# Patenting Plant Gene Ffor Enhancing Protein Content of Rice

- Dr. Bal Phondke

Every living organism has certain characteristic traits, be it a plant or an animal. Some of these are expressed on the outside of the organism in plain view of everybody. If it is a plant, its height, shape of its leaves, their colour and size, the colour, shape and aroma of its flowers and the like are all typical of that particular type of plant. In addition, there are a number of specific properties that are not so visible. They could be the edibility of the plant, nature and time of its flowering, the taste of its fruits and also whether the fruits are with seeds or without. If a part of the food chain of humankind the nutritional qualities of that particular plant variety are all unique to it.

These characteristics, internal as well as external, are inheritable and passed on faithfully from one generation to the next and to the next and so on. For long this was a puzzle. How is this achieved? Then came Gregor Mendel who not only found out how this is accomplished but also discerned the laws that govern this inheritability. He discovered that the organism contains discrete factors, which came to be later called genes, that are duplicated very very accurately and then passed on to the progeny.

Later still the gene came to be better understood. It was found that the genes are made up of Deoxyribonucleic acid, DNA. This is a polymer made up of small units each of which contains one of the four bases, A,T,G and C. The precise sequence of these units is responsible for storing information necessary to produce the unique properties.

There are a number of varieties of any species. For example take rice. Even if we go to the market to buy some the shopkeeper is bound to show us a number of different varieties each with a mouth-watering name like Basmati, Dehradun, Surti Colum, Ambemohar and a host of others. All of them are rice. Yet each one differs from the other in the precise nature of one or more of its properties. For example some like Basmati have long grain. The Ambemohar, on the other hand, has shorter grain though it is aromatic. Some other may become rather sticky when cooked while each single grain of the cooked Basmati would remain staunchly separate.

The nutritive quality of these different varieties may also show a similar broad spectrum. Then again, the growing qualities could also vary and hence the per acre yield could be in striking contrast from each other. However, the cultivating farmer and the consumer alike would like to have all the desired characteristics in one single variety. One that would always give a bumper crop and still be highly nutritious so as to satisfy the nutritional needs of the consumer would be the one that everybody would be after. That alas is a dream that hardly ever translates into reality in nature. The available varieties normally would be deficient in one or more of the desired qualities. The *Kamdhenu* that one is always pining for remains elusive.

That is what everyone thought. But as advances after significant advances were made in the field of genetics it was realised that the genes and the genetic code are universal. In other words, the DNA of all the living organisms is made up of the same building blocks. Only that the patterns in which they are organized differs from one organism to the other. Just as all the buildings are built of brick and mortar and steel and cement and yet stand clearly apart from each other, all the living organism share the same DNA and even many of the genes but the external as well as internal features of these organisms are vastly different from each other.

**Hybridisation:**

Even so, this realisation showed a way of endowing an organism of properties that nature did not bestow on it. For example, a particular type of mango plant yields fruits that are juicy and very attractive but are somewhat sour in taste. Another variety lacks the colour and flesh but its fruits are very sweet. Would it not be possible then to combine all the desired traits in one variety? Such a mango would be juicy, colourfully attractive and sweet too.

Traditionally agricultural scientists used to develop such varieties by the technique of hybridization that Mendel himself had employed in his classic experiments. Normally many of these plant species are self fertilizing. In other words, they possess both the male and female reproductive organs. Their flowers contain both stamen and pistils. The stamen consists of the filament and anther. The anther is the site of pollen production. On the other hand, the pistil consists of ovary, ovules, style and stigma. These parts receive pollen and produce seeds when the ovules are fertilized. Now if one were to cut off the stamen the particular plant would not be able to reproduce. However, now pollens taken from flowers of another variety can be sprinkled on the pistils. That would lead to fertilisation and production of seeds. But these seeds would have inherited genes from both the species. This mixing always takes place in a stochastic that is probabilistic manner. That is why even plants produced in the second generation are not all identical.

From such a crossing between two varieties one can therefore hope to get at least a few plants in the second generation that possess the desired properties from both the parental strains. Such a hybrid variety can now be propagated by self fertilisation to conserve all the desired characteristics. These traditional agricultural practices had produced hybrid varieties that satisfied the needs of a growing population of our country.

Even so, these techniques are time consuming and laborious. To get a hybrid variety having all the desired properties takes years and there is no guarantee that one crossing would do the trick. Once it came to be known that all the organisms share the same genetic code and that the basic molecule of heredity is the same in all the organisms scientists thought of more precise, less labour intensive techniques which could also cut short the time required to produce a desired variety.

**Recombinant DNA:**

That is where the technology of recombinant DNA came into play. What is done here is to cut DNA molecules of the two varieties into pieces by using special chemical scissors called restriction enzymes. Selected pieces are then joined together to form a new recombinant DNA. This would be akin to taking two different tapes on which different musical scores are recorded. One could then cut a tape at preselected places and insert choice pieces from the other tape in the gaps. When such a doctored tape is played, it would give a fusion score. A western classical symphony can then have say the Indian percussion instrument tabla keeping the beat instead of the usual drums.

This was the strategy employed to produce the first lot of genetically modified foods. In these the two different varieties which donated their features to the hybrid progeny belonged to the same species. Both the varieties were of rice or wheat or whatever other crop. However, once the technology came to be mastered scientists thought of ever novel ways of producing a recombinant DNA. That is when the barriers of species and even kingdoms came to be knocked down. DNAs of two entirely different species could be combined to give rise to a new crop altogether. For example, recombinant DNA could be produced from say wheat and rice to give rise to whice, or tomato and potato to come up with a pomato. Yet in these new species both the parental species belonged to the plant kingdom. Soon that restriction was also passed over and DNAs from a plant and an animal or a microorganism were combined. Such efforts have yielded the BT cotton, BT maize and BT Brinjal that are very much in the news.

**Prof. Asis Datta's Research:**

What Prof. Asis Datta then at the JNU and now Director of the Institute of Plant Genome in Delhi thought was to employ these biotechnological practices to bring about enhancement in the nutritional qualities of rice. Rice is a staple constituent of diet of a significant Indian population. If its nutritional potential is increased it would be a boon to many people. However, no existing variety of rice was rich in nutritional quality. So crossing any two would not have resulted in the desired variety. So the protein content of rice could be enhanced only by importing the requisite genes from some other plant.

Datta found Amaranth to be one possible candidate. Amaranth, also called Chinese Spinach, are bushy, green-coloured plants some of which have leaves that can be eaten and taste similar to spinach, and some of which produce seeds that can be used as a grain. The plant is a relative to the pigweed, which is a wild plant. Additionally, sixty species of amaranth exist in the world. Certain amaranth varieties are considered vegetables and are grown strictly for their leaves. Others are grown only for their seeds. Some of these are grown in different parts of our country. In Maharashtra, it is known as Rajgira and is considered acceptable for fast regimes followed on certain religious days. It is used to make rotis or cooked to be a replacement of rice. It is even used to make laddus. So it is very much an eatable legume and already forms a part of our diet albeit at only certain special times.

Its seeds are also used in a variety of ways including to commercially produce cereals, similar to puffed rice, pastas, and baked goods. Amaranth grows well in warm weather with conditions that include much light. Under ideal growing circumstances, amaranth plants can grow to heights of up to 4 feet. Amaranth plants are ready for harvesting 5-6 weeks after their seeds have been sown.

Amaranth seed is high in protein (15-18%) and contains respectable amounts of lysine and methionine, two essential amino acids that are not frequently found in grains. It is high in fibre and contains calcium, iron, potassium, phosphorus, and vitamins A and C.

The fibre content of amaranth is three times that of wheat and its iron content, five times more than wheat. It contains two times more calcium than milk.

Amaranth also contains tocotrienols (a form of vitamin E) which have cholesterol-lowering activity in humans. Cooked amaranth is 90% digestible and because of this ease of digestion, it has traditionally been given to those recovering from an illness or ending a fasting period. Amaranth consists of 6-10% oil, which is found mostly within the germ. The oil is predominantly unsaturated and is high in linoleic acid, which is important in human nutrition. So to combine amaranth with wheat or rice in our diet could solve the protein malnutrition problem.

That is theoretically true but there is a problem. The content of oxalate or oxalic acid in Amaranth is high. So to consume it in rather liberal quantities could prove toxic since oxalate chelates calcium and also destroys renal tissue in kidney. Oxalic acid is an essential substrate for the synthesis of the neurotoxin called ɓ-N-oxalyl I-L-Ǔ, ɓ Diamino-propionic acid (ODAP). So there is a danger of a neurological ailment developing. Datta overcame this problem by cloning and characterization of the oxalate decarboxylase gene. This was then inserted in the amaranth genome. It reduced the oxalate content in the plant.

Still, Datta thought that there was an even better solution. Why shouldnǿt one clone the genes responsible for the high protein content of the seeds and import them in rice? So he isolated a gene from Amaranthus that encodes a seed specific protein rich in all essential amino acids including lysine and sulphur rich amino acids. Interestingly, the amino acid composition of this protein corresponds to that of WHO recommended protein standard for the optimum human nutrition. It is known that seed proteins in cereals as well as in legumes (peas, etc.) are deficient, the cereal proteins being deficient in lysine and pulses being deficient in sulphur containing amino acids.

In view of this, the gene isolated from Amaranthus could be utilized for compensating the amino acid deficiencies of many seed proteins, once it is genetically engineered into the target crop plants. Efforts have been made jointly by Prof. Asis Datta and the Department of Biotechnology, Govt. of India, to obtain patent rights for this gene in the USA. Subsequently he was granted that patent. Thus he became the first holder on a cultivated plant gene. Later still he introduced the same gene in potato and produced a variety rich in proteins.

This has been a novel and highly lauded effort that at once trailed a new path in fundamental molecular biological research while simultaneously addressing a social issue vital to the countryǿs interest.

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# Catalysts in Petrochemical Industries

- Dr. Anil Lachke

## Catalysis

Chemistry is the science of substances and their transformations. Chemistry makes many wonderful substances from animals and vegetables as well as from crude oil as a raw material. Some substances occur naturally, but many have to be chemically treated in some way to make them suitable for our specific needs. . Thousands of substances have been produced that are not easily found in nature but posses unique and useful properties. The list of chemistryôs good deeds is practically inexhaustible. Chemistry feeds us, clothes us, shoes us, and gives us the things without which modern civilized society cannot function. In order to get unique substances, two or more chemicals must come together and react! After all weôve all seen images of chemists cooking things up. May be weôve even turned up the flame a few times ourselves in the kitchen! And so we know that in order to speed up chemical reactions, high temperature certainly helps. If you wish to have an economical and ecofriendly approach towards your chemical transformations then you should use an appropriate catalyst. Catalysts change the reaction rate of chemical reactions favourably without undergoing any permanent change themselves.

Any chemical reaction that takes place with the aid of a catalyst is called a catalytic reaction. For example, heating a mixture of potassium chlorate and manganese dioxide produces oxygen quicker than heating potassium chlorate on its own. The manganese dioxide acts as a catalyst to speed up the reaction, and is left unchanged at the end. For this reason, the manganese dioxide does not appear in the chemical equation that shows the reaction.

A contact catalyst is one that has a large porous surface to which other substances adhere by a process called adsorption. Atoms or molecules of different substances collect on the surface of the catalyst. While on the surface they react together and are released in a different form. An example of such a reaction is the formation of ammonia from nitrogen and hydrogen. The catalyst used in this example is the iron ore magnetite.

Catalytic converters are used to clean-up exhaust gases in automobiles. It reduces the toxicity of emissions from the internal combustion engines. They are fitted in the motor vehicle exhaust system. A catalytic converter provides an environment for a chemical reaction where in toxic combustion by-products are converted to less toxic substances. The catalyst itself can be a precious metal, like platinum, palladium or rhodium. Platinum-rhodium catalysts are used as ñreduction catalystsò and platinum-palladium catalysts are used as ñoxidizing catalystsò. Zeolites are microporous aluminosilicate minerals, commonly used as commercial adsorbents. Synthetic zeolites are widely used as catalysts in the petrochemical industry.

**Indian catalysis research**

Indian catalysis research and development today is geared to serve the needs of the country on the one hand and the more challenging global requirements on the other. The research is focused, on innovative solutions to the problems of environmental pollution, safety in industrial practice and saving the energy requirement in chemical reactions. Catalysis R & D in Indian institutions now looks forward to the development of competitive catalysts and processes that are required to meet these challenges.

Indian per capita consumption of petroleum and petrochemical products was increased considerably during 1970s. Due to this rapid growth most of the laboratories initiated projects on the development of catalysis for petrochemicals and petroleum refinery processes with an emphasis on self-sufficiency and indigenization rather than on innovation. Catalysis research is expanded to cover topics such as synthesis and application of zeolites, molecular sieves, novel materials and photocatalysis. The globalization has resulted in many partnerships between Indian and foreign organizations. For example, a large amount of catalysis research carried out in CSIRôs (Council of Scientific & Industrial Research) laboratories. Mention must be made of NCL (National Chemical Laboratory, Pune), IIP (Indian Institute of Petroleum, Dehradun) and IICT (Indian institute of Chemical Technology, Hyderabad) in this regard. These laboratories have collaborations with multinational R & D Centres. Based on these activities, many catalysts/ processes developed in India are expected to go global in coming years. IPCL (Indian Petrochemical Ltd), PDIL (Projects & Development India Ltd.), IIT (Indian Institute of Technology, Mumbai/Kanpur), CFRI (Central Fuel Research Institute, Dhanbad) have also contributed substantially t the area of catalysts.

**Mitti ka tel**

Petroleum or crude oil is one of the worldôs most important sources of energy. This makes it very valuable to the countries where it is found. In the beginning, this oil was found to be useful for burning lamps for lighting the homes. In many Western countries, the oil was found to be useful for warming homes. Several business men sent a sample of the thick black oil to Yale University of USA. In 1860s, the sample was analyzed by Professor Benjamin Silliman. He reported that the ñsampleò is full of possibly useful chemicals. In other words, nothing will go as waste from this raw material. It is the chief source of hydrocarbons. Crude oil is generally a dark-coloured liquid with a peculiar smell; found underground either in certain shale rocks or held in huge natural reservoirs under pressure between non-porous layers of rock.

***Hydrocarbons***: This oil appears to be homogenous. In reality it is a made up of thousands of different combinations of the elements ï hydrogen and carbon. These combinations are called hydrocarbons. The hydrogen atoms are arranged in various patterns around the carbon atoms. The more carbon atoms a petroleum molecule contains, the thicker and heavier the hydrocarbon. Gasoline, for example, is made up of light hydrocarbons. Kerosene has slightly heavier hydrocarbons. Lubricating oil is heavier still, and asphalt for paving streets is made of very heavy hydrocarbons. The word petroleum comes from the Latin words *petra,* meaning rock; o*leum*, means oil. This oil was different than the animal or vegetable oil. People started calling this oil as ñ*rock-oil*ò or in India ñ*Mitti ka* *tel*ò. People started using this oil for mainly for lighting their homes. Hundred years back, the oil was found to be an appropriate fuel for running the internal combustion engines. Cars started running on this liquid which was then an inexpensive fuel. Today, petroleum is much more than just a fuel for automobiles. It is used in the manufacture of thousands of productsé . From plastics to hand lotions, from asphalt to wax candles.

## In search of oil (Background)

Oil began to form deep under the earth millions of years ago when plants and animals died and their skeletons settled at the bottom of seas and lakes. The remains were slowly buried under layers of sediment and in the course of time became crude oil. The oil usually lies trapped between domes of solid rock. Often there is a layer of salt water beneath it. In many cases the richest deposits of oil lie beneath a great amount of rock and can be reached only by expensive drilling operations. Geologists know which rock strata (layers) oil is most likely to be trapped in. They start with experimental data of areas likely to be oil-bearing. Then they begin to gather their evidence.

***Fossils***: Fossils help to date and identify rocks. Radioisotopes are used to obtain more accurate measurements of their age.

***Magnetometer*** : A special instrument called a magnetometer trails behind an airplane as it flies at an even height a long a pattern of flight lines. As different types of rocks are magnetic to different degrees, the results from the magnetometer give a picture of the magnetic structure and thickness of the rocks deep underground.

***Gravimeter***: The earthôs gravity also changes from place to place. A gravimeter carried across land or mounted on a ship measures the different gravities of the rocks below dense rocks give a higher gravity reading.

***Seismic tests***: Then there are seismic tests. These are more exact. They measure the time it takes for shock waves from controlled explosions to reflect upward from rocks underground. The time it takes the shock waves to reach an underground layer and return to the surface shows how deep the layer is. It also gives clues about the type of rock from which the shock waves were reflected.

When all these tests are complete and if they show a good chance of oil being in a certain area, a test well is driven down into the rock. It is at this point that large amounts of money are needed to set up the drilling operation. It may cost billions of Rupees to develop a major oilfield before any oil is gotten out of it. Therefore, the exploration be as thorough as possible before any drilling starts. These days the computers are used to gather the information from all tests, but the sure presence of oil is still not known. If there is oil, it probably lies 3000 meters below the surface.

## Early drilling

The Chinese began drilling for oil as long ago as 320 BC, but they did not really have the right equipment to drill deep enough. The first successful oil well was sunk by Edwin L. Drake, who drilled a well about 30 meters deep in USA (Pennsylvania) in 1859. This was the start of todayôs petroleum oil industry.

The story of oil exploration in India began in the dense jungles and swamps of Assam in the 19th century.  In India, the first regular oil well was discovered in at Borbhil. The oil was also struck at Makum near Margherita at a depth of just 36 meters (118 feet). In 1890, noticing the oil seepages around Borbhil, one private company took a decision to drill an oil-well near the village. Mr. W. L. Lake was an oil enthusiastic technologist. He immediately started collecting drilling equipments, portable boilers and local labour. Elephants were used to drag the machinery on sleigh along animal tracks. Lot of digging was done. The legend has it that Mr. Lake used to urge his men ñDig boysé  Digò; hence the name ñDigboiò! With such great efforts the oil-well ñDigboi Well No. 1ò started in the month of September, 1889. Digboi Well No. 2 started in February 1891.  The oil production was going on well with 11 wells until 1894. By 1920 there were 80 wells with an average production of 350 bpd (Barrels per day). Thus, there was a modest progress of oil industry in India about 120 years back.

**Production of petrochemicals with catalysts (Oil Refining)**

The oil we used to make ñPetrolò (gasoline, or motor spirit) and other products, start out as raw black petroleum. It cannot be used as it is, straight from underground. It must be changed into the specific chemicals that people use. This process of changing petroleum into useful products is called refining. The modern oil refinery is a large and complicated factory. Automatic control of the various stages is efficient and safe. Teams of workers are needed to keep the refinery machinery ñrunningò smoothly.

The crude oil consists of many different chemicals with various chemical and physical properties. Distillation or fractionation is the first stage in petroleum refining. This separates out the various constituents) of the crude oil. Different hydrocarbons vaporize at different temperatures. Here, tall distillation columns are necessary. There are many separate trays that are fitted for collecting various chemicals.  As the heating starts, partly vaporized oil is fed into the column part of the way up. The lightest fractions are gases. The gases gather at the top of the tower. Heavier fractions that are slower to evaporate gather at each lower stage. Usually, fractions from several stages are drawn off for further processing. The residue, which is left at the bottom of the tower, contains a wide range of petroleum parts. It can be used for fuel oil without any more processing. It can be further distilled to give bitumen or lubricating oils.

A process known as ***"cracking"*** breaks down large molecules into smaller ones. This is done either by thermal cracking, using high levels of heat and pressure, or by using less heat and pressure and a catalyst. Catalytic cracking is done by the fluid technique. In this, a catalyst in the form of a fine powder is poured like a liquid through the petroleum and out to a regenerator. In the regenerator, carbon that has become attached to the catalyst is removed. The catalyst is then returned to the refining cycle.

Catalytic cracking is normally used to make gasoline. The gasoline produced by this process has a higher octane number than gasoline produced by straight distillation. The octane number is a measure of the tendency of fuels to ñknockò (make a knocking noise) when used in automobile engines. The higher the number, the less is knock.

Another refining method is called hydrocracking. In this method, hydrogen and catalysts are used under high pressure. The process results in greater amounts of gasoline and less waste than catalytic cracking. During the cracking operation some gases are always formed. These gases are collected and then put under high temperatures and pressures in the presence of a catalyst. This process is called polymerization, joins molecules together to make larger molecules. These larger molecules (polymers) are used in the production of gasoline.

**Some notes**

1. The largest refinery in the world is **Jamnagar Refinery** in Gujarat. Refining capacity per day is 661000 barrels per day.
2. One Barrel is 42 gallons or approximately 160 litres
3. What one Barrel of crude oil makes?

| | |
|---|---|
| Gasoline | 74 lit |
| Distillate fuel oil | 37 lit |
| Kerosene/Jet fuel | 15 lit |
| Residual fuel oil | 9 lit |
| Liquefied refinery gases | 7 lit |
| Coke | 7 lit |
| Asphalt &road oil | 5 lit |
| Petrochemical Feed stock | 5 lit |

4. India has witnessed a spectacular growth in the refining sector. In 1947, there was only one refinery located in Digboi, with a capacity of only 0.25 million (250,000) tones/year. Today there are at least 20 refineries in India with an installed capacity of 60.4 millions/year. By the year 2012, Indiaôs oil refining capacity would be 65.3 million tones /year.

5. India has large reserve of trained and highly skilled manpower at a relatively much lower cost compared with advanced countries.

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# Tracing India's Invisible Threads

- Dr. Manasi Rajadhyaksha

Each one of us belongs to a group of people called family. Our family is part of a family-tree, where we trace out our common ancestors. We all experience and are aware of, that we have some common invisible threads amongst every member of our family tree. But our tracing back for our ancestors remains limited for 100 or may be 200 years ago. What about years much before that? Do we, all Indians, share common ancestors? Do we all belong to one common family tree? How to find out that?

Research using modern technologies in the field of biology is of great help to find out answers to these questions. How is it possible to study a family tree of having ancestors almost thousands of years ago? Let us try to understand some basic parameters of the research.

## Chromosomes and genes:

All organisms consist of cells. In human beings and most other organisms, chromosomes are found in the part of a cell known as the nucleus. Chromosomes are tiny threadlike structures made up of Deoxyribonucleic Acid, DNA. DNA is a chain like large molecule that has a double helical structure means spiral structure having pair of strands. Every gene is a segment of a DNA molecule. Gene is a tiny biochemical structure that determines the characteristics of living things inherit from their parents. Genes influence chemical and physical processes during growth and aging.

Every cell has thousands of genes. Most genes occupy a specific place on a certain chromosome. Genes are like blueprints for building a house, except that they carry the plans for building cells, tissues, organs, and bodies. They have the instructions for making the thousands of chemical building blocks in the body. These building blocks are called proteins. Some proteins are responsible for the size, shape, and structure of the parts making up our body. Other proteins, known as enzymes, make possible the thousands of chemical reactions that occur constantly in our body. The process by which the cell makes a protein according to the instructions carried by a gene is known as gene transcriptions.

Each species of animal and plant has a characteristic number of chromosomes in its body cells. Body cells, often called somatic cells, are the cells that make up such body parts as muscles and bones. Body cells differ from sex cells. In male animals, the sex cells are sperm, in female animals, the sex cells are eggs. Human beings typically have 46 chromosomes, arranged in 23 pairs, in their body cells.

Every species of plant and animal has a certain number of genes on its chromosomes. Scientists estimate that human beings have from 50,000 to 100,000 different genes. A set of all the genes that a species has on its chromosomes is called its genome.

## Genetics:

Genetics is the scientific study of heredity, the passing on of characteristics of living organisms from one generation to the next. Geneticists investigate the structure, function, and transmission of genes. Each of the cells in the human body has 50,000 to 100,000 genes. Genetics can be divided into three major areas of study as molecular genetics, transmission genetics and population genetics.

Advances in molecular genetics led to the development of genetic engineering (techniques for altering the structure of genes). Transmission genetics is the traditional approach to the study of heredity. Transmission geneticists locate and describe where genes are arranged on chromosomes, a process called gene mapping.

Population genetics focuses on processes that change the relative frequency of genes in a population through time. A population is a group of individuals of the same species that live within the same area. Population geneticists often study how mutations and other processes of evolution, such as natural selection, interact with one another. They try to understand how such interactions affect the frequency with which certain genes occur within a population. Population geneticists believe that an understanding of the processes of evolution and genetic transmission helps explain the diversity of life on the earth--and within our own species.

**Gene flow and genetic drift:**

Gene flow is the transfer of genes from one population to another. When separate populations come into contact and interbreed, combinations of genes are introduced into each group. Consequently, the gene pool of each group comes to include genes from pools of the other populations. In this manner, the allele (different forms of the same gene are called alleles. Some alleles are dominant, and others are recessive.) frequencies of populations may change over time.

Genetic drift refers to a chance to increases or decreases in allele frequencies of a population from generation to generation. The genes of each generation represent only a sample of the previous generation's gene pool. As a result, the allele frequencies of each generation of individuals tend to vary randomly within the limitations of the preceding generation's gene pool. Such changes will probably have little effect on each generation in large populations. But they can lead to major genetic changes in small ones in a short period.

**Mitochondrial DNA:**

During fertilisation only the nuclear DNA of the sperm penetrates the nucleus of the egg. The two sets of chromosomes, one from the father and the other from the mother, come together to form pairs. All the nutrients necessary for nurturing an embryo during gestation period are provided by the mother. Even all the energy needed for the set of biochemical reactions during the process is also provided by the powerhouse of the egg cell. This powerhouse is called mitochondria. Interestingly the mitochondria too have their own DNA called as mitochondrial DNA. mtDNA is different from the nuclear DNA. Therefore, all humans have two copies of each chromosome, and therefore each gene, with one copy from the mother and one from the father. But mitochondria, and the genes in them, are almost exclusively inherited from the mother.

Mitochondrial DNA replicates only in mitochondria, and doesn't interact with the rest of the genome. This means that not only do mutations, that are changes in the mtDNA, occur completely separately, but they also won't be covered over by recombination with nuclear DNA. The other thing is that sexual reproduction involves two gametes, or sex cells. One, the ovum or the female cell, is very very large. The other, the sperm or the male cell, is very very small. So small, in fact, that it really doesn't contribute anything to the next generation other than its DNA. Mitochondria are only present and passed down in the female gamete, which, in turn, implies that every mitochondria in our body right now is shared with our mother and mother only, and not our father.

**Y- Chromosomes:**

Human Y chromosomes are male-specific sex chromosomes; nearly all humans that possess a Y chromosome will be morphologically male. Y chromosomes are therefore passed from father to son; although Y chromosomes are situated in the cell nucleus, they only recombine with the X chromosome at the ends of the Y chromosome; the vast majority of the Y chromosome (95%) does not recombine. When mutations arise in the Y chromosome, they are passed on directly from father to son in a direct male line of descent. The Y chromosome and mtDNA therefore share specific properties.

Other chromosomes, autosomes and X chromosomes in women, share their genetic material (called crossing over leading to recombination) during meiosis (a special type of cell division that occurs for the purposes of sexual reproduction). Effectively this means that the genetic material from these chromosomes gets mixed up in every generation, and so any new mutations are passed down randomly from parents to offspring.

The special feature that both Y chromosomes and mtDNA display is that mutations can occur along a certain segment of both molecules and these mutations remain fixed in place on the DNA. Furthermore the historical sequence of these mutations can also be inferred. For example, if a set of ten Y chromosomes (derived from ten different men) contains a mutation, A, but only five of these chromosomes contain a second mutation, B, it must be the case that mutation B occurred after mutation A. Furthermore all ten men who carry the chromosome with mutation A are the direct male line descendants of the same man who was the first person to carry this mutation. The first man to carry mutation B was also a direct male line descendant of this man, but is also the direct male line ancestor of all men carrying mutation B. Series of mutations such as this, forms molecular lineages.

**Haplogroups:**

Each mutation defines a set of specific Y chromosomes called a haplogroup. All men carrying mutation A form a single haplogroup, all men carrying mutation B are part of this haplogroup, but mutation B also defines a more recent haplogroup (which is a subgroup or subclade) of its own which men carrying only mutation A do not belong to. Both mtDNA and Y chromosomes are grouped into lineages and haplogroups; these are often presented as tree like diagrams. Molecular evolution is the process of evolution at the scale of DNA, RNA, and proteins. In the study of molecular evolution óhaplogroupsô play an important role. A haplogroup consists of similar haplotypes, thus making it possible to predict a haplogroup from haplotypes. Y-chromosome and mitochondrial DNA haplogroups have different haplogroup designations. Haplogroups pertain to deep interesting features. Most prominent is, there is extensive sharing of oncestral origins dating back thousands of years.[1]

**Research and society:**

Lalji Singh, David Reich and their colleagues have documented high level population structure in India. They have shown that, todayôs Indian population is the model of mixture between two ancestral populations, named as ANI and ASI. ANI means óAncestral North Indiansô is genetically close to Middle Easterners, Central Asians and Europeans, and ASI, óAncestral South Indiansô, is as distinct from ANI and East Asians is. They analyzed some 25 diverse groups in India, to provide evidence for these two genetically divergent, ancient populations. Authors drew few more conclusions in addition to the above mentioned one. One is that Indian populations bear the genetic imprint of European, Asian and even African genomes. Secondly, they found that diversity is 3 to 4 times greater than that observed within Europe. Thus they concluded that many Indian populations were founded by small numbers of individuals with subsequent limited migrations. These events can be dated by genomic data between 750 years to 2,500 years ago. Each Indian population had random genetic drift. The drift has four implications. First, one can predict a high burden of genetically recessive disorders in India, many unique to each population, estimated to be greater. Second, some diseases will have elevated frequencies in many regions of India owing to shared ANI and ASI ancestry.

Further more, Deepa Edwin and P. Majumder studied DNA samples from 160 unrelated individuals belonging to five Dravidian tribal populations of southern India. They were analysed for ten mtDNA polymorphism. There is extensive sharing of mtDNA haplotypes among all the tribal populations studied, indicating that there was a small female founding populations in India. The wide spread history of founder events in India is also medically significant because it predicts a high rate of recessive disease. Haldane wrote decades ago that if inter caste marriages in India become common, recessive diseases will become rarer. However, it has been generally appreciated that this applies to groups throughout India.

Susanta Roychoudhary, P. Majumder and their colleagues studied mitochondrial profiles of 23 ethnic populations of India from diverse cultural, linguistic and geographical background. There is extensive sharing of small number of mtDNA haplotypes, among different populations. This indicates that Indian populations were founded by a small number of females. Ethnic differentiation took place subsequently thru a series of demographic expansions, geographic dispersal and social groupings.

The results of comparison of haplotype data across populations within India helps to trace out Indiaôs invisible threads. Research reveals fundamental unity of mtDNA lineages in India, in spite of extensive cultural and linguistic diversity.

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