is the thickness of the substrate
- $\epsilon_r$  is the relative permittivity of the dielectric substrate
- $c$  is the Speed of light:  $3 \times 10^8$  m/s

Both patch are designed according to the bands proposed by Telecom Regulatory Authority of India (TRAI) and their resonant frequencies. Dimensions of both bands (lower and upper) have been calculated according to their resonant frequencies 3.3 GHz and 25.5 GHz respectively. Patch 2 is fixed inside the rectangular slot made in Patch 1. But the slot cut in patch 1 itself generates the resonant frequency of a higher mode. The high frequency generated by the rectangular slot should not interfere in both the bands, thus, it is important to take this frequency between the two bands. The resonant frequencies of higher modes generated by rectangular slots created in patch 1 can be changed by changing the slots' dimensions [33-34]. A PBG structure has been built on the ground plane to improve the desired bandwidth and other characteristics of antenna. The top and bottom views of the fabricated antenna with PBG structured ground plane is presented in Figure 2. A periodic PBG structure is designed on the ground plane with the help of 16 small squares. A coaxial probe with 50-ohm characteristic impedance has been used to feed both the patches (Patch 1 and Patch 2) with the help of two PIN diodes.

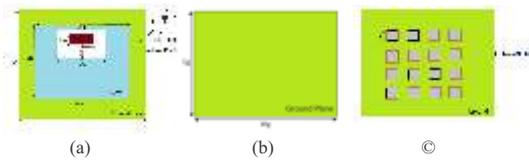


Fig. 1 Geometry of the proposed antenna - (a) Top view (b) Bottom view without PBG (c) Bottom view with PBG.

The switching ON or OFF of these two PIN diodes is controlled by an external biasing circuit with the help of a microcontroller as shown in Figure 3. This biasing circuit consists of two blocking capacitors of value  $0.1 \mu\text{F}$  each and two inductor coils of value  $6.8 \text{ nH}$  each. Two blocking capacitors (Cb1 and Cb2) help to protect the antenna from the DC voltage.

Table 1. Design Parameters of the Antenna.

Dimensions	Values (mm)
$L_{p1}$	26
$W_{p1}$	30
$L_{p2}$	4.5
$W_{p2}$	8.5
$L_r$	8
$W_r$	12
$L_E$	44
$W_E$	48
A	5

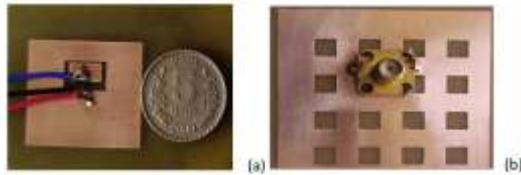


Figure 2. Fabricated Antenna with PBG structure (a) Top view (b) Bottom view.

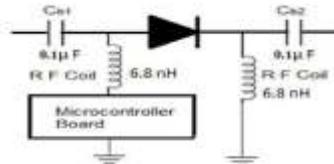


Figure 3. Biasing Circuit using microcontroller board.

### 3. Results and Discussions

The patches can be connected with the coaxial feed probe by turning PIN diode 1 and PIN diode 2 in ON or OFF state.

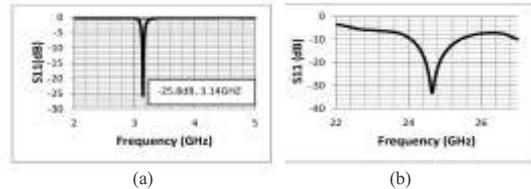


Figure 4. Return Loss of the antenna without PBG structure (a) Lower band (b) Upper band.

When PIN 1 turns on, patch 1 excites and radiates in the

lower band of 5G with resonant frequency 3.14 GHz and the reflection coefficient of -25.8 dB as shown in Figure 4 (a). Similarly, on the excitation of patch 2, the antenna radiates in the upper band of 5G with resonant frequency 24.63 GHz and reflection coefficient of -32.54 dB as shown in Figure 4 (b).

From Figure 4, it can be observed that the bandwidth of the lower and upper bands (without PBG structure) is 50 MHz and 1420 MHz, respectively, which is insufficient for 5G applications. For bandwidth enhancement, a 2D PBG structure is etched at the ground plane. This periodic pattern of sixteen square blocks is shown in Figure 1 (c).

The dimensions of square blocks are optimized for wider bandwidth using optometric analysis. Return loss simulations are carried out for different dimensional values of side 'a' (a= 3, 4, 5 and 6 mm) of the square block as shown in Figures 5(a) and 5(b).

It is clearly evident that, on increasing the size of the square block made in the PBG structure, the bandwidth of both bands also increases. The return loss and corresponding bandwidth at different values of square slot dimensions are tabulated in Table 2. It is evident from the optometric analysis of both the bands that keeping a=5 mm, best results can be obtained. The PBG structure not only increases the bandwidth of the antenna but also improves its gain and directivity. The gain of the antenna (simulated and measured) at the lower and upper bands without and with PBG structure is shown in Figure 6. In the upper band, the gain pattern is not very smooth as evident from Figure 6 (b). Due to the cutting of slots, side lobe and back lobe levels are increased slightly at the upper band. This owes to the fact that the size of the PBG structure becomes comparable to the wavelength at higher frequencies. At the same time, the Bandwidth is increased many folds in upper band due to cutting of the PBG structure at the ground plane. So, there is a trade off with the sidelobe and back lobe radiation to some extent to get wider bandwidth in the upper band of 5G. The measured and simulated return losses with the PBG structure of the lower and upper bands of 5G are shown in Figure 7. All results (return loss, gain, and bandwidth) of the lower and upper band without and with PBG structure are tabulated in Table 3. By using PBG structure, gain, bandwidth, and reflection coefficient are improved by 3.54 dB, 530 MHz, and -3.2 dB in the lower band and 1.2

dB, 1200 MHz, and -5.36 dB in the upper band respectively.

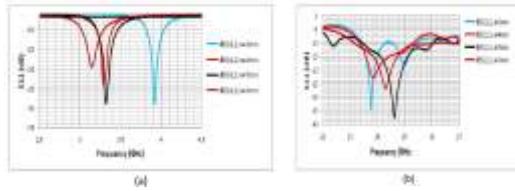


Figure 5. Return loss at different PBG dimensions for (a) Lower band (b) Upper band.

The surface current distribution of patch 1 and patch 2 is shown in Figure 8. When patch 1 is excited, the surface current density can be observed everywhere on patch 1 and negligible current lies on patch 2 due to the mutual induction between patch 1 and patch 2. It shows that the mutual induction between patch 1 and patch 2 is negligibly small, i.e. the performance of patch 1 will not be deteriorated due to the presence of patch 2. On the other hand, when we excite patch 2, the surface current density can be observed everywhere on patch 2, a significant but very small current lies on patch 1 due to the mutual induction between patch 1 and patch 2. From Figure 8(b), it is clear that the current on patch 1 due to induction ends within very small distance i.e. the performance of patch 2 will not be deteriorated significantly. Cross-polarization is the orthogonal polarization and it should be as low as possible.

Table 2. Results of optometric analysis.

a(mm)	Lower Band			Upper Band		
	$S_{11}$ (dB)	Range (GHz)	BW (MHz)	$S_{11}$ (dB)	Range (GHz)	BW (MHz)
3	-28	3.79-4.03	240	-34.7	23.4-24.2	800
4	-23	3.19-3.44	250	-22.7	23.3-25.2	1900
5	-28.5	3.19-3.46	270	-37.6	23.49-25.96	2470
6	-19.3	3.01-3.30	290	-26.7	23.12-25.9	2780

A simple way of minimizing such effects is by using a defective ground plane [35]. The number of squares cut on the ground plane is optimized to reduce this effect. Measurement of cross polarization is calculated as the ratio of maximum gain of cross-polarization to

maximum gain of co-polarization. The cross-polarization and co-polarization of the lower and upper frequency bands at the two values of the angle  $\phi$  ( $0^\circ$  and  $90^\circ$ ) are shown in figures 9 and 10, respectively. Table 4 gives the values of cross polarization at different values of  $\phi$ .

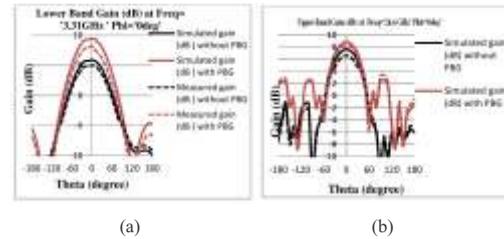


Figure 6. Measured and simulated antenna gain without and with PBG structure of (a) Lower band (b) Upper band.

Table 3. Comparison of parameters (without PBG structure and with PBG structure).

Bands	Type of Ground	Simulated Results			Measured Results		
		$S_{11}$ (dB)	Gain (dBi)	Bandwidth (MHz)	$S_{11}$ (dB)	Gain (dBi)	Bandwidth (MHz)
Lower Band	Without PBG Structure	-19.8	3.92	50 (3.3-3.15 GHz)	-19	5.02	40 (3.23-3.258 GHz)
	With PBG Structure	-25	9.40	100 (3.25-5.71 GHz)	-25.20	8.26	100 (3.34-5.52 GHz)
Upper Band	Without PBG Structure	-52.3	7.90	1470 (14.26-25.59 GHz)	-49.90	6.04	1410 (13.51-24.30 GHz)
	With PBG Structure	-48	8.8	550 (13.4-20.02 GHz)	-41.30	6.16	3900 (13.5-20.1GHz)

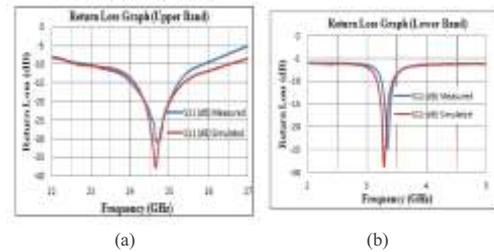


Figure 7. Simulated and measured return loss with PBG structure (a) Lower band (b) Upper band.

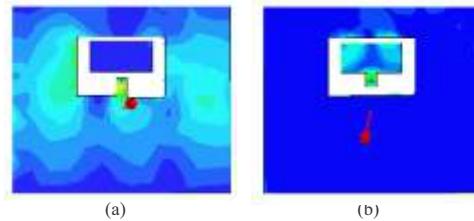
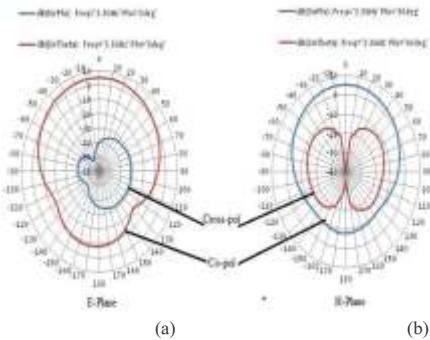


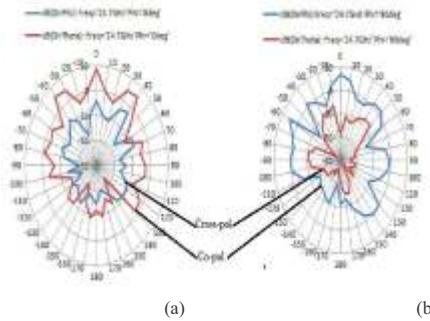
Figure 8. Surface current distribution when (a) Patch 1 is excited (b) Patch 2 is excited.

**Table 4. Cross Polarization values in lower and upper bands.**

S.No	Angle $\phi$	Cross polarization in dB	
		Lower frequency band	Upper frequency band
1	$\phi=0^\circ$	-37.05	-11.09
2	$\phi=90^\circ$	-20.41	-13.11



**Figure 9(a). Cross Polarization effect at lower frequency band (a)  $\phi=0^\circ$  (b)  $\phi=90^\circ$**



**Figure 9(b). Cross Polarization effect at upper frequency band (a)  $\phi=0^\circ$  (b)  $\phi=90^\circ$**

After observing the results, it can be seen that there is a substantial improvement in the antenna characteristics like gain, return loss, bandwidth after employing PBG structure. From Table 3, it can be observed that the simulated and measured results are in good agreement.

**4. Conclusion**

The proposed antenna provides the flexibility to work in either a low-frequency band or an upper frequency band of 5G. Both bands can be switched alternately by electronic methods. Besides, this novel antenna based on PBG structure, has enhanced the characteristics of

antenna like gain, bandwidth etc. manifold. From the simulated and measured results, it is observed that the antenna's gain, bandwidth, and return loss are significantly improved by using a PBG structure. Therefore, PBG structures are helpful in enhancing the characteristics of antenna, thus making them suitable for future 5G and high frequency applications.

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## Association of Polycystic Ovarian Syndrome with Different Disease/Disorder

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### Article Info

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**Abstract:** The polycystic ovary syndrome (PCOS) is the most common endocrinopathy among women of reproductive age. The aim of this study was to investigate main mechanism of different disorder with PCOS. Importantly, PCOS women are at increased risk for glucose intolerance, type 2 diabetes and cardiovascular disorders. Complications of pregnancy associated with maternal PCOS include increased prevalence of early pregnancy loss (EPL), gestational diabetes (GDM), pregnancy-induced hypertensive

**Keywords:** PCOS; psychological stress; eating disorders; PCOS, insulin resistance, diabetes, dyslipidemia, fatty liver disease

### Introduction

There are number of ailments which are gender-specific, in females, Gynecological issues involves impairment in the reproductive or estrogen monitoring system of the body. Although some of these Gynecological problems are curable, whereas some can be chronic, or fatal and Some of these disorders interfere with fertility. With the upsurge in the exposure to chemicals and sedentary lifestyle, the hormonal disturbances are on sharp rise causing endocrine dysfunction to a greater extent. Some of the commonly arising hormonal and reproductive anomalies include fibroids, amenorrhea,infertility, endometriosis, polycystic ovary syndrome, ectopic pregnancy, miscarriage, ovarian cancer etc.[1–6].PCOS is also a heterogeneous disorder that affects many body functions, resulting in several health complications, including infertility, menstrual dysfunction, hirsutism, acne, obesity, metabolic syndrome as well as autoimmune disease.

PCOS is a common endocrine disorder with a collection

disorders (PET/PIH), and the birth of small-for-gestational-age (SGA) babies. Recently reports indicate an unexpectedly high prevalence of obstructive sleep apnea (OSA) in PCOS. Alterations in sex steroids (i.e. high androgen and low estrogen levels) and increased visceral adiposity in PCOS could potentially contribute to the increased prevalence of OSA in this disorder. This holistic review with multiple hypotheses might facilitate to devise better PCOS management approaches.

of symptoms, affecting women of reproductive age. It is a heterogenous disorder affecting different body functions resulting in severe complications such as menstrual dysfunction, acne, hirsutism, infertility, oligomenorrhea, obesity and also impairs functioning of other systems as well. This is due to the imbalance in female sex hormones, leads to the formation of cysts in the ovarian antral follicles. A cyst is a water-filled sac containing ovum, that should be released from the ovary for the fertilization. The conversion of the ovum into a cyst, called 'functional cyst', which prevents ovulation, is resulting in the disruption of the menstrual cycle causing oligomenorrhea, amenorrhea and dysmenorrhea. When multiple cysts are formed in the antral follicle of ovary it is termed as Polycystic ovary syndrome (PCOS). The cysts can be of 10mm size, which can increase the ovary size up to 10mm wide. Anovulation caused due to the PCOS prevents fertilization and thus causes infertility [5,7] and if implantation occurs, abortion, eclampsia and birth risk may occur. It can cause pregnancy associated other

complications such as pregnancy-induced hypertension, gestational diabetes, [8]. Normally, ovarian theca cells support the growth of ovarian follicles assisting the formation of mature oocyte [9]. But in PCOS, these cells become hyper responsive to the stimulatory effects of insulin, proliferating and causing ovarian hyperthecosis. Insulin resistance is exacerbated which amplifies the synthesis of androgen aggravating PCOS [10]. Also, the hyper sensitivity of theca cells to gonadal steroid gonadotropin stimulation promotes androgenism in PCOS. Disrupted pulsating secretion of gonadotropin-releasing hormone (GnRH) from hypothalamus is a major factor responsible for PCOS [11], which impairs the secretion of hormone Follicle stimulating hormone (FSH) and luteinizing hormone (LH) from the pituitary gland. These two hormones are essential for the both the phases of menstruation. But in PCOS, these hormones are in small amount, therefore the egg is either not formed, or cannot be released from the follicle. So, the menstrual cycle is disturbed and amenorrhea occurs, which can be classified as two types i.e primary and secondary amenorrhea. Primary amenorrhea is the inability to reach menarche due to the chromosomal issue whereas, secondary amenorrhea is the absence of menstrual cycle up to 3 or more consecutive months, also termed as hypothalamic amenorrhea [12].

As human body is a complex and all the systems are inter-related, the disturbances in any can affect the other as well. Disrupted level of hormones(anti- Müllerian hormone (AMH), insulin, cortisol, prolactin, androgens), neurotransmitters, lipids, proteins, glucose and peptide are associated with PCOS manifestation. Several researches also suggests the comorbidities, such as coronary heart disease including dyslipidemia, hypertension and visceral obesity[13,14], impaired glucose tolerance (IGT), and type 2 diabetes mellitus (DM) [15], metabolic syndrome [16], psychiatric disorders [17,18,19,20] associated with this syndrome. The main aim of the study is to emphasis on the pathophysiological mechanisms that may underlie in the disorders associated with PCOS.

Disorders Associated With PCOS-

**1. Metabolic syndrome:** The prevalence rate of the metabolic syndrome with PCOS is 43-47%, which is two times as high with general population of comparable age, even after anormal BMI [21]. The manifestations of metabolic syndrome most commonly occur in PCOS are

central obesity, elevated blood pressure, low high-density lipoprotein cholesterol (HDL), impaired glucose tolerance[21].

**a) Dyslipidemia:** Lipid abnormality is highly prevalent i.e 70% in women with PCOS. Dyslipidemia with PCOS, is characterized by increased serum level of low density lipoprotein cholesterol (LDL-c) and very-low density lipoprotein cholesterol (VLDL-c), and increased free fatty acid concentration and serum triglycerides(Tg) with decreased serum level of high density lipoprotein cholesterol (HDL-c) levels, due to decreased apolipoprotein A-I (apoA-I) [22-24]. In PCOS, smaller and dense LDL particles predominates to form more atherogenic lipids converging TYPE2 Diabetes mellitus[25]. Women with PCOS have high concentration of oxidized LDL-c irrespective of BMI, which can further raise a risk for CVD[26]. The atherogenic profile is exacerbated in patients with obesity and insulin resistance (IR)[22-25]. In particular, IR decreases the elimination of VLDL and chylomicrons and enhance the hepatic secretion of VLDL whereas increases the elimination of apolipoprotein A, the major component of HDL-c [27].

**b) Hypertension:** Obesity is one of the common manifestations in PCOS and is itself a major risk factor for hypertension. Additionally, a study monitoring day time ambulatory blood pressure among young (approx. 26yr) over-weight women (mean BMI approximately 26 kg/m<sup>2</sup>) found that women with PCOS had high blood pressure as compared to regularly -menstruating women. Although, the pathogenesis has not been fully and clearly understood [28], but there are several mechanisms possibly responsible for the development of hypertension in PCOS. Thus, the etiology of hypertension associated with PCOS is also multifactorial, including factors such as, obesity, insulin resistance, hyperandrogenemia and increased sympathetic nervous system activity.

**c) Androgen Excess:** Excess androgens have also been associated with increased cIMT in women with PCOS. Increased cIMT has been widely used as a preclinical biomarker for atherosclerotic disease, a contributing factor for hypertension [29]. However, Insulin resistance can be another major factor the development of hypertension in PCOS.

**d) Insulin Resistance:** Hypertension may be the secondary factor to enhance sodium retention,

contributing for hyperinsulinemia [30]. Hyperinsulinemia has been associated with subsequent increased in the intracellular sodium and calcium level [31] and increased insulin-like growth factor-1 (IGF-1) which may be associated with vascular smooth muscle hypertrophy.

**e) Obesity:** obesity is the primary etiology implicating high blood pressure in women with PCOS [32]. It estimates 60% of the women with PCOS are obese or overweight. [33-35]. A population study established that women with PCOS were four times more prone to be obese as compared to non-PCOS women. Therefore, Obesity can be a key contributor for to elevate blood pressure in women with PCOS.

**f) Sympathetic Nervous System:** In addition, some studies demonstrated the effect of sympathetic nervous system in the etiology of hypertension in PCOS. Greater sympathetic nerve activity was found to be increased in women with PCOS, which is highly correlated with testosterone and cholesterol level. In addition, excess androgen [36] increased insulin resistance [37] and increased obesity [38] have been implicated in stimulating the autonomic nervous system each serving as a potential mediator for hypertension in PCOS.

**2. Coagulation disorders:** Increased fibrinogen and plasminogen activator inhibitor 1 (PAI-1) level have been found in women with PCOS as compared to non-PCOS, irrespective of BMI. This impairment of fibrinolysis and coagulation are associated with low SHBG level and hyperinsulinemia [41]. Increased Homocysteine concentrations have been found in PCOS, Irrespective of BMI [39]. The effect of oral contraceptives (OC) also augments the risk of venous thromboembolism in women with PCOS [40].

**3. Insulin resistance and Type 2 diabetes mellitus:** Insulin resistance (IR) is the key factor in the metabolic manifestations in PCOS women, independent of obesity. 30% of lean and 70% of obese women acknowledging insulin resistance with PCOS [42]. Women with PCOS have a higher risk of glucose intolerance and IR compared to the women with same age and weight without PCOS [42,43]. 68-82% of the females of reproductive age with PCOS suffers with type 2 diabetes mellitus (DM2)[44]. More than 50% of women develop sign and symptoms of irregular menstruation and hyperandrogenism. Low sex

hormone-binding globulin (SHBG) and high testosterone level are associated with IR[43,45]. With respect to PCOS and IR phenotype, it has been found that anovulatory and hyperandrogenic is the most insulin resistant, independent of BMI and central adiposity[45]. follicle number per ovary (FNPO) is also related to both biochemical hyperandrogenemia and IR[45]. The main defect is in insulin signaling occurred due to decreased tyrosine phosphorylation and increased serine phosphorylation of insulin receptor and insulin receptor substrate-1-affecting metabolic pathway in adipocytes, skeletal muscles and ovaries. Decreased insulin receptor- $\beta$  abundance in omental adipose tissue, decreased glucose transporter 4 (GLUT4) in subcutaneous adipocytes (leading to decreased glucose uptake), constitutive activation of serine kinases in the mitogen-activated protein kinase/extracellular signal-regulated kinases (MAPK-ERK) pathway, mitochondrial dysfunction and genetic disruption of insulin signaling in the central nervous system are the additional contributing factors in the development of IR in women with PCOS [46].

**4. Endometrial cancer:** There is molecular evidence that suggest the role of insulin resistance in endometrial cancer(EC). Risk factors of insulin resistance include excessive androgens, adipokines and inflammatory mediators which are also contribute in the etiology of EC. Elevated level of insulin directly and indirectly augment the development of EC. The direct mechanism involves the activation of signaling pathway involving Ras/MAPK and PI3K/Akt, IGF-1, estrogen and signaling pathway crosstalk among insulin whereas indirect mechanism involves the elevated level of androgen, high estrogen level and low blood SHBG levels due to excess insulin.

**5. Depression and anxiety:** The detailed mechanism is currently not clear, although many factors may play a potent role for predisposition for these disorders. Obesity is one of the common morbidities seen in up to 80% of the women with PCOS, which play an important role in the increased risk of metabolic complications such as type 2 DM and dyslipidemia [47]. Increased insulin resistance is another cause for anxiety and depression, which is known to present in both lean and obese women with PCOS when compared with the non PCOS women [48]. Elevated androgens level such as testosterone and clinical hyperandrogenism are associated with higher depression scores [49, 50]. The prevalence of depression

and anxiety has been reported to 7-26% and 14-23% [51-55] respectively, making infertility a key player for occurrence of psychiatric disorders in women with PCOS. Abnormalities of the Hypothalamic–Pituitary–Adrenal Axis Stress increased cortisol, increased corticotropin-releasing hormone (CRH) and associated alteration in the hypothalamic–pituitary–adrenal (HPA) axis, are the factors implicating a probable mechanism for depression and anxiety in women with PCOS [56]. PCOS is the disorder with chronic low-grade inflammation associated with some markers such as IL-6, IL-8, IL-18 and TNF- $\alpha$  etc., but not all markers have been described [57]. Low vitamin D has been associated with inflammation which estimates from 37-72% in women with PCOS [58]. In both depression and anxiety, serotonin imbalances have also been observed [59].

**6. Psychological Distress and Eating Disorders:** In most of the studies, it has been observed that Women of reproductive age with PCOS are affected by mild to moderate psychiatric disorders, such as eating and mood disorders [65,66–68]. Around 20% of them developed a depressive disorder within two years [60]. Firstly associated symptoms are subfertility and menstrual irregularity can contribute to psychological stress, which can eventually result in psychiatric disorder [61]. Similarly change in physical appearance like Acne vulgaris, weight gain, scalp hair thinning may diminish the self-esteem and may alter the body image. The exact mechanism of this pathology is not known. Stressors may also affect health and well-being by impairing neuroendocrine functioning. Stressful events may lead to the production of epinephrine, norepinephrine and cortisol associated with the sympathetic response. While chronically elevated level of stress hormones may exacerbate the PCOS. Elevated testosterone level may promote food craving via a poor impulse control [62], which attributes for the link between PCOS and eating disorders. The psychological stress may also seem to interfere with the serum Anti-Müllerian Hormone level and decreases its level in subfertile women [63]. Studies reported the reduced serotonin level in the women with PCOS, inhibiting the pulsatile release of GnRH/LH [64], that regulate both appetite, mood and circadian rhythm.

**7. Cardiovascular Risk:** High serum level of sensitive C-reactive protein (hsCRP), a vascular inflammatory marker, may predict the development of type 2 DM [70]

and CVD [69].

Elevated insulin level seems to affect Homocysteine (Hcy) and also affects its metabolism by affecting glomerular filtration or influencing enzymes activity involved in Hcy metabolism [i.e., Hepatic Cystathione  $\beta$ -Synthase (CBS) and Methyltetrahydrofolate Reductase (MTHFR)] [71, 72]. Elevated Hcy level is the major factor for the development of cardiovascular disease [73]. It also induces endothelial cell injury, increased inflammatory cytokine expression/activity, muscle cells proliferation and atherogenesis, and thereby deteriorate the established atherosclerotic plaque [74]. It has been established by the available data that cerebrovascular diseases as well as coronary heart diseases are common in postmenopausal PCOS patients.

**8. Thyroid Dysfunction:** The most common connection is the increased BMI and insulin resistance in both the condition. Obesity, associated with altered milieu with increasing insulin resistance and pro-inflammatory markers. Through this undefined mechanism, it leads to decrease deiodinase-2 activity at pituitary level resulting in elevated TSH level and relative T3 deficiency [75].

Another pathway is based upon leptin, whose level gets increased in obesity and has been proposed to act directly on hypothalamus resulting in increased TRH secretion [76]. Raised TSH levels, with either of the above pathway act on adipocyte and increase their proliferation. In Culture studies, TSH has been shown to increase the production of inflammatory mediators or increases the adipocyte proliferation via acting on TSH receptors present on adipocytes. Thyroid peroxidase (TPO) antibodies have shown to be present more in PCOS patients when compared to non PCOS i.e., 27% and 8% respectively [77].

**9. Menstrual irregularity:** In fourth decade of life more than 70% of women with PCOS spontaneously reach the menstrual irregularity. Amenorrhea and oligomenorrhea are the conditions of the chronic state of anovulation present in these patients [78]. The anovulation is associated with the alterations in the endocrine and paracrine due to an increased pulse frequency for the luteinizing hormone (LH). The increased pulse frequency of the hypothalamic GnRH promotes the transcription of the beta subunit of LH compared to the beta subunit of follicle-stimulating hormone (FSH). [79] It is not clear whether this increased pulse frequency is due to an abnormality of the

intrinsic GnRH pulse generator or caused by low levels of progesterone due to the chronic state of anovulation as the progesterone slows the GnRH pulse generator [80]. Increased concentration of intrafollicular androgens acts in a paracrine manner. The cause of such menstrual like bleeding is not always due to an occurrence of ovulation but also it may be caused by a sharp fall in plasma levels of estrogen [81].

**10. Infertility:** The main cause of infertility in women with PCOS is due to chronic anovulation. The subfertility may be related to the increase in plasma levels of the LH in the follicular phase of the cycle that causes a resumption of the second meiotic division of the oocyte and the premature release of the oocyte [82]. The mechanism linking PCOS and miscarriage is not yet well known; however, various factors involved in the process of steroidogenesis, estrogen [oocyte maturation and reduced endometrial receptivity contribute to this vicious cycle between PCOS and miscarriage [83].

**11. Non-alcoholic steatohepatitis or Nonalcoholic fatty liver disease (NAFLD):** Increased prevalence of NAFLD has been reported in patients with polycystic ovary syndrome (PCOS), one of the most common endocrinopathies in premenopausal women, which has been redefined as a reproductive and metabolic disorder after the recognition of the important role of insulin resistance in the pathophysiology of the syndrome [84,85].

**12. Polycystic ovary syndrome and spontaneous miscarriage:** Women with PCOS are at risk of early pregnancy loss (EPL) and generally cause miscarriage during their first trimester. The percentages of spontaneous miscarriage are high in PCOS women with 30 to 50% than healthy women with 10 to 15%. [86,87] There are some distinct factors associated with EPL in PCOS with several mechanisms underlying the increased risk of EPL in women with PCOS proposed and that they aren't exclusive.

**i) Luteinizing Hormone and Early Pregnancy Loss:** Most of the studies suggested a link of LH levels with EPL in women with PCOS. Due to this the rate of conception decreased and also miscarriage increased irrespective to those with normal LH in PCOS women. [88] In most of the studies, it was stated that the patient with long term pituitary suppression with a GnRH agonist shows decreased miscarriage rate in PCOS.[89]

However, two succeeding studies in women with PCOS of normal BMI have not shown the improvement in live birth rate with LH suppression using GnRH agonists.[90] The differing results from earlier studies may be confounded by the effects of obesity on pregnancy outcome.

**ii) Androgens and Early Pregnancy Loss:** Hyperandrogenemia (high levels of androgens in females) or clinical hyperandrogenism are presently defined as an essential precondition for diagnosis of PCOS. [91] In two different studies it was found that Elevated free/total testosterone ratios and isolated elevated free and total testosterone levels were found in PCOS women [91].

**iii) Impaired Fibrinolysis and Early Pregnancy Loss:** High plasminogen activator inhibitor-1(PAI-1) activity has been found which was associated with recurrent pregnancy loss in women with unexplained recurrent miscarriages. It also found to be significantly higher in women with PCOS independent of BMI. PAI-1 activity to be an independent risk factor for miscarriage, possibly due to impaired fibrinolysis, which results in placental insufficiency through increased thrombosis of the placental bed [92].

**iv) Insulin Resistance and Early Pregnancy Loss:** PCOS women are believed to be strongly associated with insulin resistance and compensatory hyperinsulinemia, which has shown to be independently contributed by obesity prevalent among PCOS women.[93] This hyperinsulinemic insulin resistance is implicated in pathophysiology of EPL. This includes its effect on oocyte maturation, glucose uptake and metabolism, implantation, altered expression of HOXA10 gene, and reduction of serum glycodeclin and IGF-binding protein-1 (IGFBP-1) concentrations.

Impaired glucose uptake caused by downregulation of the IGF-I receptor has been documented to result in blastocyst apoptosis.[94] Additionally, GLUT 4 expression was revealed to be significantly lower in endometrial cells of hyperinsulinemic obese PCOS patients compared with those from normoinsulinemic PCOS patients or controls.

**v) Endometrial Dysfunction and Early Pregnancy Loss:** Endometrial receptivity is the main factor which seems to be affected in PCOS or other gynecological disorder. Initial attachment of the embryo

occur via certain cell adhesion molecules like  $\beta 3$  integrin located on endometrium of the luminal surface [95] and these molecules are decreased in PCOS women.[96] Endometrial secretory proteins like glycodeilin and IGFBP-1 are crucial for implantation and maintenance of pregnancy. The Glycodeilin help in early placental development through its modulatory effect on immune and trophoblast cells whereas IGFBP-1 plays an important role in human female reproductive physiology regulating menstrual cycles, puberty, ovulation, decidualization, and fetal growth. Both serum glycodeilin and IGFBP-1 levels were shown to be significantly lower in women with EPL in first trimester. [97]

**vi) Obesity and Early Pregnancy Loss:** There is a strong inverse relationship between BMI and serum IGFBP-1 in the general population.[98] A recent studies show the role of IGFBP-1 in PCOS pathogenesis controlling for the influence of BMI.[99] It suggested that a decreased serum level of IGFBP-1 does not have a role in the pathogenesis of PCOS but is likely to result from the high prevalence of obesity in the PCOS women.

**13. Gestational diabetes:** Recently it has been observed that GDM complicates 40 to 50% of PCOS pregnancies. GDM occurs in pregnancy when pancreatic  $\beta$  cells cannot overcome the superimposed insulin resistance of pregnancy on intrinsic insulin resistance of PCOS women. GDM can be treatable and if controlled, does not cause significant problems for the mother or fetus.

PCOS women to be at increased risk of gestational diabetes independent of body mass index. An increased risk of GDM and preeclampsia is shown in non-overweight/obese women. BMI  $>25$  kg/m<sup>2</sup> to be the greatest predictor for GDM[100,101].

**14. Pregnancy-induced high blood pressure-Preeclampsia:** HDP occurs in 8% of PCOS pregnancies. Preeclampsia is a sudden increase in blood pressure after the 20th week of pregnancy. It can affect the mother's kidneys, liver, and brain. If left untreated, preeclampsia can turn into eclampsia. Eclampsia can cause organ damage, seizures, and even death. Currently, the primary treatment for the condition is to deliver the baby, even preterm if necessary. The precise mechanism of link between PCOS to preeclampsia remains unknown, although it seems an aberrant placental growth may play a role. Pregnant women with

preeclampsia may require a C-section delivery, which can carry additional risks for both mother and baby. [102]

**15. Preterm birth:** The babies deliver before the 37 weeks of pregnancy are termed as Preterm. In this condition neonates (both right after birth and later in life) are at high risk with many diseases and sometime it is serious like Preeclampsia. Around 6 to 15% of pregnant women with PCOS get complication. [103]

**16. Cesarean or C-section delivery:** PCOS with Pregnancy is a major problem and this lead to C- sections due to major complications during the pregnancy like pregnancy-induced high blood. The recovery in this state takes longer time as compare to normal delivery. [104]

**17. Polycystic Ovary Syndrome and Obstructive Sleep Apnea:** PCOS women are at high prevalence to occur (OSA) obstructive sleep apnea. Variation in sex steroids like increased visceral adiposity, low estrogen levels and high androgen may potentially contribute to increase the occurrence of OSA in PCOS. The pathophysiological mechanisms behind PCOS and OSA remain unexplained. While preparing the goal of treatment, the clinician should also monitor the prevalence of OSA in these patients.[105]

**18. Polycystic Kidney Disease (PKD):** The two of the most common PKD diseases, which result in end-stage kidney failure in adults and children, respectively are-

a) ADPKD (Autosomal dominant polycystic kidney disease) - caused by mutations in PKD1 (encoding polycystin-1) and PKD2 (encoding polycystin-2)

b) (ARPKD) Autosomal recessive polycystic kidney disease) - arises due to mutations in PKHD1 (encoding fibrocystin).

Polycystic kidney diseases are characterized by the presence of fluid-filled cysts in the kidneys, which leads to renal failure. Along with cystic manifestation, Polycystic kidney disease (PKD) patients and animal models also exhibit abnormal arterial remodeling, non-cystic phenotype, including hypertension, intracranial aneurysm, left ventricular hypertrophy among others. Surprisingly fact is, autopsy results of PKD patients show that more than 80% patients die of cardiovascular reasons than end-stage renal failure.[106]



Figure 1: Pathophysiology of PCOS associated Disorder

## Conclusion

All findings of hormonal dysfunction in PCOS are manifested together or independently. During PCOS women are at high risk of to produce various diseases like- cardiovascular diseases, linked to metabolic dysfunction due to its peculiar hormonal pattern, characterized by hyper-androgenism, insulin resistance, dyslipidemia and inflammatory state. Apart from this, recent foregoing studies underline common features like patients with cardiovascular risk factors i.e. inflammation, hypertension, diabetes and hypercholesterolemia. At last, it was found that PCOS women are at high risk of adverse pregnancy and birth outcomes and this parameter leads to increased surveillance during pregnancy and parturition.

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## Ocular Drug Delivery System: A Novel and Promising Approach

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**Abstract:** Ocular drug delivery is a challenge faced by formulation scientists because of the unique and complex anatomy and physiology of the eye. Topical administration is the most convenient and non-invasive route of drug administration. Drug delivery to anterior and posterior segments of the eye slows down because of anatomical barriers, physiological barriers, efflux pumps and metabolic barriers. A significant increase in advancement is seen in ocular drug delivery research in

the past two decades. Various drug delivery techniques came into notice which surpasses the barriers and maintains drug level within tissues. Conventional topical solutions are modified with permeation and viscosity enhancers to deliver the drug in the anterior segment of the eye. On the other hand, for posterior drug delivery, drug-releasing devices and nanoformulations have been developed to treat chronic vitreoretinal diseases.

## Introduction

### INTRODUCTION

The human eye is a very complex organ of our body. It has very interesting and exciting anatomy and physiology. The formulators face a lot of difficulties in ocular drug delivery.[1] Because of having unique anatomy and physiology of the eye, the technologist should design the most efficient drug delivery system to overcome the ocular barriers and not produce tissue damage.[2] Topical administration is the most acceptable and convenient non-invasive route of drug administration. 90% of the marketed ophthalmic formulations belong to conventional dosage forms.[3,4] the basic problem with the ocular drug delivery system is the extensive loss of conventional eye drops from the eye[5-7] Drug loss occurs mainly because of lachrymal drainage and drug dilution by tears. Topical drug administration has very low bioavailability. Very few amounts of topically applied doses reach deeper ocular tissues.[9]

**Table 1. Marketed product of Ocular Drug Delivery System [10]**

Brand name	Dosage form	Use
Armal	4.5mg/ml tetracycline 0.45% in a single use vial	Anterior: Cataract surgery
Alceril	2% in a clear, yellow, sterile solution	Allergic conjunctivitis
Elasta	0.05% epinephrine ophthalmic solution	BCS Allergic conjunctivitis
Ourdex	0.1 mg fluorometholone intraocular ocular implant	Retinal vein occlusion
Prota Forte	1% prednisolone ophthalmic suspension, USP	Bilateral conjunctiva
Triovar	0.1mg/ml acetazolamide injection	Sympathetic ophthalmia
Zymar	0.3% gatifloxacin ophthalmic solution	Bacterial conjunctivitis
Zymaral	0.5% gatifloxacin ophthalmic solution	Bacterial conjunctivitis

According to the reports of the World Health Organization (WHO); every five seconds a person goes blind in the world due to corneal diseases and a child loses his sight every one minute.[11]

The ocular diseases affect the quality of life of a person by affecting their vision. Extensive research has been done in the last decade at the preclinical and clinical levels and helps in the development of therapeutics for various kinds of ocular diseases including glaucoma, cataracts etc. To deliver the therapeutics, various kinds of drug delivery systems came into the practice for

effective ocular drug delivery, for example; eye drops, ocular inserts, contact lenses, implants, intraocular injections etc.[12-14]

### Anatomical and physiological barriers to ocular drug delivery

Cornea, conjunctiva, iris, ciliary body, lens, and aqueous humour comes under the anterior segment while sclera, choroid, retina, and vitreous body come under the posterior segment.<sup>15</sup> Drug delivery to anterior and posterior regions of the eye slows down because of various kinds of anatomical and physiological barriers.[16]

The eye is divided into two segments:

- 1) Anterior segment
- 2) Posterior segment

These includes [17,18]:

- Physiological barriers such as nasolacrimal drainage, lacrimation rate, and blinking.
- Anatomical barriers such as static and dynamic
- Efflux pump
- Metabolism in ocular tissues
- Tear film prevents drug absorption on the topical application as it acts as a barrier

Drug entry remains limited into the anterior chamber of the eye because of its static barriers (like corneal epithelium, stroma and blood-aqueous barrier) and dynamic chambers (such as conjunctival blood, lymph and low lacrimation). Drug entry remains limited into the posterior chamber of the eye because of its static barriers (like sclera, choroid, Bruch's membrane and blood-retinal barrier) and dynamic chambers (such as choroidal blood and lymph low)[19]

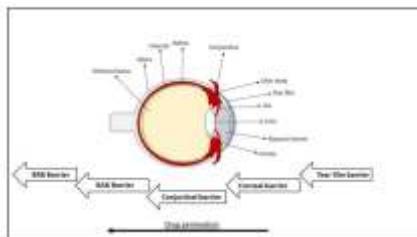


Fig.1 Shows the anatomy of the eye and the physiological barriers to ocular drug delivery[20]

### Benefits and limitations of ocular drug administration routes

There are various routes for drug delivery to the eye. Some of them are:

- 1) Systemic administration
  - Oral route
  - Parenteral route
- 2) Topical administration
- 3) Ocular injections[21]
  - Subconjunctival
  - Periocular
  - Intra-vitreous

**1) Systemic administration-** Parenteral and oral routes of drug administration fall under this category. Here, the blood supply to the eye is very low as compared with other body parts. Only 1-2% of the administered drug is allowed by junctions of retinal pigment epithelial cells to reach the retina and vitreous region. Frequent administration of high doses can automatically cause serious kind of systemic side effects which can worsen the situation.[22,23]

Systemic side effects are mostly seen in infants and children and the reason behind this is the presence of insufficient multi-resistant protein, i.e., P-glycoprotein in the immature blood-brain barrier.<sup>24,25</sup> This is the main reason because of why we find it difficult to deliver the drugs to the posterior segment of the eye by systemic administration.

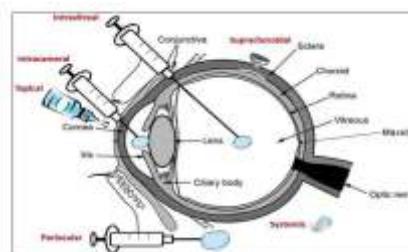


Fig 2:It represents the routes of administration for ocular drug delivery[21]

**2) Topical administration-** It is the most acceptable method to deliver drugs to the eye. There are various formulations which are responsible for drug delivery and show better patient compliance. Some of them are eye drops, suspensions and ointments.[26] anatomical

barriers impede drug absorption and cause low bioavailability. [27] This is one of the main reasons that eye drops should be administered at frequent intervals of time to maintain the drug concentration. Ointments are avoided by the patients because of poor patient compliance. Ointments cause blurred vision.[26]

**Table 2: Routes of administration, benefits and challenges for ocular delivery system**

Route	Benefits	Challenges	References
Topical eye drop	High compliance, adjustable, non-invasive	Higher tear dilution, self and immune - tone, cornea acts as a barrier, often pumps, permeability (BA) < 5%	[28]
Oral/systemic	Patient compliance	Blood aqueous humor (BAH), BBB, high dosing, neurotoxicity, BA < 1%	[28]
Intravitreal	Direct delivery to the posterior region, retinas and vitreous, sustains drug levels, avoids BBB	Retinal detachment, haemorrhage, cataracts, endophthalmitis, vitreous clumping, patient compliance	[28]
Intracameral	Provides higher drug levels in the anterior chamber, allows the use of topical drops, and reduces the corneal and systemic side effect	TAAS, toxic anterior segment syndrome, TECCOS, toxic endothelial cell destruction syndrome	[29]
Subconjunctival	Delivery to the anterior and posterior segment, a site for drug formulation	Conjunctival and choroidal stimulation, poor ocular diffusion of the drug	[30]

**3) Ocular injections-** Intravitreal injection is a surgical procedure which includes penetration of a needle through eyeball layers. This is the most invasive route for ocular drug delivery.[31] Drug distribution in the vitreous region depends upon the molecular weight of the drug and the pathophysiological condition of vitreous region.[32]

### Importance of Nanomedicine in Ocular drug Delivery System

To overcome the limitations associated with ocular therapy and ensure targeted and controlled drug delivery, nanocarriers are designed.[33,34]

There are a lot of systems that have been investigated as carriers for ocular drug delivery. Some of them are [35-37]-

- Microemulsions
- Nanosuspensions
- Nano micelles
- Solid lipid nanoparticles
- Polymeric nanoparticles
- Liposomes
- Niosomes

Some of the examples of nanocarriers for the treatment

of ophthalmic diseases are given below in the table.

**Table 3. Summary of recent research on nanocarriers for the treatment of anterior and posterior eye disease**

Drug	Type of formulation	Polymer/lipid	Technique used	Observation	Reference
Amikacin	Liposomes	Cholesterol, stearylamine	Solvent evaporation method	antibiotic liposomes showed enhanced corneal penetration compared to the amikacin solution	[38]
Pranprolol hydrochloride	NLCs	copolymer of ATG, BBL, oleic acid	Cold homogenization method	They demonstrated that the surfactant/lipid ratio played the main role in drug loading and corneal penetration. Initial burst release and sustained release for 48 hours were observed	[39]
moxifloxacin	SLL loaded in situ gel	Glycerol monostearate (GMS) and MCM	Hot homogenization and Caprol method	In-vivo permeation studies demonstrated that moxifloxacin-loaded NLCs in situ gel showed a 2-fold increase in permeation and retention compared to free drug-loaded in situ gel. No corneal tissue damage was observed	[40]
dexamethasone	Dendrimers	hydroxylated functionalized polyethyleneimine conjugates	Synthesized dendrimers-dexamethasone conjugates	Compared to free dexamethasone, the dendrimers-dexamethasone conjugate attenuated corneal inflammation by reducing macrophage infiltration and proinflammatory cytokine	[41]

### Conclusion

Targeted drug delivery is done to deliver the drugs to deeper tissues of the eye, especially to anterior and posterior segments of the eye are done by using nanomedicine. Various kinds of efforts are being put into ocular research to develop safe, effective and patient compliance novel drug delivery strategies. The unique characteristics of the eye hinder the ocular bioavailability of the eye because tear fluids wash off the topically applied solutions of the drug. So, the design and development of a novel drug delivery system for the ocular drug delivery system are mandatory.

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## A Review: Impact of Covid-19 Pandemic on Education System

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### Article Info

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**Abstract:** The pandemic of COVID-19 has affected whole humanity in various forms. The education system is one of the important areas which were affected by COVID-19. Schools, colleges and universities are closed to control and reduce the effect of the corona viruses. Under these situations, the government obligatory nationwide lockdown on March 25, 2020 to fight COVID-19 and it has made several impacts on the educational system. All Educational Institutes closure brings difficulties for students, teachers and parents, so the online mode of learning is a solution to continuing the education system, but students facing problems due

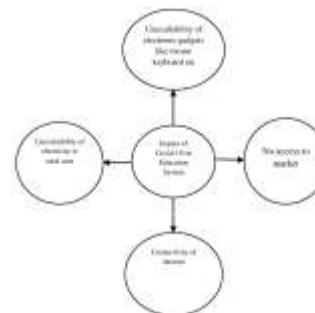
to lack of internet connectivity, computers, and availability of light is challenging in the online mode of learning system in our country. It has worked as a catalyst for educational institutions to raise and choose a platform with various technologies which had not been used earlier. The objective of this paper is to study the impact of COVID -19 on the education system, focusing on education during online teaching and assessment of students getting online classes in this pandemic from sitting at home. Here we also discussed both the positive and negative aspects of the COVID-19 pandemic in the education system.

**Keywords:** COVID-19, online classes and education system.

### Introduction

The global break out of the COVID-19 pandemic has emitted across the world. It has had an extreme impact on worldwide and nationwide economies irrespective of the level of various impacts on the people of individual nations. Lockdown and social distancing play major role in the COVID-19 pandemic have led to closures of Educational Institutes in most countries. The COVID-19 pandemic has affected education systems around the world, leading to the almost complete closure of schools, universities and colleges, As We Know that Education play important role in improving one's life. Education for a child begins at home. It is a lifelong process. Education always improves the quality of one's knowledge, skills and develops the personality and

attitude. The closures of Educational Institutes are not only affecting students, teachers and families.



**Figure1. Problem phase during online classes**

But have far-reaching economic and social

implications. The impact was harsh for disadvantaged children and their families, causing learning disruptions, poor nutrition, childcare problems and, as a result, economic costs for families unable to work.

### Literature Review:

Online teaching has become a crucial role to education system all Educational Institute pursue to reduce the risk of transmission in the community. Due to the COVID-19 pandemic, several educational institutions have started teaching classes using zoom, Microsoft team, and Goggle meet etc. Lack of access to technology or fast and reliable internet connectivity can obstruct students in rural areas [1].

This paper states that how teaching has shifted from the offline mode to the online mode of teaching system. Due to the corona epidemic, there was a changed in teaching methodology. Educational institutions are finding new plans to solve problems. All this happened because of the COVID-19 pandemics. On one side the online mode of teaching is providing chance for the students to teach on other hand the various problems are involved with the new methodology of teaching [2].

All Educational Institutes routine activities like examinations, school admissions, entrance tests of various universities and competitive examinations and others are being held during this period. The arrangement of the Indian education system i.e. learning approach, teaching practices & valuation methodologies are quite affected, resulting in a shift to online education with most focus on virtual education to accomplish the set aims and objectives [3].

In this paper we have observed that teaching is affected globally due to the Covid-19 pandemic. There has been a shutdown of all Educational Institutes and social distancing has been forced everywhere, e.g. educational institutions in the Philippines are facing challenges in planning, implementation, and assessment. The pandemic has opened opportunities to upgrade educational mode also. [4].

Presently we are analyzed that Covid-19 has a serious impact on the educational institutions of India. It has created many challenges for students, parents as well as teachers. The Government of India has also been tried very hard to solve this problems. All the educational institutions should support their knowledge and information technology infrastructure to face Covid-19

situations [5].

The whole Scenario of Covid-19 is going to analyzed under following steps-

**1. Impact of COVID-19 on Education System:** In a recent survey, it has been found that all Educational, Institutes students have suffered a lot in education due to the epidemic. In order to manage the spread of the novel corona virus, Central and State governments have taken action for the closure of all Educational Institutions across the country. It was declared in the second week of March as a provisional measure to avoid the public mob. The danger is for students when educational institutions are opened, but due to the closure, many Educational Institutes are on the verge of ending their existence. During this time, there were several events taken place which were very vital, such as competitive examinations and entrance tests of various universities, board examinations and semester examinations at universities.

**2. Impact on Teachers and Students:** It has been notice that both teachers and students are looking so many problems during online teaching process. For Example at home, a lack of basic facilities, like internet connectivity, stationary materials and electronic gadgets not available properly during online teaching. Online learning is a solution to pursue the education system, but it is tough in developing countries because many parents have not themselves been to school and there is a lack of the necessary Information and Communication Technology (ICT) infrastructures, computers, radio, and television to provide online learning. Access to computers and access to the internet is basic to successful online teaching.

**3. Impact of COVID-19 on Higher Education:** The closure of Institutes and universities has also influenced the student's education. In order to confirm the continuity in institutes and universities, one fast measure is crucial. To conduct the class efficiently, online teaching practice is accepted. Many Indian students who have been taken their admission in foreign Universities, were also suffered due to the worldwide closure of the institutes and universities, it is likely that it will reduce the demand for the international higher education. E-learning solutions are make teaching and learning possible in this situation, but engagement is a big problem attached with the learning.

**4. Impacts COVID-19 on online classes on parents:** In order to sustain attendance or not miss the classes, children are compulsory to continue their education at home. This paper described that key inputs into a child's learning are provided by the families as these are treated as essential to education. Parents are facing issues with accepting the new method of teaching. Some parents are not very techno friendly. Thus, they are not capable of monitoring their child to take classes online. Connectivity to the internet is also a big issue for all teachers, students and parents. Many conflicts have to arise due to the poor internet connectivity [7].

**5. Positive impact on the education system:** Though the epidemic of COVID-19 has had many negative effects on education, educational institutions of India have accepted the issue and tried their best to deliver continuous support facilities to the students during the pandemic. The Indian education system got the chance to change from a traditional system to a new situation.

**6. Improve the use of soft copies of learning materials:** In lockdown situations, students were not able to collect the hard copies of study materials and hence most of the students used soft copy materials for reference. This will be analyzed as below.

**i. Enhancement in collective work-** There is a new opportunity where collaborative teaching and learning can take on new forms.

**ii. Increase in online meetings-** The pandemic has created an enormous rise in teleconferencing, virtual meetings, and webinars and e-conferencing occasions.

**iii. Globally exposure-** Instructors and learners are receiving occasions to interact with peers from around the world online education during pandemics.

**7. Demand for Open and online Learning:** During the pandemic conditions, most students preferred Open and online learning mode, as it inspires self-learning providing chances to learn from various resources and modified learning as per their needs.

**8. Negative impact on the Education system:** The Indian education structure has suffered a lot due to the break out of COVID-19. It has shaped many negative impacts on education and some of them are as pointed below:

**i. Different types of Educational activity hampered-** All the Institutes are closed and classes have been deferred. Different boards have already suspended the annual examinations and entrance tests across India.

**ii. Parents' role-** In urban parts, some educated parents are able to guide but some may not have the sufficient level of education wanted to teach children in the house.

**iii. Digital Gadgets-** Mainly in rural area many students have partial or no internet access and several students may not be able to have enough money for a computer, laptops or supporting mobile phones in their homes. The closure of schools and colleges has affects poor students very hard in India as most of them are unable to explore online learning, according to various reports.

**iv. Create Difference-** This online teaching-learning technique creates a big gap between rich vs. poor and urban vs. rural students.

## Conclusion

The COVID -19 has proved that although humans are powerful and have arms that skilled at obliterating the entire world, a still, if humans are creating a mess with nature then even now, nature is itself enough to obliterate humans with this small virus which is having very common symptoms like cold and cough. The COVID -19 impacted enormously on the education sector of India. Although it has created many challenges, various opportunities have evolved. The closure of schools, colleges and universities is interrupting the learning of students and also disturbing the in-house assessment and public assessments for qualifications. The conventional techniques of teaching have been replaced by online teaching. On one hand, online teaching provides opportunities for students to learn another hand, there are various issues are attached with the new methodology of teaching. Education Institutions are searching for a way to solve the issue which arose due to lockdown and putting their efforts into educating the loss of learning.

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## Effective Contribution of Cloud and Grid Computing in Education System

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**Abstract:** Cloud computing is becoming an adoptable technology for several of the organizations with its dynamic scalability and usage of virtualized resources as a service through the net. It will likely have a big impact on the academic environment within the future. Cloud computing is a superb alternative for educational institutions which are especially under budget shortage so as to work their information systems effectively

**Keywords:** Cloud Computing, E-learning, Online Learning, Web-based Learning, Distance Learning, and Education Systems. Grid Computing, Distributed System, Web service, Lab, Higher education institutions, Remote areas.

### Introduction

The emergence of cloud computing and grid computing as a brand-new, optimistic paradigm that offers IT services as computing utilities for businesses, academic, and corporations has just lately been noticed. IT industries have been impacted by it. A cloud, in the words of IBM, is a collection of a range of distinct workloads can be hosted on virtualized computer resources, allowing them to be through the quick provisioning of virtual or physical machines, deployed, and scaled-out; supports monitoring of resource utilization and redundant, self-recovering, highly scalable programming models real-time to allow for rebalancing of allocations as necessary.

The challenges associated with service deployment are reduced by this type of cyber infrastructure. It is necessary to account for sharing their capabilities and resources while creating the Clouds to offer services to

without spending any further capital for the computers and network devices. Universities profit of obtainable cloud-based and grid-based applications offered by service providers and enables their own users/students to perform business and academic tasks. In this paper, we will examine the benefits that cloud computing and grid computing infrastructure will have on the educational sector, where computer use is more prevalent.

users. Although clouds and grid computing have a similar aim, there are still some very significant differences.

### Cloud Computing

Delivering computer services through the cloud, including servers, storage, databases, networking, software, analytics, and intelligence, is known as cloud computing (Internet). cloud computing also provides alternative to the on site data center. With an on-premises datacenter, we have to take care of everything, including buying and installing hardware, setting up virtual machines, installing the operating system and any other programmers that are needed, establishing the network, setting up the firewall, and setting up data storage. We are now in charge of sustaining it throughout its whole existence after setting everything up.

## Advantages of Cloud Computing

**Cost:** It is cost effective for hardware and software.

**Speed:** It provides high speed resources that are accessible very fast.

**Scalability:** It can increase or decrease the resources according to the requirements.

**Productivity:** cloud computing provides less effort to maintain hardware and software.

**Reliability:** it is very reliable for Backup and recovery of data that are less expensive and fast.

**Security:** it provides secure network that offer set of policies, technologies, and controls for data security.

## Types of Cloud Services

**1. Infrastructure as a Service (IaaS):** Infrastructure as a Service (IaaS): With IaaS, we may hire cloud service providers to provide IT infrastructures including servers and virtual machines (VMs), storage, networks, and operating systems. Any software we desire can be installed on a virtual machine running Linux or Windows. We don't have to worry about the virtualization software or the hardware while using IaaS, but we do have to handle everything else. Although IaaS gives us the most freedom, upkeep still requires more work.

**2. Platform as a Service (PaaS):** It offers a flexible environment for creating, testing, distributing, and managing software applications. The application is the developer's responsibility, and the PaaS vendor offers the capacity to deploy and run it. While flexibility is reduced when using PaaS, the environment's management is handled by the cloud vendors.

**3. Software as a Service (SaaS):** This model offers end customers centrally hosted and managed software services. It provides on-demand, subscription-based software delivery through the internet. For instance, Office 365, Wordpress, Dropbox, Microsoft One Drive, and Amazon Kindle. SaaS is utilised to reduce operational costs as much as possible.

## Grid Computing

Grid computing is a type of distributed computing in which resources are coordinated and shared across dynamic and geographically dispersed organizations. The vision of grid computing was to allow computers to

access computer-based resources in the same way as real-world utilities. The development of Virtual Organizations (VOs) led to the idea. Through the creation of VOs, it was possible to access all resources as though they were owned by a single organization.

## CLOUD COMPUTING vs. GRID COMPUTING

Viewed in a very broad sense, the concepts of grid and cloud computing seems to own similar features. This section puts light to differentiate in numerous perspectives and provides an end-to-end comparison. It may well be understood easily when represented during a tabular form as given in *Table 1*.

Table 1. Cloud Computing vs. Grid Computing

Parameter	Grid computing	Cloud computing
Goal	Collaborative sharing of resources	Use of service (eliminates the detail)
Workflow management	In one physical node	In EC2 instance (Amazon EC2+S3)
Level of abstraction	Low	High
Degree of scalability	Normal	High
Multitask	Yes	Yes
Transparency	Low	High
Time to run	Not real-time	Real-time services
Requests type	Few but large allocation	Lots of small allocation
Allocation unit	Job or task (small)	All shapes and sizes (wide & narrow)
Virtualization	Not a commodity	Vital
Transmission	Suffered from internet delays	Was significantly fast
Security	Low (grid certificate service)	High (Virtualization)
Infrastructure	Low level command	High level services (SaaS)
Operating System	Any standard OS	A hypervisor (VM) on which multiple OSs run
Ownership	Multiple	Single
Interconnection network	Mostly internet with latency and low bandwidth	Dedicated, high-end with low latency and high bandwidth
User management	Decentralized and also Virtual Organization (VO)-based	Centralized or can be delegated to third party
Resource management	Distributed	Centralized/Distributed
Allocation	Decentralized	Both central/decentralized
Interoperability	Open grid forum standards	Web Services
Failure management	Limited	Strong

## Conclusion

Cloud computing is an advanced development in the modern age of technology. It is an emerging area now that helps IT sectors and businesses make efficient use of their hardware and software resources and enables on-demand, service-oriented network access to resources is rapidly scalable with the promise of reduced costs. It has a broad computing application aspect and provides a global platform for everyone. It is useful for all industries, from business users to educational purposes.

In addition to traditional instruction, students will benefit from online lessons delivered through the internet or the cloud. Institutions in a weak financial

position can have high computing facilities at low cost. This article discussed many implementations of the education cloud platform that create virtual labs using preexisting services like OpenStack or code for their own testing. The appropriate deployment model was chosen as IaaS because it allows the installation of all desired applications and associated security measures. Building a private cloud ensures that the connection is secure and shielded from the outside world and requires a factor of authentication and authorization for the external network to connect to the internal network of the clouds private cloud.

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## **The Nightmare of Partition that has (never) Passed and Train to Pakistan**

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**Abstract:** The independence of India and Pakistan paved the way for the biggest migration in the history of human civilizations. It carried with itself the bloody legacy of partition which made thousands of people homeless and ruined their destinations. The marked the communal violence and thereafter gave way to numbers of gory riots in India where, in the name of religion people became assassins of each other. The harmony of fraternity that the country was preserving was threatened and humanity got murdered. Khuswant Singh's oeuvre "Train to Pakistan" betrays the glimpses of the horror keeping the partition scenes at the backdrop. It is a multilayered novel, depicting religious perspectives, violence, communal hatred, corruption and women's position. It has a sense of post-colonialism anxiety and through the characters Singh has also

mapped out the sense of subalternity that the Indian felt. From the feminist approach it deals with the condition of women and how their body became the matter of subjugation under patriarchal domination. It also deals with the psychological perspective of the colonized class as a victim of "false ideology". Being a realistic piece of work, the issues that Singh dealt with are still in practice. Though the Constitution of India promotes equality and fraternity still the riots that India faced bears the example of the genocide and legacy of partition. Keeping with all these, Singh has tried to paint the true spirit of religion and love through some of the characters and holds high the concept of brotherhood and humanity as Jugga, helps to pass the train to Pakistan.

**Keywords:** Partition, Subalternity, Post-colonialism, Constitution.

### **1. Introduction**

"The political partition of India caused one of the great upheaval in annals of history. Never before or since have so many people exchanged their homes and countries so quickly. In the space of a few months, about twelve million people moved between the new, truncated India and the two wings, East and West, of the newly created Pakistan"(Butalia Urvashi, *"The Other Side of Silence"*)

The independence of these two states marked the biggest migration history of human civilization. Keeping humanity at a stake, the bloody legacy of partition began with the killing of thousands of innocents. The sense of brotherhood that the nation always tried to preserve was breathing its last in the hands of this religious divide.

People who were staying in harmony for decades became the slayers of each other, in the name of religion and community. It was a petrified outbreak of communal violence, with massacres ferocious sexual violence. Near about seventy five thousand women were physically assaulted and many of them were dismembered.

During the eleventh century, Lahore was captured marking the first Islamic conquest in India and by the end of 1323, the sultanates spread their branches almost in every part of the country and with this emerged a hybrid of Indo-Islamic culture, with languages like Sanskrit and Urdu India became a rich heritage for cultural diversity. The Sufis often regarded the Hindu holy writs as divinely and gracefully inspired. In many parts of the undivided India and Pakistan, the folk tradition brought

the two cultures together. The sense of religious enmity was not so prevailing as the Hindus also paid visit to the graves of great Sufi masters. The Sheikh or Sufi masters were great in numbers in the regions of Punjab and Bengal – that few decades later witnessed the blood shaded history of partition.

By the end of 1948, more than fifteen million people were displaced and became absolute migrants. Women and children were the worst sufferer of this genocide, neither the Muslims nor the Hindus regarded them even as human beings and torned apart every inch of their body. Nisid Hajari in “*Midnight's Furies*” writes,

“Gangs of killers set whole village aflame, hacking to death men and children and the aged while carrying off young women to be raped. Some British soldiers and journalists who had witnessed the Nazi death camps claimed Partition's brutalities were worse: pregnant women had their breasts cut off and babies hacked out of their bellies; infants were found literally roasted on spits.”

### **Significance of Train to Pakistan in modern context**

The subjugation of women is also a terrifying issue, as depicted in the novel “Train to Pakistan”. They have been the targets of physical and sexual violence during the partition. Women from both the nations witnessed calamitous end. We first come across Ram Lal's wife and mother, who tried to hide him from the dacoits. But after they fail to save Ram Lal, we never see or hear anything from them. Another female character Nooran, Jugga's lady love, whose motivation drives Jugga to spoil the train plot, is also a victim of subjugation as many a times we see people, calling her “Muslim girl” and trying to make her inferior from others for her religious identity. Another girl, Haseena, a muslim prostitute girl also represents, the status of female in the society. Later on, Sundari has been introduced through Hukum Chand's memories of the past and we see how her body got subjugated and was used as a weapon in the struggle between Sikhs and Muslims. The issue of women marginalization is one of the major issues of the novel. Juggut Singh compares the Indian womens as black buffaloes and the English mem-sahibs as paragon of beauty. In many scenes we observe, that even high rank officers' associates female figures like mother and sister

as slangs. Many of the male characters violently abuses women chastity in order to take revenge from another male. Even female characters like Haseena's grandmother, also forces her to stay with Hukum Chand and make him satisfied as it is the soul work of female prostitutes to make men happy.

In the Indian subcontinents the concept of modern identity revolves around partition as the Holocaust is among the Jews with haunted memories of the past. Renowned Pakistani historian Ayesha Jalal writes,

“A defining moment that is neither beginning nor end, partition continues to influence how the people and states of postcolonial South Asia envisage their past, present and future.” (qtd. in *The Great Divide* 2-3)

In 1946, during the religious massacre that took place in Calcutta, five thousand people were killed. The photojournalist Margaret Bourke-White, who had seen the opening of the gates of Nazi concentration camp, wrote about the streets of Calcutta as “looked like Buchenwald.”

On the occasion of 14th August 1947, when the last viceroy of India Mountbatten and his better half mellow down to watch a movie, Jawarhalal Nehru the first Prime Minister of India made his historical speech and asserted that when the world is sleeping, India is awake for its freedom. But while Nehru was making his speech, the newly divided nations were burning in the fire of communalism and corpses of near and dear ones were shouting out of their misfortune. The gore of men marked the border of the nations, and the heart wrenching cry of getting uprooted from their ancestry was gusting with the wind of independence. Sadat Hasan Manto, the Bombay-based writer stated that human beings of both the countries became slave of religion which led them to animal instincts and barbarity.

Religious massacre is one of the propulsion in “*Train to Pakistan*” as with the partition, almost ten million people found themselves in the “wrong” country. Muslims trying to flee from India met death, physical assault and pillaging, Sikhs fleeing from Pakistan also faced the same catastrophe. The unknown train that came with the dead bodies of people in Mano Majra depicts the holocaustic sense of the situation. Khuswant Singh never tries to uproot the reasons for partition rather

through the characters of the novel he depicts the hidden prejudices that a community possess against other religion as, a young Sikh man accuses the Muslims for “stealing their salt” (Singh Khuswant, “Train to Pakistan”) on the other hand Muslims accuse Sikhs as “barbarous infidels with ill intent” (Singh Khuswant, “Train to Pakistan”).

The blood shaded independence of India not only demarcated the borders, rather gave birth to a new era called post colonialism. Colonialism has been an inherent past of life and society in many nations like Asia, Africa and South America. The concept of colonialism came out as a “process of industrial modernity and its capitalist modes of production.” (Nayar Pramod K, “*Comtemporary Literary and Cultural Theory*”) Postcolonial study looks into the oppression faced by the colonized world by colonizers and how they have exploited the wealth of them to emerge as a world power. The study also showcases the despotism of the white race on the black mass. The structure of colonial dominance as created and administrated by racialism, underpinned the difference between the colonial rulers and the natives.

The novel also illustrates the psychological impact of people after decades of subservience. Louis Althusser, a popular Marxist philosopher propounded the idea of “false consciousness” in which the oppressed class never questions the dominance of the ruling class as the dominant class creates a false environment with his Ideological State Apparatus and the victim class follows it blindly. In “Train to Pakistan” the author uses the character of Banta Singh to justify this issue as; Banta Singh talks about his own experience when he fought in World War I from the side of the colonizer. He stated that as he looked to the English officers, they “were better than the Indian” (Singh Khuswant, “Train to Pakistan”). Meet Singh authenticates this by saying that his brother, “a havildar,” who says “sepoys are happier with English officers than with Indians” (Singh Khuswant, “Train to Pakistan”) and his niece still receives gift from “mem-sahib.” The tone of the two elevates the role of the British soldiers over the Indians not basing on their military skill rather on their personal interactivity. The comments from Banta Singh, Meet Singh and Imam Baksh infuriate Iqbal, and he compares the British as the race of four-twenties in accordance to Section 420 of Indian Penal Code which determines the offense of

cheating. He criticises Mountbatten's affection for India that of “the missionaries”. Iqbal's experience of living in Britain gave him an equitable view of the colonizers and thus he tries to convince the three men against the colonial rule. This effort of Iqbal highlights his political commitment to develop the sense of self determination in the Indians.

The search for root and identity as an independent creates the post colonial anxiety in the novel. Through down the memory lane that Hukum Chand recalls of Sunder Singh and the fate his family meet after partition, grows a devastating impact on the readers. As Hukum Chand remembers of Sunder Singh, he says that he was a big and brave Sikh, doing well in the army with row of medals won by him. The government provided him land in Sindh and he was travelling with his wife and three children in a compartment meant to carry “40 sitting 12 sleeping”, though it was taking over five hundred men and women to their destination. It was 115 degrees in the shades and “the train was held up at a station for four days. No one was allowed to get off. Sunder Singh's children cried for water and food. So did every one else. Sunder Singh gave them his urine to drink. Then that dried up too. So he pulled out his revolver and shot them all. Shangara Singh aged six with his long brown blonde hair tied up in a topknot. Deepo aged four with curling eyelashes, and Amro, four months old, who tugged at her mother's dry breasts with her gums and puckered up her face till it was full of wrinkles, crying frantically. Sunder Singh also shot his wife. Then he lost his nerve. He put the revolver to his temple but did not fire. There was no point in killing himself. The train had begun to move. He heaved out the corpses of his wife and children and came along to India. He did not redeem the pledge. Only his family did” (Singh Khuswant, “Train to Pakistan” 203-204). The ending of the family mirrors the disastrous state of mind of the people who became the victim of a political decision.

The first few pages of the novel delineate the people of Mano Majra as living in harmony without having any hint of disruption in the outer world. We being the reader are well aware of the facts and wait with growing anxiety. A train from Pakistan to Mano Majra carrying the corpses of the Sikhs came as a haunting symbol of the communal disturbance which is going to take Mano Majra in its grip soon. Just after few days of the arrival of the train two officers, one Sikh and another Muslim

came to the village with their battalions to inform the Muslim villagers and to take them to the camps from where they will be sent to Pakistan and without knowing their end destination the Muslim villagers were forced to leave their ancestral belongings within few minutes. Both the Sikhs and Muslims begged and pleaded but none, paid any heed to them and uprooted the people. As, they were sent to the camps the village became deserted and the Sikhs stayed together in the gurudwara shedding tears for their Muslim brothers. That night the young officer came back and through his speech “for each Hindu or Sikh they kill, kill two Mussulmans. For each home they loot, loot two. For each trainload of dead they send over, send two across. For each road convoy that is attacked, attack two. That will stop the killing on the other side. It will teach them that we can also play this game of killing and looting” (Singh Khuswant, “*Train to Pakistan*”, 171). The fulminating words worked successfully and the Sikh brothers bent down to become the assassins of the Muslims. Hukum Chand and the sub-inspector know the plot but completely ignore their responsibility as government officials rather they set free Iqbal and Jugga to stop the mob. Through the characters like Hukum Chand, sub-inspector of the police and the young officer, the author has depicted the corruption in the system itself which, added fuel to the burning circumstances.

Between all these hatred and genocide, characters like Imam Baksh and Meet Singh uphold the true spirit of their religion and humanity. Imam Baksh, a Muslim weaver and mullah of the local mosque didn't possess any narrowness for the Sikhs and is a respected man in the village. Meet Singh on the other hand being the priest of the gurudwara, laments for Imam Baksh while he was leaving for the Muslim camp. Meet Singh didn't not even participated in the plot of killing the Muslims of Mano Majra and tried to convince others not to do so. Here Khuswant Singh sustained the holy spirit of religion.

The novel also highlights the importance of love in saving humanity as, Juggat Singh, a Sikh, a dacoit, having a relationship with a Muslim girl Nooran, daughter of Imam Baksh points at the futility of enmity. His compassion and love makes him to go against his own clan. It is his love for Nooran that drives him to sacrifice his own life and save the innocents. The unblemished relationship that Juggat Singh and Nooran

possess goes beyond the boundaries of religious hatred. Keeping in the backdrop blood, bullets and swords, Khuswant Singh has painted the relation between Jugga and Nooran as the most pure form of love standing against all kinds of hatred. Though both of them will never meet again and as Jugga is shot dead while saving the people of Mano Majra and Nooran is sent to Pakistan, the love story stands as an example for all.

The historical novel *Train to Pakistan*, published in 1956, recounts the pathetic Partition of India in August 1947 from the perspective of a small fictional border village of India Mano Majra, is still relevant in modern context of the Indian society. The communal hatred that paved its way during the partition is still persistent. The seed of religious blindness that was sowed got germinated through ages and has its roots deep down the social structure and for this India has seen number of communal violence and riots. Over 10,000 people have been assassinated in the name of communal violence since 1950. Movies like “Bombay” by Mani Ratnam, based on the Hindu-Muslim riot after the destruction of Babari Masjid and “Parzania” by Rahul Dholakia based on Gujrat riot illustrates the bloody legacy of partition and though we are declared as a “secular” country in the Preamble of The Constitution of India, most of the population are way behind from the concept of secularism. People still have the psychological difference between being “Hindu” and being “Muslim” and no one cares about humanity.

The corruption in the system that Khuswant Singh interpreted through characters like Hukum Chand, sub-inspector of police and the young officer are still very much relevant in modern context of the society. Iqbal talks about this first while discussing with Meet Singh “the police system which, instead of safeguarding the citizen, maltreats him and lives on corruption and bribery” (Singh 58). It represents the “cultural hegemony” where the dominant class wield and mould the culture of that society which affects the values, perception, beliefs and more so that the perspective of the dominant and ruling class becomes the believed cultural norm. It helps them to hold their power and practice their oppression on the subaltern group and as the marginalized section stays under the false ideology and never questions the authority.

The position of women, though has improved at lot, still

women have to fight for her rights in the society. A great division between upper caste and lower caste is still in practice. In our country nearly fifty percent population constitutes women. But from cradle to grave they are denied from their human rights. In many parts, infanticide is at its peak where people think that the birth of a girl child is a curse. Sexual abuse and flesh trade are worrying evils, threatening the existence of women as “independent”. As portrayed in the novel also, rape is a weapon to subjugate women and according to 2019 annual report of National Crime Records Bureau 32033 rape cases on women were recorded making an average of 88 cases daily. As we see the character of Haseena in the novel, there are thousands of Haseena's working as prostitutes either forcefully or as a victim of economic and social crisis.

The history of migration during the division of the nations got reflected once again in the worldwide pandemic situation. It brought under light the agonies and adversities as well as the physical and psychological traumas along with discrimination faced by the indigent people. They were stuck in the relief camps with no means of bread, income and in no way to retreat back to their homes, the situation that Khuswant Singh has depicted in the novel, the conditions of the people in the camps with nothing to survive and becoming refugees in their own motherland within a blink of an eye.

### 3. Conclusion

Ramchandra Guha in his “INDIA AFTER GANDHI” writes,

“Gandhi was not alone in choosing to mark the day of independence for India, 15 August 1947, as a day of mourning rather than celebration. Across the borders in Pakistan, where independence had come a day earlier, the poet Faiz Ahmad Faiz wrote of  
This leprous daybreak, dawn night's fangs have manged-

This is not that long-looked for break of day,  
Not that clear dawn in quest for which those comrades  
Set out, believing that in heaven's wide void  
Somewhere must be the stars' last halting-place,  
Somewhere the verge of nights' slow-washing tide,  
Somewhere the anchorage for the ship of heartache.”  
(Guha Ramchandra, 30)

India has come across many decades from pre-colonial to post-colonial era and has observed drastic changes in

socio-cultural and political aspects. The rights for every citizen have been established and governed by law. People do have their Fundamental Rights guaranteed by the Constitution of India and Article 15 under Right to Equality assures “Prohibition of discrimination on grounds of religion, race, caste, sex or place of birth” (Sankaranarayanan Gopal, “The Constitution of India”), But as a realistic novel it addresses the some of the prevalent issues of the society and puts under question the issue of discrimination. It also questions the religious division though India being a secularist country got divided on the basis of religion and this has a great impact till today.

One of Khuswant Singh's artistic accomplishments is his pragmatic novel *Train to Pakistan*. It towers very high as one of the finest novels in the history of Indo Anglian fiction of Post-world war II. It has an accurate structure, with a well knitted plot, captivating narrative style and appealing portrayal of characters. The symbolic framework under a meaningful atmosphere with a powerful expression makes the novel more dynamic and realistic. The narrator has precisely interpreted the sufferings and the adverse effects of separation.

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## The Regulatory Framework of the Indian Capital Market

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### Introduction

Regulations are of crucial importance in the securities market and for the growth of capital markets all over the world. The development of a market economy depends on the capital market's growth. "The regulation of a capital market encompasses the regulation of securities. These rules enable the capital market to function more competently and fairly." There is an absence of conditions of perfect competition and the existence of information asymmetry makes it possible for certain participants to take unfair advantage of investors by exploiting regulatory inadequacy. Malpractices such as price manipulation and fraud cause substantial financial loss to investors and disable the orderly functioning of securities markets and the efficient allocation of investible resources to the economy. Increased integration of India's capital markets with global markets implies that the state of the regulatory environment in the Indian securities market is now of relevance to both domestic investors as well as NRI/foreigners tapping the Indian financial market. Thus, a well-regulated market has the prospect to boost additional investors to participate and contribute in, promoting the development of the economy.

As we all are aware the fact that the capital market is the backbone of every country as it can affect the financial position of the country and regulate the economy. The heart of economic growth lies in the capital market which helps in providing the allocation of funds and mobilization of resources. The major understanding and regulation of the capital market have been an important requirement for the industrial and commercial development of the country. The capital markets cater to the need for a long-term fund that is required for the development of the industrial and commercial sectors. It is the place that acts as the platform between the

suppliers and the buyers. The savings and investments are channelized between the persons who have capital and the person who needs capital. In simpler terms, the market is where buyers and sellers trade financial securities like bonds, stocks, etc. However, the market is much wider than securities. The participants during such transactions can be an individual as well as an institution. It includes all types of lending and borrowing. The capital market is generally for the raising of long-term funds. The markets deal mainly with debts and equity securities.

"India has multiple regulatory architectures in the financial sector. The design has developed complexities over time due to the number of regulatory, quasi-regulatory, non-regulatory- but still-regulating bodies, overlapping ambiguous operational design and their influence. There are different types of buyers such as businessmen, companies, government, or it can be general people. The major regulatory body is the RBI (Reserve bank of India) assisted by the Ministry of Finance and the SEBI (Security Exchange Board of India)."

This article deals with the regulatory aspects of the Indian Securities Market and analyses the position of the Indian market in terms of regulatory infrastructure as well as compliance.

### Background of the Capital Market in India

Indian Stock Markets are one of the oldest in Asia. Its history dates to nearly 200 years ago. The earliest records of security dealings in India are meager and obscure. The East India Company was the dominant institution in those days and business in its loan securities used to be transacted towards the close of the eighteenth century. The history of the Indian capital markets and the stock market, in particular, can be traced

back to 1861 when the American Civil War began. The opening of the Suez Canal during the 1860s led to a tremendous increase in Exports to the United Kingdom and the United States, several companies were formed during this period and many banks came to the fore to handle the finances relating to these trades. With many of these registered under the British Companies Act, the Stock Exchange, Mumbai, came into existence in 1875. It was an unincorporated body of stockbrokers, which started doing business in the city under a banyan tree. The business was essentially confined to company owners and brokers, with very little interest evinced by the public. There had been much fluctuation in the stock market on account of the American war and the battles in Europe. Sir Premchand Roychand remained a kingpin for many years.

### 1. Pre-independence

The Indian capital market was not properly developed before Independence. The growth of the industrial securities market was very much hampered since there were very few companies and the number of securities traded in the stock exchanges was still smaller. Most of the British enterprises in India looked to the London capital market for funds than to the Indian capital market. A large part of the capital market consisted of the gilt-edged market for government and semi-government securities.

### 2. Post-independence

Since Independence and particularly after 1951, the Indian capital market has been broadening significantly and the volume of savings and investment has shown steady improvement. All types of encouragement and tax relief exist in the country to promote savings. Besides, many steps have been taken to protect the interests of investors. A very important indicator of the growth of the capital market is the growth of joint stock companies or corporate enterprises. In 1951 there were about 28,500 companies both public limited and private limited companies with a paid-up capital of Rs. 775 crores. In the 1950s, Century Textiles, Tata Steel, Bombay Dyeing, National Rayon, and Kohinoor Mills were the favorite scrips of speculators. As speculation became rampant, the stock market came to know the Satta bazaar. The planning process started in India in 1951, with importance being given to the formation of

institutions and markets. The Securities Contract Regulation Act 1956 became the parent regulation after the Indian Contract Act 1872, a basic law to be followed by security markets in India. To regulate the issue of share prices, the Controller of Capital Issues Act (CCI) was passed in 1947.

The 1960-the 70s were characterized by war and droughts in the country which led to bearish trends. These trends were aggravated by forwarding trading called badla, technically called 'contracts for clearing'. Financial institutions such as LIC and GIC helped revive the sentiment by emerging as the most important group of investors. The markets have witnessed several golden times too. Retail investors began participating in the stock markets in a small way with the dilution of the FERA in 1978. Multinational companies, with operations in India, were forced to reduce foreign shareholding to below a certain percentage, which led to a compulsory sale of shares or issuance of fresh stock. Indian investors, who applied for these shares, encountered a real lottery because those were the days when the CCI decided the price at which the shares could be issued. There was no free pricing and their formula was very conservative.

In the 1980s emerged an explosive growth of the securities market in India, with millions of investors suddenly discovering lucrative opportunities. Many investors come into the stock market. The next big boom and mass participation by retail investors happened in 1980, with the entry of Mr. Dhirubhai Ambani. Dhirubhai can be said to be the father of modern capital markets. The Reliance public issue and subsequent issues on various Reliance companies generated huge interest. The general public was so unfamiliar with sharing certificates that Dhirubhai is rumored to have distributed them to educate people.

Mr. V.P. Singh's fiscal budget in 1984 was path-breaking for it started the era of liberalization. The removal of estate duty and reduction of taxes led to a swell in the new issue market and there was a deluge of companies in 1985. Dr. Manmohan Singh as Finance Minister came up with a reform agenda in 1991. Liberalization and globalization were the new terms coined and marketed during this decade. The mid-1990s saw a rise in leasing company shares, and hundreds of companies, mainly listed in Gujarat, got listed on the BSE. The 1991-92

securities scam revealed the inadequacies of and inefficiencies in the financial system. It was the scam that prompted a reform of the equity market. The Indian stock market has changed in terms of technology and market price.

The 2000s saw the emergence of Ketan Parekh and the information; communication and entertainment companies came into the limelight. This period also coincided with the dot-com bubble in the US, with software companies being the most favored stocks. There was a meltdown in software stock in early 2000. Mr. P Chidambaram continued the liberalization and reform process, opening up the companies, lifting taxes on long-term gains, and introducing a short-term turnover tax. The markets have recovered since then and we have witnessed a sustained rally that has taken the index over 21000 during the year 2008.

This history shows us that retail investors are yet to play a substantial role in the market as long-term investors. Retail participation in India is very limited considering the overall savings of households. Investors who hold shares in limited companies and mutual fund units are about 20-30 million. Those who participated in secondary markets are 2-3 million. Capital markets will change completely if they grow beyond the cities and stock exchange centers reach the Indian villages. Both SEBI and retail participants should be active in spreading market wisdom and empowering investors in planning their finances and understanding the markets.

It has been a drastic long journey for the Indian capital market. In recent time's capital market is performed very well, integrated, mature, and more global. The Indian capital market is one of the best in the world in terms of technology. There are many business news channels, newspapers, and magazines, are issued in India. Online trading becomes a global phenomenon. Indian capital market would be integrated with the international market.

### **Role of the Indian Capital Market**

While from a broader perspective, Capital Markets is viewed as a market of financial assets with long or infinite maturity, it plays a very important role in mobilizing resources and allocating them to productive channels. So, it can be said that the process of economic growth of a country is facilitated by Capital Markets.

The important functions and significance of the markets have been discussed below: –

**1. Economic Growth:** Capital Markets help to accelerate the process of economic growth. It reflects the general condition of the economy. The capital Market helps in the proper allocation of resources from the people who have surplus capital to the people who need capital. So, we can say that it helps in the expansion of industry and trade in both public and private sectors leading to balanced economic growth in the country.

**2. Promotes Saving Habits:** After the development of Capital Markets, the taxation system, and the banking institutions provide facilities and provisions to the investors to save more. In the absence of Capital Markets, they might have invested in unproductive assets like land or gold or might have indulged in unnecessary spending.

**3. Stable and Systematic Security prices:** Apart from the mobilization of funds, Capital Markets help to stabilize the prices of stocks. Reduction in speculative activities and providing capital to borrowers at a lower interest rate help in the stabilization of the security prices.

**4. Availability of Funds:** Investments are made in Capital Markets continuously. Both the buyers and sellers interact and trade their capital and assets through an online platform. Stock Exchanges like NSE and BSE provide the platform for this and thus the transactions in the capital market become easy.

### **Factors Influencing the Growth of Capital Market**

The growth of the capital market is influenced by various factors such as the level of savings and investment of the household sector, the health of the economy, corporate performance, and trends in the industry. The investment pattern of the household sector, in turn, is governed by various factors such as the state of the capital market, the government policy for the promotion of the capital market, the political stability, and the performance of the economy and corporate sector. The performance of the economy is measured by several economic indicators such as growth in Gross Domestic Product, agricultural production, interest rates, tax rates, industrial growth,

inflation, the position of balance of payments and balance of trade, foreign exchange reserves, and growth in capital formation Corporate fundamentals embrace the performance indicators like gross profits, operating profits, return on capital employed and net worth, earnings per share, book value per share, profitability ratios, etc.

### Role of Capital Market Regulators

**1. Proper Allocation of Funds:** The capital market is an important platform for allocating idle savings from the people to productive channels of an economy. Itspuha idle funds in proper investment.

**2. Formation of capital:** The capital market helps in the formation of capital by adding capital to the existing capital in the economy. This helps in the expansion of capital in the economy.

**3. A platform for Investment:** The capital market raises resources for longer periods. Thus, it provides an investment avenue for people who wish to invest resources for a long period. It provides suitable interest rate returns also to investors. Instruments such as bonds, equities, etc. definitely provide diverse investment avenues for the public.

**4. Accelerates Economic Development:** The financial requirements of the businesses are met by the capital market regulators as it makes funds available for a longer period. Capital market regulators also help in research and development. This results in increasing the productivity of the economy.

**5. Provides Service:** Capital Market regulators provide various services like medium and long-term loan consultancy services. export finance etc.

### Classification of the Capital Market

The capital market can be classified as a primary market and a secondary market.

#### Primary Market

Broadly, the capital market comprises two segments: the new issue market which is commonly known as the primary market, and the stock market which is known as the secondary market. In the primary market, the securities are offered for subscription by the issuers for

the first time. This could be either to raise fresh capital or for listing by the offer for sale by the existing shareholders.

The primary market consists of the companies making the issue of securities and the members of the public subscribing to them. The primary market also includes a further offering of securities by a listed company, the offer of securities to the shareholders of the company on a rights basis, preferential issues and private placements to select investors, preferential issue to Qualified Institutional Buyers (QIBS), and bonus issue of securities.

#### Secondary Market

The secondary market is the market for the purchase and sale of previously issued securities. It is the market where securities, both equity, and debt, after being initially offered in the primary market and listed at the stock exchanges are traded. The trading is done in the secondary market mostly through recognized stock exchanges.

The market can also be classified on the type of securities as the stock market and the bond market.

**a. The Stock Market** is also known as the share market or equity market. It is a place where the shares are bought and sold or the economic transactions that have a certain monetary value. The price of shares is highly dynamic as it can change from the fluctuations of demand and supply or the status of the company. The stock market has all the publicly listed companies that can be owned by the private, government, or joint ventures.

**b. The Bond Market** is also known as the debt securities market in which the investors purchase the securities in terms of bonds. The credit market can have various types of issue markets such as the government issue market, the corporate debt issue market, etc.

### The Regulatory Framework and Legislation: A detailed description

The regulation of capital markets has been very important for development and growth as they provide a stable, steady, and secure platform for both the suppliers

and the buyers. If not, then there can be massive loss or gain in finance which would be unfair to the general public. Various organizations regulate the market to keep the economy stable.

### 1. Regulatory Agencies

India has product-wise regulators—the Reserve Bank of India (RBI) regulates credit products, savings, and remittances; the Securities and Exchange Board of India (SEBI) regulates investment products; the Insurance Regulatory and Development Authority (IRDA) regulates insurance products, and the Pension Fund Regulatory and Development Authority (PFRDA) regulates pension products. The Forward Markets Commission (FMC) regulates commodity-based exchange-traded futures (which was merged with the SEBI in late 2015).

### 2. Quasi-regulatory Agencies

Several other government bodies perform quasi-regulatory functions—the National Bank for Agriculture and Rural Development (NABARD), the Small Industries Development Bank of India (SIDBI), and the National Housing Bank (NHB). NABARD supervises regional rural banks as well as state and district cooperative banks. NHB regulates housing finance companies, and SIDBI regulates state finance corporations (SFCs).

### 3. Central Ministries

Certain ministries of the GoI are also involved in policymaking in the financial system. The Ministry of Finance (MoF) is most prominently involved, through its representatives on the Boards of SEBI, IRDA, and RBI, MoF representatives are also on Boards of public sector banks (PSBs) and Development Financial Institutions (DFIs).

### 4. State Governments

Through the Registrar of Cooperatives, which is under the departments of agriculture and cooperation, the state governments regulate the cooperative banking institutions in their respective states.

### 5. Special Statutes for Certain Financial Intermediaries

Some key financial services intermediaries like SBI (and its Associate Banks before their consolidation with SBI in 2017–18), Public Sector Banks, LIC, and GIC are governed by their statutes. These statutes give a special

status to these institutions vis-à-vis the other institutions performing the same functions.

### 6. Establishment of FSDC

A few years back, an important addition was made to the regulatory architecture—the Financial Sector Development Council (FSDC) was set up which replaced the High-Level Committee on Capital Markets. The council is convened by the Ministry of Finance and does not have statutory authority—it is structured as a council of regulators, with Finance Minister as chairman. The council resolves inter-agency disputes; looks after the regulation of financial conglomerates that fall under various regulators' purview and performs wealth management functions dealing with multiple products.

The regulatory structure has been framed under four pillars which are the Ministry of Finance, the Reserve Bank of India, the Security and Exchange Board of India, and the National Stock Exchange.

**a. Ministry of Finance (MoF)**- The ministry depicts that the Government of India plays a very important role, and their economic policies and manifestos help in market regulation and framework. They formulate rules and analyze them for the efficient and effective growth of the market. The Department of Economic Affairs which manages the market works under certain sets of laws are the Depositories Act, 1996, the Securities Contract (Regulation) Act, 1956, and the Securities and Exchange Board of India Act, 1992. There are many other laws such as the Companies Act, of 2013, etc.

**b. Reserve Bank of India**- The body that was established in 1934 frames the policies, formulate the bodies and regulates the rules as per the current situation. RBI has active participation in the stock market and also sets the various parameters that are used in the transactions of debt, equity, and other types of securities. They are the bank regulators also as they have access to many bank accounts as they have large funds to control the capital market since banks have the most generated capital on hold. They also set various parameters for regulation such as repo rate, reverse repo rate, etc. They are the intermediary body between the market and the government. They have other various functions in capital markets such as the implementation of various monetary policies, managing the foreign exchange system, settlement, and payments systems.

**c. Security and Exchange Board of India (SEBI)-**

This body can also be considered the apex body of capital market regulators. SEBI is a principal regulatory body that is also a statutory body established under the SEBI Act, of 1992. SEBI was earlier established as a non-statutory body in 1988. They not only protect the interest of investors in securities but also promote the market. It supervises, controls, and manages several institutional brokers, investors, companies, and all other associated persons related to the market. The body's primary function is to prohibit malpractice or unfair trade practices such as insider trading or manipulating funds. The stock exchanges work under the direct control of this body as they adopt a flexible and adaptable approach to regulating the market. They perform many other such regulatory functions as mining intermediaries, citing stock expansion changes, and regulating and registering mutual funds.

Recently, the review and merger of SEBI (Issue and Listing of Debt Securities) Regulations, 2008 and SEBI (non-convertible Redeemable preference shares) Regulations 2013 into a single regulation- SEBI (Issue and Listing of Non-Convertible Securities) Regulations, 2021.

### Acts governing the Capital Markets

**a. The Depositories Act, 1996-** The Act regulates the depositories in Securities. The primary objective of this Act is to ensure the free transferability of securities with speed, accuracy, and security. The Act eases the ownership of transferability of ownership from one person to another in a convenient way. It has made the securities freely transferable in the case of Public limited companies along with the securities.

**b. Securities Contract (Regulation) Act, 1956-** The regulatory Act deals with all types of issues related to Stock trading. The Act aims at the smooth functioning of the stock exchanges. It prevents any kind of defective transactions. It especially deals in listing stock exchanges and contracts in securities.

**c. Security and Exchange Board of India Act,1992-** This Act provides statutory powers to the SEBI organization. The governing body regulates the market in a multifarious manner by protecting the interest of the

shareholders, preventing any kind of malpractices in the market, and promoting the development of the Securities Market. The Act provides wide powers and scope to the SEBI to run the capital market effectively and efficiently.

### Accounting Principles

The financial statements of an issuing company in its disclosure documents are prepared by India's generally accepted accounting principles (GAAP). The increasing exposure of Indian listed firms to international investors has compelled them to adopt more internationally accepted accounting principles. The Institute of Chartered Accountants of India has issued a note to introduce new accounting standards starting the fiscal year 1995/96. Yet, Indian GAAP is considerably different from that of internationally accepted principles.<sup>3</sup> To raise the credibility of corporate financial statements and transparency, accounting principles should be improved further to make them consistent with international practice. This, the credibility of the accounting profession should also be enhanced through stricter enforcement of punitive measures for inaccurate accounting practices.

### Legal Mechanism

The problems of the court system and legal mechanism to settle disputes in India have been frequently raised. After floating shares in the market, investors should be able to monitor corporate performance closely to protect their interests. Prompt and effective settlement of disputes is also critical. According to a recent survey by Gupta (1998), 65 percent of those who brought complaints to the court indicated that the cases have not been resolved. Even minority shareholder can now bring their complaints to court, they are discouraged from doing so because the legal mechanism is very slow. Measures are therefore needed to expedite court decisions and protect small investors' interests.

### Conclusion

The law can be a medium to facilitate capitalism, which in turn facilitates economic growth. One of the crucial aspects to facilitate capitalism of economic growth is found in the ability of individuals to invest in the

resources of the companies productively and help them to gain profit while simultaneously benefiting others by creating employment opportunities and maximizing wealth. Companies need cash or cash equivalents to purchase raw materials for the advancement of technologies or to hire more labor force. Financial resources are very essential requirements for any business to grow, come up with new technologies or purchase raw materials, or hire workers. New companies with no profit to invest in have a particular scent for this as outsourcing of finance. Well-developed markets help them to ensure the efficient allocation of financing. They direct resources to users with the highest return and permit greater specialization. They also facilitate the diversification of investment and the consequent reduction of investor risk. Additionally, financial markets contribute to the development of innovations and advanced technologies.

Thus, with the help of this article, one can conclude that the Indian capital market has undergone many changes after the challenges and the irreparable loss faced over years and there have been massive and revolutionary changes over years, and some significant changes have reduced financial scam cases. Also, there has been a reduction in malpractices of trade over the years. The capital market has made tremendous progress in terms

of institution building. They have transformed and developed the lives of investors and market intermediaries. The market has been friendlier by boosting performance and eliminating challenges.

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## **Brand Building Blocks: Strength of Slogan and Public Appeal: An Empirical Study**

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**Abstract:** Great brands can gain success in competitive markets, and certainly become the most valuable assets of a business. Marketers involved in branding always thrive to align the company's outlook with the brand's experience and build the image that a brand associate with a product or service has certain attributes that make it stand out of the crowd.

The definition, functions, and the essence of brand has changed over time. Now a days, it is what brand do for people that matters more and how they engage audience. Brand is all about how it achieves company's' ambition effectively and efficiently. The aim of brand has now become more of emotional and psychological connection rather than mere identification and

**Keywords:** Brand, Branding, Brand recall, Brand awareness, User imagery, Brand attributes, Brand image, Brand Association, Brand building, Brand laddering, Brand recognition, Brand personality

### **Introduction**

Coke provokes feeling of happiness and festivities, AXE deo makes you Confident, Nike provokes feeling of inspiration, and Horlicks makes you a strong and genius!

Welcome to the world of brand.....

Building brand involve the brand positioning and making it distinct from just a product features to more abstract values. Branding is moving from a focus from product attributes to emotional appeal and consumer engagement.

innovation for which the concept of brand came into existence.

When we think Nike, we might think of an advertising campaign prompting "Just Do It." When we think Volvo, we think of think safety. When you think IBM, you might think "Big Blue." Or "Yeh Dil Mange More" of Pepsi. In fact, consumers tend to remember the brand name and have positive associations with the brand makes selection of product easier for them and improve the value proposition from the product.

This article will designate significance of Brand knowledge and mantra of creating and maintaining a brand. With the study we tried to show that "*an idea can change your brand image*"

For example, Amazon have successfully undertook brand building and positioned on a more abstract benefit (from A to Z) rather than the product/functional aspects of clothing like fashion, texture, quality etc.

Companies need to be very careful while trying to position their brands on abstract value rather than functional attribute.

### **Brand building**

**The first stage** of building is establishing the brand's association with product attributes. Attributes are the material properties of a product or service that convey the expected values to the consumer.

When Marketer launches a brand, the focus is always remain to portray a particular image of product. The main assignment is to set up category and also to achieve equivalence with competitors on functional performance of product or services.

For example, packaged food brands will be trying to convince the customer about their product properties like ingredients, quality and wholesomeness etc. While a smart phone marketer will focus on features like processor, camera quality, technology etc.

Once these attributes are firmly established in the mind of the consumer, the brand moves into the next step in the building process. This stage involves positioning the brand on product benefits. Now a day, the brand shifts from a physical attributes focus to the abstract benefit focus. For example, Maggi Noodles had built its brand based on qualities like “easy to cook and good taste”. Maggi recently tries to reposition itself on the health benefits with the latest tagline of Maggi – *Taste Bhi, Health Bhi*.

The most critical stage of building process is to associate the brand to abstract benefits. Abstract benefits are values and benefits which focus on a deeper need of consumers over and above the product physical benefits. Generally the abstract values are emotional and aspirational in nature.

In recent times, most brands try to move from a physical and basic benefit based positioning to a more on achievement of abstract value. Airtel is about Expressing Yourself. This is an abstract value associated with the Airtel tries to position itself on. Fair & Lovely brand has come up to the abstract concept of confidence and empowerment of women.

Abstract benefits touch customer at emotional level and helps boost the aspirational value to the brand. It also allows the brand to connect itself to larger segment of market as its positioning is no more just rational value and not limited to just functional attributes of a product.

**The last stage** in the Brand building process is when the brand achieves the status of synonymous with the abstract benefit. Coke becomes symbol of festivities where as Johnson & Johnson is symbolizing with mother – child relationship. This is the stage where marketer develops brand essence.

Brand building helps a marketer in many ways. The two

most important benefits are that abstract attributes gives easy recognition and more flexibility to the marketer can experiment with various communication themes in terms that brand can be portrayed away from the most rational attributes. This allows brand to be more innovative and creative in its advertisings. Onida Television was able to create highly popular campaigns because it focuses on an aspirational benefit of “Neighbors Envy, owners' pride”.

The fundamental objective of brand building is to create icons. Significantly noticeable brands are the one which personifies aspirational values. For example, Woodland personifies toughness, Nike personifies athleticism, Harley Davidson is synonymous with masculinity and rebelliousness and Chumbek personifies quirkiness.

No doubt, branding is a great marketing strategy but it requires certain preparation for successful execution. There are various brands in the market but a brand is successful only if the brand is able to establish its association with emotional attributes. If a brand only tries to establishing its functional expertise, consumers may not believe in the brand's claim.

The highly acclaimed “just do it” campaign of Nike is a successful brand laddering exercise because it was done to establish its functional expertise to a larger emotional appeal. For the same, brand must establish its Points of Parity and competitive advantages to its competitors. Only then, the emotional laddering will be accepted by the consumers.

Another important condition is the abstract attribute should be relevant to the brand. For example, Horlicks and stronger childhood have obvious connection. Dove and gentle beauty are connected with each other.

To start a brand positioning and laddering exercise, the marketer first must decide on which brand essence need to be associated. The brand essence should be chosen carefully because this is something which is going to be a long-term association often a permanent one.

Generally, brand laddering is done on a benefit derived out if the core brand mantra. Brand mantra is something what the brand stands for, or the DNA of the brand. And like DNA, brand's mantra also relatively irreversible. So choosing the right Brand Mantra is very important and it enables the brand to ladder up effectively and efficiently.

But even after a successful brand building, a brand

should not leave its focus on functional attributes completely. Because ultimately products and services need to deliver performance. Sometimes, the brand should do a laddering down to emphasize its association with functional attributes for which the product is meant for. This could be done by parallel promotional campaigns focusing on functional values. This laddering down should be done if there is a change in consumer's perception or if the competitors launch an innovative feature. In such cases, the brand should emphasize its functional attributes to the consumers.

### Developing Brand Personality

Brands are basically developed for the recognition as symbol of ownership in form of name, taglines, logo, and symbol. In functionality and contextually they are proprietary visual, emotional, rational, and cultural image that you associate with a company or a product. For a marketer, brand management starts with understanding real meaning for 'brand'. This starts with the owner of the company who define the brand and control its management. It also reaches in the core value of company and to the people who create the products that customers use. Brand management is a wide-ranging attempt to build certain image of product and services in the mind of consumers and it requires commitment, support and contribution from every stakeholders in the company.

For example:

Brands	Personality
Pomb	Sensitivity
Thrills up	bravery / daring
Bingo	Humor
IPL	Entertaining
BMW	Sophistication (upper class)
Woodlands	Toughness & outdoorsy
Thor	Strong
Marlboro	Ruggedness
Ruff & Tuff	Bravery
Zhoda Chavapash	Strong immunity
Britania little hearts	Love & Affection

### Pause & Ponder

#### Apple– Powerful technology brand

Apple' one the world's most valuable brand has distinct personality. The slogans “Think Different” only emphasize innovative technology, thereby resulting in brand personality of trending. It also stands for reliability and quality. The advertisements also played major role in supporting to the unique personality.

### Endorser

The Choice of an endorser is crucial, as the attributes and personality of the endorser can have a huge impact onto the brand. For example, Provogue has acquired Hrithik Roshan to project strong image owing to presence of sophisticated and mysterious endorser. Urban cruiser acquire Ayushmaan Khurana to gave macho image to the brand. Endorser may be real or fictional. Using celebrities as brand endorser has its own pros & cons. Both brand and celebrity enjoys instant recognition & goodwill that can be transferred mutually. Now a days , local celebrities and social media influencer are also can be used in to shows brand fit.

A number of social media celebrities endorse number of brands. Choosing the right celebrity and their qualities is also very important, otherwise celebrity endorsement may become non productive or backfire exercise which end up involving wastage of money. Celebrities cut across all demographic groups and have mass appeal.

### Pause & Ponder

Endorser stands for certain obvious and favorable values of the brand such as performance, style and reliability etc. Brand Personality and brand image of celebrity should complement each other. Appropriate selection of celebrity for endorsement ensures instant awareness, acceptability and positive attitude towards the brand, which is precursor to buying. This will be providing much needed assurance to the consumers and also protect brand image & values.

The component of creativity is very important while using celebrity for endorsements. Otherwise celebrity may overpower, and overshadow the brand, this is called Vamping Effect.

The Different celebrities also have different branding for themselves:

Endorser	Attributes
Amitabh Bachchan	Resident, professional, charismatic unassuming
Shruti Khan	Youth Icon, Stylish, successful
Sachin Tendulkar	Excellence, determination faith hardwork
Akshay Kumar	Physically powerful, strong, stylish challenger
Irfan Khan	Sensible, realistic, funny
M.S. Dhoni	Sheer power play
Priyanka Chopra	Youthful, enthusiastic

### Brand Elements

Brand elements are the components of a brand that are constructed and put collectively to empower and

strengthen brand's image. A brand is basically consists of following brand elements:

- Brand name and logo
- Symbol and character
- Packaging
- Slogan

**There are five standards to judge whether these are good brand elements:**

- The recall value of Brand name should be high. The brand recall value will be higher if brand name will be simple, easy to pronounce and easy to understand. And the brand name must be capable of making connection between the need of the consumer and the product or services. The brand name must also signify what does product or service stands for.
- The symbol and character being used as brand elements should also gel well with product features and characteristics and they should be in good term to identify the product with.
- In addition, the **transferability** of brand elements should be high. It should offer company with a feasible choice to build brand extension or brand line and it should able to create appropriate recognition for the brand.
- The logo, symbol, packaging, slogan all should be catchy and flexible over time. They should not look outdated over time neither they should be changed repeatedly. There should be consistency in logo so that it should be meaningful for several years and reflect the brand image. They should represent brand essence, what the brand stands for, and it should communicate a unified message that depicts the brand image in changing scenario. The components should have adaptability and should be flexible enough to be able to change as per the need of time and customers.
- Brand name, logo, symbols, packaging indentations etc. should be protected with the use of registered trademark under Intellectual property protection is the fifth criteria.

**Executional elements:**

The elements including design, layout, color scheme in print ads and visual appearance etc contribute to the brand personality. Intelligent and creative ads deliver brand personality. The brands like Wipro, HCL, in

which advertising also played leading role in their success. Mozart symphony played in Titan Ad. success of absolute Vodka in U.S.A. is also attributed to clever execution of the advt in which bottle image figures always in intelligent way, with Witty Puns.

**Tangible aspects of the Brand**

Brand's tangible aspects like package and other elements like price are also key elements. Attractive package of various perfumes gives distinct personality to brand. Coke, transparent and unique shape of the bottle played key role in brand personality.

**Symbols & Logos**

Logos and symbols are vital tool for effectively to communicate brand values and attributes. Ferrari uses horse in logo to representing power and sturdiness. Puma brand uses leaping horse represent activeness.

Apple uses symbol of apple as it represents innovation and unique ideas. Air India group has "Mascot doing Namaste" as its logo, which captures the Indian traditional way of welcoming the people. These symbols or mascots make brands more recognizable and appealing.

**Logos should be**

- Unique but easy to recognize.
- Worth remembering and represent ideas etc.
- Look effortless and yet secure wider meaning.
- Relevant and in tune with the time.

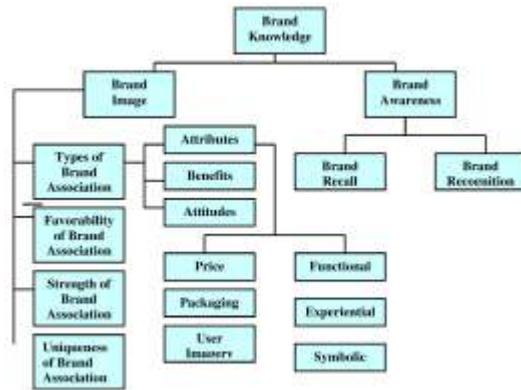
Nike represents action, Swoosh symbol represents it.

**Pause & Ponder**

Brand personality of **Titan** as sophistication, elegance etc. **Nirma's** price & transparent package, Yellow colour of the detergent powder, symbolize 'Down to Earth' personality of Nirma. **Britania little hearts** uses 'heart logo' symbolizing love and affection.

**Brand Knowledge Method:**

Brand knowledge can be understood as a sum of brand awareness and brand image in the mind of consumers. Each of the parameters like brand recall/strength of brand associations/ attitudes/ user image contribute to the brand knowledge. And the weighted sum of all these parameters is the measurement of brand equity. The brand knowledge is sum of various factor as shown in the figure given below:



### Dimensions of brand knowledge

#### Brand recall:

Here is an illustration to measure brand recall. Suppose you want the consumer to recall, Amazon the following set of questions can be asked:

What brand comes to your mind when I say “buy things from A to Z online”? (This is called top-of-mind-awareness.)

Which online platform comes to your mind when I say "Lowest price and easiest return?"

If the answer to the first question is “Amazon” then its Brand Recall score is high. If the respondent does not have any brand on top-of-mind awareness identifies Amazon for second question which contains a stronger clue, his association with the brand is that much weaker.

This method is one of the most comprehensive procedures if product or service can be accepted by consumers as the focus of brand equity. Such methods supports that brand equity does not lie in the price of product, at which a brand can sold, but in the mind of the customer. This consideration depends on how people has created the image of the brand or its customer based brand equity.

#### Pause & Ponder

If we talk about youthful sun glasses or watch the first name comes to mind is “Fast tracks”, whenever we say “thanda matlab” immediately we recall Coca-cola. Colour orange recall us Mirinda. If we think about Budget meal we recall Mc.Donalds, “haque se mango”—Priya Gold, Child’s strength concern-- Boost etc.

### Brand Image

Consumers differ in the feeling as to which brand features they feel as most significant and the value they associate to each attribute, is called brand association. Consumer will pay most of their attention to the features that deliver the required benefits. A market segmentation is based often according to the attributes that are prominent to different consumer groups. The consumer also prepares a set of beliefs about where each brand positions on every attribute. These set of beliefs make up brand image for the brand and called Brand identity and it need to be distinguished among the lot. Brand identity encompasses the methods that a company intends to identify itself or its product. Brand image is the manner the consumer perceives the company or its products. Brand image is influenced by many internal and external factors which sometimes beyond the company's control.

An effective image does three things:

- It establishes the product's character and value proposition. It expresses the character of brand in a unique way so as the consumer would not get confuse it with the competitor's image.
- It delivers emotional power beyond a mental image.
- The image of a brand may contain different types of associations in memory: attributes benefits and attitudes.

### BRAND ASSOCIATIONS

The association build when consumer associate and explore the brand. And this association of consumers make with brand promotes brand equity. The Brand associations include customer association with product attributes, a celebrity, a symbol or a cause.

Brand associations promote brand identity means what the organization wants the brand to recognize for in the mind of consumers. A key factor responsible for brand building is to develop and implement brand identity. The key to effective brand building is to create a unique brand identity in the mind of customers so that they know what the brand meant for and for expressing that brand identity effectively.

Customers connect with different attributes of the product including its use or the cause which is supported by the brands. Brand association is anything that linked

to the memory of a brand in the mind of consumer. Thus a jingle like “Daar kea age jeet hai” has been associated in the customer's mind with Sprite. Surf Excel is linked with the economy-minded middle class with “Daag achche hai” in the advertisement campaigns.

#### Pause & Ponder

Mahindra Thor has clearly positioned itself as the “Adventure” car. The name Tata motors is associated with quality. Fortrune brand Associate with “ Ghar Ka Khana”. It is important to know how strong this association which are the products with which make association is the strongest.

### BRANDS ATTRIBUTE ASSOCIATIONS

The brand attribute association are rational features, which are used to illustrate a product or service. The attributes could be distinguished based on how directly or indirectly they are depicting the product or service performance. The product related physical attributes are most important components for the products and service performance. These product related attributes includes packaging, user usage imagery and price.

#### Pause & Ponder

In the case of Redtape shoes the product related attributes would be: leather shoes, formal and casual, unique sole, stylish etc. The non-product related attributes would be: price, packaging, user-young, tough; usage-outdoors and loungewear.

### BRANDS BENEFIT ASSOCIATIONS

**Functional:** These are the consequence of the functions performed by a product of service. These are the intrinsic benefits derived by consuming a product or service.

**Experiential:** These accumulate to the user in the form of emotions and feelings.

**Symbolic:** These are non intrinsic benefits derived not directly out of the product and correspond to non-product related benefits.

#### Brand Attributes

Brand attributes are functional or emotional associations that are allocated to a brand by its customers and prospects customers. Brand attributes can be either negative or positive and can have varying degrees of relevance and importance to different

customer segments.

Examples of Brand Attributes:

- Influential
- Innovative
- Inclusive
- Relevant
- Connecting
- Leadership
- Humane

**Packaging** again plays an important role in brand image. Packaging colour, pattern, style and even size is unique or different that we easily recall the particular brand. For example Kit Kat has different packaging and unique style to open. Dairy milk chocolate has unique packaging colour. Appy has unique shaped bottle. And even attractive and unique packaging makes brand effective.

#### User Imagery

User imagery majorly focuses on association of users personality with the brand personality and describes who or what type of person, might use that product / brand. Somebody may identify himself belong to erudite class as Mercedes or Audi owner. A TV commercial of Raymonds, showcasing a man playing with puppies focuses on soft side of man (i.e. caring and loving). These are the examples of the focus is on emotional aspects rather than on functional a attributes. Not only this, user imagery also conveys about the life style of the user. User imagery results in user-driven image which is transferred to the Brand. So it is important for a brand that brand personality needs to be flexible enough to be updated with change in user imagery while retaining the essence of brand contemporary and appropriate in larger perspective.

The Coke is classic examples for 'user imagery' contributing to brand personality & success. In fact, such brands have become cult brands in which brand personally played leading role.

Nykaa attained distinct personality as fun, frolic and lively fashion and cosmetics brand supported by their ads and social media collaborations. Philips has developed innovative personality and all their innovative promotions are in tune with the brand personality. Fasttrack has become coolest brand among the youth as channel, with sensible promotions using youth icon and believed in talking to the audience/youth and localization of the content.

### **The power of brand imagery**

*Powerful imagery can make or break a brand.*

CONSUMERS are exposed to several kinds of advertisements during a day — some of them may have a conscious impact and some sub-conscious. (A consumer may start liking the brand or develop a certain association with it because of the constant exposure over a period of time even without realizing it.

On social media platforms we are forced watched several kinds of advertisements. These reminders subconsciously force consumers to consume these products. Some brands use lifestyle appeals and some use celebrities. Given the clutter of marketing communication and the limited time which consumers have to comprehend these, it is critical to have the right kind of imagery associated with the brand.

Brand imagery is the type of associations a brand could able to connect consumer over a period of time. It has an impact on how consumers perceive the brand and how they will react towards the brand in the long run. Brand imagery plays a significant role in developing the association in the consumer at psychological level. It is a tedious job that is why only a few brands in most categories can develop an association with a brand. Once an association was developed it stayed with consumers for a long time. Today's context is different, with several brands attempting to create an image.

Old and inflexible brands are in a tough situation and it is difficult for them to abruptly develop trendy new imagery, and the images which they have built over years are neither very relevant in contemporary world nor have any competitive advantages over the brands which are developing more relevant images. For several years, Robin Blue was associated with whiteness in fabric wash. The packaging and the bird on it symbolized whiteness and was a household brand. Bajaj Scooters had a 'family vehicle' image. Now Honda, which leads in the scooter category, has developed a different image. Iodex, a brand which was identified with sprains, is overshadowed by other brands which have developed several associations which may be relevant to the times. It may be interesting to find out how many consumers currently think of pioneering brands in any category and the reasons they probably do not think about them when the need arises. We can now see that various revolutionary brands have a very low

market share and some of them are no longer there in the market. Brand imagery or not being able to sustain it is one of the reasons for their being absent in consumers' 'consideration set.')

### **Ending Notes**

What goes into making a strong brand? To answer this question, one popular myth needs to be done away with — “Brands are all about image, advertising, logo and naming”.

It is about having in place people, processes and measures to ensure that no matter what happens, the customer sees one consistent face and experiences the same sensation every single time they visit your outlet!

Today no one goes in to a departmental store looking for: “soap” or a “deo” or even “some cheese”. Everyone goes in to shop for a Dove, an Axe or Amul. Indeed, people are no longer just visiting a department store either. They are visiting a Food World, a Monday to Sunday or a Nilgiris!

So what's the difference? The difference is that today the brand plays as important a role in the retail arena as in any other, and it takes some good hard thinking to first of all identify what it is that your retail brand will offer;

No matter what your brand is, or where your market is, it is important to remember that the brand is an asset that requires investment of not only money, but also of time, love and devotion and with proper nurturing, it can one day be the most valuable asset on your balance sheet!

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## A Detailed Review on Transdermal Drug Delivery System As a Novel Approach

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**Abstract:** The human skin is a possibility to be reached surface for drug delivery. The skin of an average adult body covers a surface of approximately 2 m<sup>2</sup> and receives about one-third of the blood circulating through the body. Over the past decades, developing controlled drug delivery has become increasingly important in the pharmaceutical industry. The human skin surface is known to contain, on average, 10- 70 hair follicles and 200-250 sweat ducts on every square centimetre of the skin area. It is one of the most readily accessible organs of the human body. The skin has a site for drug application both for local and systemic effects. However, the skin, in particular the stratum corneum,

**Keywords:** Transdermal, Skin, Drug Delivery, Modification, Novel Drug Delivery System (NDDS).

### Introduction

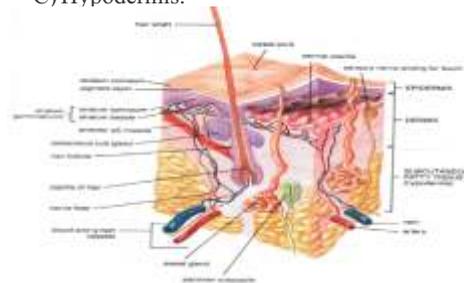
The human skin is a possibility to be reached surface for the delivery of the drug. Over the past three decades, developing controlled drug delivery has become increasingly important in the pharmaceutical industry. The pharmacological response, both the desired therapeutic effect and undesired adverse effect of a drug is dependent on the concentration of the drug at the site of action which in turn depends upon the dosage form and the extent of absorption of the drug at the site of action[1]. Tablets and injections have been the traditional way to take medications; new options are becoming increasingly popular. One highly successful alternative delivery method is transdermal. The skin of an average adult body covers a surface of approximately 2 m<sup>2</sup> and receives about one-third of the blood circulating through the body. The deliver a drug into the body through the transdermal layer of skin, it is

poses a formidable barrier to drug penetration thereby limiting topical and transdermal bioavailability. Skin penetration enhancement techniques have been developed to improve bioavailability and increase the range of drugs for which topical and transdermal delivery is a viable option. While the past decade, the number of drugs formulated in the patches has hardly increased, and there has been little change in the composition of the patch systems. Modifications have been mostly limited to refinements of the materials used. The present review article explores the overall study of the transdermal drug delivery system, which leads to a novel drug delivery system.

necessary to understand the skin.

Anatomy and physiology of skin: Human skin comprises three distinct but mutually dependent tissues [2-5]:

- A) The stratified, vascular, cellular epidermis,
- B) The underlying dermis of connective tissues and
- C) Hypodermis.



**Figure 1: Structure of skin [5]**

**Epidermis-** The multilayered epidermis varies in thickness, depending on cell size and the number of cell layers of the epidermis, ranging from 0.8 mm on palms and soles down to 0.06 mm on the eyelids. Table 1 gives the thickness, water permeability and diffusivity of water through the epidermis. It consists outer stratum corneum and viable epidermis [2-5].

- **Stratum Corneum-** The stratum corneum is the outermost layer of skin also known as the honey layer. It is approximately 10mm thick when dry but swells to several times this thickness when fully hydrated. It contains 10 to 25 layers of dead, keratinized cells called corneocytes. It is flexible but relatively impermeable. The stratum corneum is the principal barrier to the penetration of the drug. The architecture of the honey layer may be modelled as a wall-like structure. In this model, the keratinized cells function as protein “bricks” embedded in lipid “mortar.” The lipids are arranged in multiple bilayers. There is sufficient amphiphilic material in the lipid fraction, such as polar free fatty acids and cholesterol, to maintain a bilayer form.
- **Viable epidermis-** The viable epidermis is situated beneath the stratum corneum and varies in thickness from 0.06mm on the eyelids to 0.8mm on the palms. Going inwards, it consists of various layers as stratum lucidum, stratum granulosum, stratum spinosum and the stratum basal. In the basal layer, mitosis of the cells constantly renews the epidermis and this proliferation compensates for the loss of dead honey cells from the skin surface. As the cells produced by the basal layer move outward, they alter morphologically and histochemically, undergoing keratinization to form the outermost layer of the stratum corneum.

**Dermis-** The dermis is a 3 to 5mm thick layer and is composed of a matrix of connective tissue, which contains blood vessels, lymph vessels and nerves. The cutaneous blood supply has an essential function in the regulation of body temperature. It also provides nutrients and oxygen to the skin while removing toxins and waste products. Capillaries reach within 0.2 mm of the skin surface and provide sink conditions for most molecules penetrating the skin barrier. The blood supply thus keeps the dermal concentration of a permeant very low and the resulting concentration difference across the epidermis provides the essential concentration gradient

for transdermal permeation [2-5].

**Hypodermis-** The hypodermis or subcutaneous fat tissue supports the dermis and epidermis. It serves as a fat storage area. This layer helps to regulate temperature and provides nutritional support and mechanical protection. It carries principal blood vessels and nerves to the skin and may contain sensory pressure organs. For transdermal drug delivery, the drug has to penetrate through all these three layers and reach into the systemic circulation.

**Fundamentals of skin permeation-** Until the last century, the skin was supposed to be impermeable except for gases. However, in the current century, the study indicated the permeability of lipid-soluble drugs. Also, it was recognized that various layers of skin are not equally permeable i.e. epidermis is less permeable than the dermis. After a large controversy, all doubts about stratum corneum permeability were removed and using isotopic tracers, it was suggested that stratum corneum greatly hamper permeation [6].

- **Stratum corneum as a skin permeation barrier-** The average human skin contains 40-70 hair follicles and 200-250 sweat ducts per square centimetre. Especially water-soluble substances pass faster through these ducts, still, these ducts don't contribute much to skin permeation. Therefore most neutral molecules pass through the stratum corneum by passive diffusion. Regional variation in water permeability of stratum corneum showed in *Table 1*.

#### Series of steps in sequence-

1. Sorption of a penetrant molecule on the surface layer of stratum corneum.
2. Diffusion through it and viable epidermis and finally reach the dermis.
3. The molecule is taken up into the microcirculation for systemic distribution.

Sr. No.	Skin region	Thickness (mm)	Permeation rate (mg/cm <sup>2</sup> /hr)	Diffusivity (cm <sup>2</sup> /sec (x10 <sup>10</sup> ))
1	Abdomen	13.0	0.34	6.0
2	Volar forearm	16.0	0.31	5.9
3	Back	10.5	0.29	3.5
4	Forehead	13.0	0.85	12.9
5	Scrotum	5.0	1.70	7.4
6	Back of hand	09.0	0.56	32.3
7	Palm	400.0	1.14	835.0
8	Plantar	600.0	3.90	930.0

**Table 1:** Regional variation in water permeability of stratum corneum [5]

- **Intracellular versus transcellular diffusion-** Intracellular regions in the stratum corneum are filled with lipid-rich amorphous material. In a dry stratum corneum, the intracellular volume may be 5% to 1% in a fully hydrated stratum corneum [6].

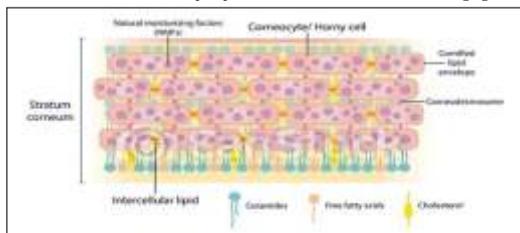


Figure 2: The microstructure of stratum corneum [5]

- **Permeation pathways-** Percutaneous absorption involves the passive diffusion of substances through the skin. A use two diffusional routes to penetrate normal intact skin, the appendageal route and the epidermal route[7-9].

- **Appendageal route-** The appendageal route comprises transport via sweat glands and hair follicles with their associated sebaceous glands. These routes circumvent penetration through the stratum corneum and are therefore known as “shunt” routes. This route is considered to be of minor importance because of its relatively small area, approximately 0.1 % of the total skin area [5].

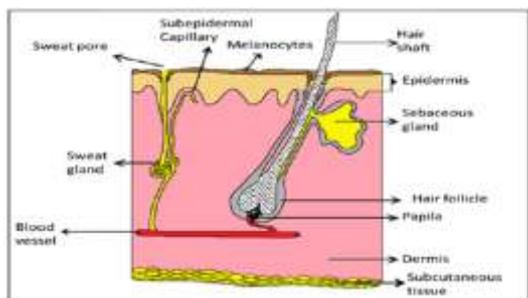


Figure 3: Routes for drug permeation in skin [5]

- **Epidermal route-** For drugs, which mainly cross-intact horny layer, two potential micro routes of entry exist, the transcellular (intracellular) and intercellular pathways.

**Components of TDDS-** The main components of a transdermal patch are:

- **Release Liner-** Protects the patch during storage. The liner is removed before use [10-13].
- **Drug reservoir-** The most important part of TDDS is the drug reservoir. It consists of drug particles dissolved or dispersed in the matrix. To make the drug soluble, solvents and cosolvents are used. The effect of solvent and cosolvent should be considered while doing the selection [10-13].
- **Adhesive-** Serves to adhere the components of the patch together along with adhering the patch to the skin. The adhesive must possess sufficient adhesion property so that the TDDS should remain in place for a long time. Pressure-sensitive adhesives are commonly used for the transdermal patch to hold the skin. Commonly used adhesives are silicone adhesives, poly iso butylenes adhesives and poly acrylate-based adhesives [10-13].
- **Membrane-** The membrane controls the release of the drug from the reservoir and multi-layer patches. It may or may not contain a rate-controlling membrane. It should be flexible enough not to split or crack on bending or stretching. Some rate-controlling membranes are polyethylene sheets, ethylene vinyl acetate copolymer and cellulose acetate [10-13].
- **Backing-** Protects the patch from the outer environment. The backing layer should be impermeable to drug and penetration enhancers. - serves the function of holding the entire system and protecting the drug reservoir from the atmosphere. The commonly used backing materials are polyesters, aluminized polyethene terephthalate and siliconized polyethene terephthalate [10-13].

#### General clinical considerations in the use of TDDS-

The patient should be advised of the following general guidelines. The patient should be advised of the importance of using the recommended site and rotating locations within the site. Rotating location is important to allow the skin to regain its normal permeability and to prevent skin irritation [7, 13].

- TDDS should be applied to clean, dry skin relatively free of hair and not oily, inflamed,

irritated, or broken. Wet or moist skin can accelerate drug permeation time. Oily skin can impair the adhesion of the patch. If hair is present at the site, it should be carefully cut, not wet shaved nor should a depilatory agent be used, since later can remove stratum corneum and affect the rate and extent of drug permeation [7, 13].

- The use of skin lotion should be avoided at the application site because lotions affect the hydration of the skin and can alter the partition coefficient of the drug.
- The patient should not physically alter TDDS, since this destroys the integrity of the system.
- The protecting backing should be removed with care not to touch fingertips. The TDDS should be pressed firmly against the skin site with the heel of the hand for about 10 seconds.
- A TDDS should be placed at a site that will not subject it to being rubbed off by clothing or movement. TDDS should be left on when showering, bathing or swimming.
- A TDDS should be worn for a full period as stated in the product's instructions followed by removal and replacement with a fresh system.
- The patient or caregiver should clean the hands after applying a TDDS. The patient should not rub the eye or touch their mouth during handling of the system.
- If the patient exhibits sensitivity or intolerance to a TDDS or if undue skin irritation results, the patient should seek reevaluation [7, 13].

Upon removal, a used TDDS should be folded in half with the adhesive layer together so that it cannot be reused. The used patch is discarded in a manner safe for children and pets.



Figure 4: Use of transdermal patch [5]

It is important to use a different application site every day to avoid skin irritation.

#### Suggested rotation is-

- Day 1 – Upper right arm
- Day 2 – upper right chest
- Day 3 – Upper left chest
- Day 4 – Upper left arm,
- Day 1- Then repeat from

Table 2: Examples of marketed transdermal drug delivery systems [14-17]

Sr. No.	Therapeutic agent	TDDS	Design
1	Clonidine	Capren-TTS (Boehringer Ingelheim)	Four-layer patch
2	Estradiol	Estraderm (Novartis)	Four-layer patch
3	Estradiol	Vivelle (Novartis)	Three-layer system
4	Estradiol	Climate (Novartis)	Three-layer system
5	Fentanyl	Duragesic (Janssen)	Four-layer patch
6	Nicotine	Prostep (Lalor)	Multilayer round patch
7	Testosterone	Testoderm (Alza)	Three-layer patch
8	Nicotine	Habitrol (Novartis Consumer)	Multilayer round patch
9	Nicotine	Nicoderm CQ (SmithKline Beecham Consumer)	Multilayer rectangular patch
10	Nicotine	Nicotrol (McNeil Consumer)	Multilayer rectangular patch

**Transdermal patches-** The transdermal system delivers medications through the skin directly into the bloodstream. The transdermal route of drug delivery is becoming popular because a large number of drugs can be delivered by this route to treat various diseases. Currently, transdermal patches are used in several therapeutic areas like pain management, smoking cessation, treatment of heart disease, hormone replacement and management of motion sickness [9].

#### Types of Transdermal Patches- [18-22]

**Single layer drug in adhesive-** In this type, the adhesive layer contains the drug. The adhesive layer not only serves to adhere the various layers together and also responsible for releasing the drug to the skin. The adhesive layer is surrounded by a temporary liner and a backing.

**The multi-layer drug in adhesive-** This type is also similar to the single layer but it contains an immediate drug release layer and the other layer will be a controlled release along with the adhesive layer. The adhesive layer is responsible for the release of the drug. This patch also has a temporary liner layer and a permanent backing.

- **Vapour patch-** In this type of patch, the role of the adhesive layer not only serves to adhere the various layers together but also serves the market,

commonly used for releasing essential oils in decongestion. Various other types of vapour patches are also available in the market which is used to improve the quality of sleep and reduce cigarette smoking conditions.

**Reservoir system-** In this system, the drug reservoir is embedded between an impervious backing layer and a rate-controlling membrane. The drug releases only through the rate-controlling membrane, which can be microporous or non-porous. In the drug reservoir compartment, the drug can be in the form of a solution, suspension, gel or dispersed in a solid polymer matrix. The hypoallergenic adhesive polymer can be applied as an outer surface polymeric membrane which is compatible with the drug.

• **Matrix system-**

- **Drug-in-adhesive system-** In this type, the drug reservoir is formed by dispersing the drug in an adhesive polymer and then spreading the medicated adhesive polymer by solvent casting or melting (in the case of hot-melt adhesives) on an impervious backing layer. On top of the reservoir, unmediated adhesive polymer layers are applied for protection purposes.
- **Matrix-dispersion system-** In this type, the drug is dispersed homogeneously in a hydrophilic or lipophilic polymer matrix. This drug-containing polymer disk is fixed onto an occlusive base plate in a compartment fabricated from a drug impermeable backing layer. Instead of applying the adhesive on the face of the drug reservoir, it is spread along with the circumference to form a strip of the adhesive rim.
- **Microreservoir system-** In this type, the drug delivery system is a combination of the reservoir and matrix-dispersion system. The drug reservoir is formed by first suspending the drug in an aqueous solution of water-soluble polymer and then dispersing the solution homogeneously in a lipophilic polymer to form thousands of unreachable, microscopic spheres of drug reservoirs. This thermodynamically unstable dispersion is stabilized quickly by immediately cross-linking the polymer in situ by using cross-linking agents.

**Penetration Enhancers-** Many drug substances will not diffuse into the skin at sufficient rates to obtain therapeutic concentrations. Substances that reduce the skin's ability to perform its barrier function are collectively known as penetration enhancers. These substances make the skin more permeable and allow drug molecules to cross the skin at a faster rate. For both safety and efficacy, water is the optimum permeation enhancer. By increasing the hydration of the stratum corneum, the barrier function of the skin can be reduced. Alcohol is commonly considered a solvent in transdermal patches; it serves as an effective penetration enhancer. Some penetration enhancers remove lipids from the skin.[23-25]

**Evaluation Parameters-[26]**

1. Interaction studies
2. The thickness of the patch
3. Weight uniformity
4. Folding endurance
5. Percentage Moisture content
6. Percentage Moisture uptake
7. Water Vapour Permeability (WVP) evaluation
8. Drug content
9. Uniformity of dosage unit test
10. Polariscope examination
11. Shear Adhesion test
12. Peel Adhesion test
13. Thumbtack test
14. Flatness test
15. Percentage Elongation break test
16. Rolling ball tack test
17. Quick Stick (peel-tack) test
18. In vitro drug release studies
19. In vitro skin permeation studies
20. Skin Irritation study
21. Stability studies

**Advantages-[27-28]**

- They can avoid gastrointestinal drug absorption difficulties caused by gastrointestinal pH, enzymatic activity and drug interactions with food, drink and other orally administered drugs.
- They can substitute for oral administration of medication when that route is unsuitable, as in the

case of vomiting and diarrhoea.

- They avoid the first-pass metabolism and avoid drug deactivation by liver enzymes.
- They are non-invasive so avoid the inconvenience of parenteral therapy.
- They provide extended therapy with a single application, improving compliance over other dosage forms, and requiring more frequent dose administration.
- Drug therapy may be terminated rapidly by the removal of Transdermal drug delivery systems from the surface of the skin.
- They are easily and rapidly identified in emergencies (e.g. unresponsive, unconscious or comatose patients) because of their physical presence, features and identifying markings.
- They can be used for drugs with a narrow therapeutic window.

#### **Disadvantages[27-28]**

- The limitations of transdermal drug delivery are mainly associated with the barrier function of the skin, so it is limited to potent drug molecules.
- Skin irritation or contact dermatitis due to drugs, excipients and enhancers is another limitation.

**Future of Transdermal Therapy-** Ten years ago, the nicotine patch revolutionized smoking cessation; patients were being treated with nitroglycerin for angina, clonidine for hypertension, scopolamine for motion sickness and estradiol for estrogen deficiency, all through patches. At that time, biotech medicine was still being developed. During the past decade, the number of drugs formulated in the patches has hardly increased, and there has been little change in the composition of the patch systems. Modifications have been mostly limited to refinements of the materials used. The reason is that only a limited number of drugs fit the molecular weight and potency requirements for transdermal absorption.

#### **Conclusion**

Successful transdermal drug application requires numerous considerations. Bearing in mind that the basic functions of the skin are protection and containment, it would seem exceptionally difficult to target the skin for drug delivery. However, with our greater understanding

of the structure and function of the skin, and how to alter these properties, more and more new drug products are being developed for transdermal delivery. The properties of the drug, the characteristics of the transdermal device, the selection of the in-vivo model and the status of the patient's skin are all important for safe and effective drug delivery. The transdermal drug delivery system could be one day one of the best novel drug delivery systems.

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