

*Journey of Genomics Across Time*



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**Xcelris Labs Ltd.**

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## About us



*Xcelris Genomics is India's leading Genomics research organization and service provider offering cutting edge solutions to the bioscience industry and research institutions. With a solid reputation for quality data generation and bioinformatics as well as flexibility in customizing projects to meet the specific client needs, Xcelris has emerged as the ideal research partner for a continually expanding clientèle, across various scientific domains. Xcelris endeavors to offer a comprehensive range of services, to present our clients as a one-stop solution provider for all their research needs.*



# Genomics Journey

*One of the greatest scientific feats of our era is the astonishing progress made in understanding the intricate machinery of life. We are living in the most productive phase so far in this quest, as researchers delve ever deeper into the workings of living systems, turning their discoveries into new medical treatments, improved methods of growing food and innovative new products. Rapid progress in genomic science and a glimpse into it's potential applications have spurred observers to predict that Genomics will be the foremost science of the 21<sup>st</sup> century. The knowledge of DNA sequences of the genome of organisms has become inevitable for basic research. Next Generation Sequencing (NGS) technology has made a major impact in genomic sciences and pharmacogenomic research. Moreover, NGS technology has significantly reduced the cost and time for complete analysis of the whole genome. At Xcelris, we realize the power of this science and we have contributed our bit having completed more than 200 NGS Projects. This book summarizes selected projects, across various species in which Xcelris has provided NGS services. This book also encompasses the journey of biological science and all the major milestones that have opened new pathways for further research. It is a tribute to all the great scientists whose vision paved the way for Genomics to achieve what it is today.*



## Bamboo

*Bamboo belongs to Poaceae family. It is not a tree, but actually a fast growing grass. India has the second largest bamboo genetic resources in the world with over 136 species growing in the country. Bamboo was actually the first plant to re-green the environment after the atomic blast in Hiroshima. The genome sequence will help researchers to understand how the plant reacts to climatic factors, and also which species are related and therefore may share common characteristics, including flowering habits & adaptive traits such as resistance to drought and temperature stress.*

*Xcelris project on Whole Transcriptome Analysis of Bamboo aims to decipher the genes and pathways to improve salinity and drought tolerance in Bamboo and also to increase it's growth and biomass yield.*

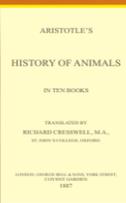
*Project Id: XLL\_NGS:WTA\_Bamboo*

## Rubber

*Rubber belongs to Euphorbiaceae family. The source of natural rubber is Hevea brasiliensis, a tree first found in the Amazon. Discovery of vulcanized rubber by Charles Goodyear was a happy accident and now it is used in everything from tyres, to shoes, to hockey pucks. Rubber gives us surgical gloves, balloons, band-aids, sporting goods, tennis shoes and chewing gum. Imagine a world without sneakers and bubble gum. Genomics studies will help to improve breeding by allowing marker assisted selection to assist in latex production, wood development, disease resistance and allergenicity in rubber.*

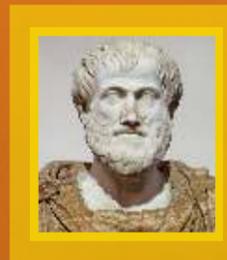
*Xcelris project on Whole Genome Sequencing of Rubber aims to decode one of the most complex plant genomes to assist in marker assisted clonal selection.*

*Project Id: XLL\_NGS:WGS\_Rubber*



### 327 BC: ARISTOTLE

*Regarded by many as the most intelligent man to ever walk on this planet, this genius was born in 384 BC in Northern Greece. Though Aristotle's work in zoology was not without errors, it was the grandest biological synthesis of the time. Aristotle's classification of animals grouped together animals with similar characters into genera and then distinguished the species within the genera.*



1600



### 1665: ROBERT HOOKE

*Born in 1635 at England, Robert Hooke was possibly the most famous biologist of all time. He was famous for his discovery of cells and the golden microscope. He wrote a very popular book, "Micrographia" in which he noted his observations. He discovered the law of elasticity, now known as Hooke's law. He also invented the conical pendulum and was the first person to build a Gregorian reflecting telescope.*





## Starfish

Starfish belongs to class Asteroidea. They consist of around 1,500 species across the world. It is not a Fish but an 'echinoderm', a type of marine animal that is spiny-skinned. It does not have gills, scales or fins. If a starfish is chopped into pieces, each piece can grow into a whole new starfish. They neither have brains nor blood in their body. The life span of starfish varies from 5 to 30 years. Some starfish have as many as 40 arms! They may serve as useful models for studying wound healing and regeneration in humans. Scientists are analyzing gene expression in the Gray Sand Star and Luidia foliolata, to identify genes involved in regeneration.

**Xcelris project on RNA Sequencing of Starfish resulted in identification of functions associated with genes in starfish thereby improving molecular understanding on starfish.**

**Xcelris Project Id: XLL\_NGS:RNA\_Starfish**

## Catla Fish

Catla Fish is a member of Cyprinidae family. Bhakur is the famous name of this fish in India. It is commonly found in rivers and freshwater lakes of North India and other parts of India like Indus Plain. It is a common and well-accepted food fish in India. It is typically a surface-dwelling fish, and needs warm waters in 18-28°C range. It resides in the upper feeding place of the pond with silver carp in the six species composite system with Rohu, Mrigal, Common carp, Grass carp and Silver carp. Genomic studies on Carp have added to our understanding of diversity and evolution of mitochondrial genome in fishes.

**Xcelris project on Whole Transcriptome Analysis of Catla Fish improved researchers understanding on molecular pathways and their association with genes in traditional Indian Carp.**

**Xcelris Project Id: XLL\_NGS:WTA\_Catla Fish**



### 1670: ANTON VAN LEEUWENHOEK



The Dutch scientist was one of the first microscopists in history. His research on discovery of protozoa & the first-ever description of red blood cells gave us a window to the invisible world of biology. He never received any formal education but learned to grind lenses. The Royal Society elected him a fellow although he never found the time to visit London to sign the register. The microscopes he created with the appropriate lighting, allowed him to magnify objects up to 275 times!



1700



### 1735: CAROLUS LINNAEUS

Carolus Linnaeus was a Swedish botanist, naturalist, physician and zoologist. He was the first person to lay down the principles to determine the natural genera and species of organisms and to form a uniform system for naming them (also known as binomial nomenclature). Linnaeus is considered to be the founding father of modern Taxonomy as well as ecology. Carolus Linnaeus put out his work "Systema Naturae" in 1735, the first edition of which explains about classification of living things.

1800



## Rice

Rice is also known as "Food from the Gods" across many countries of the world. It has been feeding mankind for more than 5,000 years and helps feed over half of the global population. There are more than 40,000 different varieties of rice of which only 10% are marketed and sold. Fully cooked rice swells to three times its original weight. India is famous for its Basmati variety of rice. The wealth of SNP and SSR information will accelerate marker-assisted breeding, positive cloning and facilitate advances in Rice improvement.

*Xcelris project on Identification of Novel Transcripts of Rice will help in identifying cellular mechanisms and differential gene expression in various Rice varieties, under biotic and abiotic stresses.*  
Project Id: XLL\_NGS:NT\_Rice

## Jute

Jute is known as the golden fibre and is an important foreign exchange earner for India. Tossa jute, world's top producer is a variety thought to be native to India. One hectare of jute plants can absorb up to 15 tons of carbon dioxide and release 11 tons of oxygen. After the jute cultivation, remnants and waste of jute mix with the soil, which acts as manure and improves fertility of the soil. The gene sequencing of jute would help improve the fibre length and quality, including colours and strength, develop high yielding, saline and pest-tolerant jute varieties through genetic studies.

*Xcelris project on RNA Sequencing of Jute resulted in giving us information on the function of each gene along with a comparative analysis with different species.*  
Xcelris Project Id: XLL\_NGS:RNA\_Jute

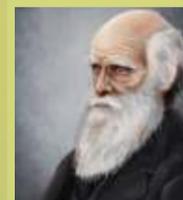


1800



### 1839: SCHWANN & SCHLEIDEN

Schwann, a German physiologist and Schleiden, a German botanist proposed Cell theory. It stated that all living things or organisms are made of cells and their products. Cells are the basic building units of life. New cells are created by old cells dividing into two. Schwann also discovered Pepsin enzyme & coined the term "Metabolism". Scheilden's great abilities earned him the title of "Reformer of Scientific Botany".



### 1859: CHARLES DARWIN

When it comes to the topic of evolution, one of the most well known researchers mentioned is certainly Charles Darwin. His 1859 opus, "On the Origin of Species," revolutionized biology by explaining how life evolves and diversifies, and it remains as relevant today as ever. For Darwin's 25<sup>th</sup> birthday on February 12, 1834, Captain FitzRoy named a mountain after him, Mount Darwin. It is the highest peak in Tierra del Fuego, an archipelago off the southernmost tip of the South American mainland.

1860



## Castor

*Castor is a member of family Euphorbiaceae. The seed of Castor plant contains valuable purgatives of castor oil. Besides being used medicinally, the oil is also employed for lubricating purposes, burning and for leather dressing. One of the main toxic proteins in castor seeds is Ricin, a potent cytotoxin but a weak hemagglutinin. Poisoning by ingestion of the castor bean is due to Ricin. Ricin toxin is so potent that just one milligram of Ricin can kill an adult! Castor oil is one of the oldest commercial products and was used in lamps by the Egyptians more than 4,000 years ago. Deeper understanding of the castor bean will allow improvements in Castor oil production without the problem of Ricin, by genetic improvements in Castor.*

*Xcelris project on SNP Discovery in Castor will result in crop improvement in Castor by knowing the underlying genetic mechanisms.*

*Xcelris Project Id: XLL\_NGS:SNP\_Castor*



## Pigeonpea

*The Pigeonpea plant is a legume belonging to the family "Fabaceae" or "Leguminosae". It is a perennial plant used extensively as a livestock feed and for manufacturing pulses. The peas themselves are both edible and high in protein, which makes them good food source and the plant's root are known to capture atmospheric nitrogen and fix it in soils, thereby increasing the fertility of soil. The reference genome sequence will facilitate the identification of genetic bases of agronomically important traits and accelerate the development of varieties that would improve food security.*

*Xcelris project on Whole Genome Sequencing of Pigeonpea resulted in complete genome sequence of the traditional Indian plant along with all it's genes.*

*Xcelris Project Id: XLL\_NGS:WGS\_Pigeonpea*



1860

### 1865: GREGOR MENDEL

*Gregor Mendel, an Austrian monk spent his time crossing pea plants and discovered the basic principles of heredity through experiments in his garden. Mendel's discoveries earned him the title of "Father of Genetics". What makes Mendel's contributions so impressive is that he described the basic patterns of inheritance before the mechanism for inheritance (namely genes) was even discovered!!*



### 1869: FRIEDRICH MIESCHER

*Friedrich Miescher was a distinguished scientist from Switzerland. He was an excellent student despite his shyness and a hearing handicap. He was the first to isolate and chemically characterize DNA, from nuclei of leukocytes found in pus from bandages. He was a visionary and in 1869 he proposed that "nuclein" might be the basis of heredity. The kitchen of the castle in Tübingen(Germany) was one of the first biochemistry labs in the world where Miescher discovered 'nuclein'.*

1900



## Strawberry

Strawberries are a member of Rose family. In India, Panchgani-Mahabaleshwar region accounts for about 85% of the country's strawberries. During the months from November to March, the fruits are available in almost every major city. They are one of the first fruits to ripen in spring. They are only fruit with seeds on outside. There is a museum in Belgium for strawberries called "Musee de la Fraise". Development in genomics is expected to unlock possibilities for breeding tastier, harder varieties of the berry. They were one of the smallest plant genomes to be sequenced.

*Xcelris project on RNA Sequencing of Strawberry resulted in understanding the functional role of each of the genes in strawberry production and disease management.*

*Xcelris Project Id: XLL\_NGS:RNA\_Strawberry*



## Tomato

Tomato is botanically a fruit and not a vegetable. They are the richest source of lycopene, currently the most powerful antioxidant thought to play a role in preventing cancer and heart disease. Scientifically, the tomato genome was sequenced from the "Heinz 1706". The genome sequence provides the gene responsible for taste, pest resistance, along with insights into fleshy fruit evolution. Knowing the genome sequence of one variety of tomato will make it easier to sequence other varieties for research and development.

*Xcelris project on SNP Genotyping of Tomato resulted in better understanding of the genetic structure of tomato thereby giving researchers knowledge of genomic variation in plants.*

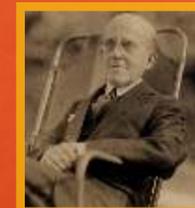
*Xcelris Project Id: XLL\_NGS:SNP\_Tomato*



1900

### 1928: ALEXANDER FLEMING

No scientific story illustrates the power of luck coupled with ingenuity quite like the discovery of penicillin. Fleming carried out an experiment on various bacterial cultures. After some time, he observed that some of the dishes were contaminated with a fungus, which ruined his experiment. He was about to discard the dishes, when he noticed that in one dish, the bacteria failed to grow in an area around the fungus. He successfully isolated the fungus and established that it was from the *Penicillium* group or genus. He won the Nobel Prize for Medicine in 1945 for his discovery of penicillin.



### 1952: ERWIN CHARGAFF

Erwin Chargaff, an Austrian Biochemist was one of a handful of scientists who expanded on Levene's work by uncovering additional details of the structure of DNA, thus further paving the way for Watson and Crick. He proposed that the total amount of purines (A+G) and the total amount of pyrimidines (C+T) are usually nearly equal. This major conclusion is known as "Chargaff's rule". Chargaff's research was vital to the later work of Watson and Crick paving the way for double helix DNA.



## Banana

Annually over 100 million tonnes of bananas are produced making them the world's most popular fruit. They are the first non-grassy plant in monocotyledons, whose entire genome has been sequenced. They have an amino acid, tryptophan which helps our bodies to produce serotonin, a natural substance with calming effect on the brain. The largest ever bunch of bananas grown in Canary Islands weighed 130kg and contained 473 bananas. Decoded genome would help to develop more disease resistant varieties of fruit that require less chemicals to grow.

*Xcelris project on RNA Sequencing of Banana resulted in genomic information which will be helpful in further crop improvement in Banana owing to better yield and stress tolerance mechanisms.*

*Xcelris Project Id: XLL\_NGS:RNA\_Banana*

## Mango

Mango is known as the 'King of Fruits' throughout the world. India is the world's largest producer of mangoes accounting for nearly half of the world's production. English word "Mango" originated from the Tamil word 'Mangkay'. There are around 400 varieties of Mangoes all over the world. Mangoes have been in cultivation for over 4,000 years. The International Mango Festival is held annually in Delhi. Genomic studies have helped to develop mango hybrids which promise a three-four times higher yield than the existing varieties, higher pulp content and longer shelf life.

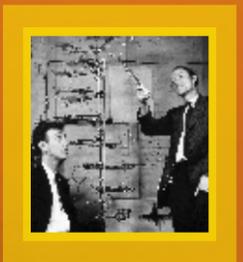
*Xcelris project on RNA Sequencing of Mango resulted in genetic information which will be useful in crop improvement along with genetic breeding of Mango.*

*Xcelris Project Id: XLL\_NGS:RNA\_Mango*



### 1952: ROSALIND FRANKLIN

Rosalind Franklin was distinguished by extreme clarity and perfection in everything she undertook. One of her photographs provided key insights into the DNA structure which formed a base for other scientists to use it as the basis for their DNA model. The rules of the Nobel Prize forbid posthumous nominations and as Rosalind Franklin had died in 1958 she was not eligible for nomination of the Nobel Prize subsequently awarded to Crick, Watson, and Wilkins.



### 1952: CRICK AND WATSON

Crick and Watson, together with Maurice Wilkins, won Nobel Prize in Medicine for their discovery of the structure of DNA. This was one of the most significant scientific discoveries of the 20<sup>th</sup> century. In April 1953, they published the news of their discovery, a molecular structure of DNA based on all its known features - the double helix. Their model served to explain how DNA replicates and how hereditary information is coded on it. This set the stage for the rapid advances in molecular biology that continues till date.



## Fenugreek

*Fenugreek (Methi) is one of the oldest cultivated crop plants. From ancient times through the late 19<sup>th</sup> century, fenugreek played a major role in herbal healing. Now things are once again looking up for the herb, whose taste is an odd combination of bitter celery and maple syrup. Modern scientific research has found that it can help reduce cholesterol levels and control diabetes. The ancient Egyptians regarded this aromatic seed as a tonic and used it as an ingredient for flour and as a spice. The knowledge of their genetic relationships has contributed in designing intraspecific crosses between different cultivars of fenugreek.*

*Xcelris project on Whole Transcriptome Analysis of Fenugreek resulted in identification of genes pertaining to specific secondary metabolites.*

*Xcelris Project Id: XLL\_NGS:WTA\_Fenugreek*

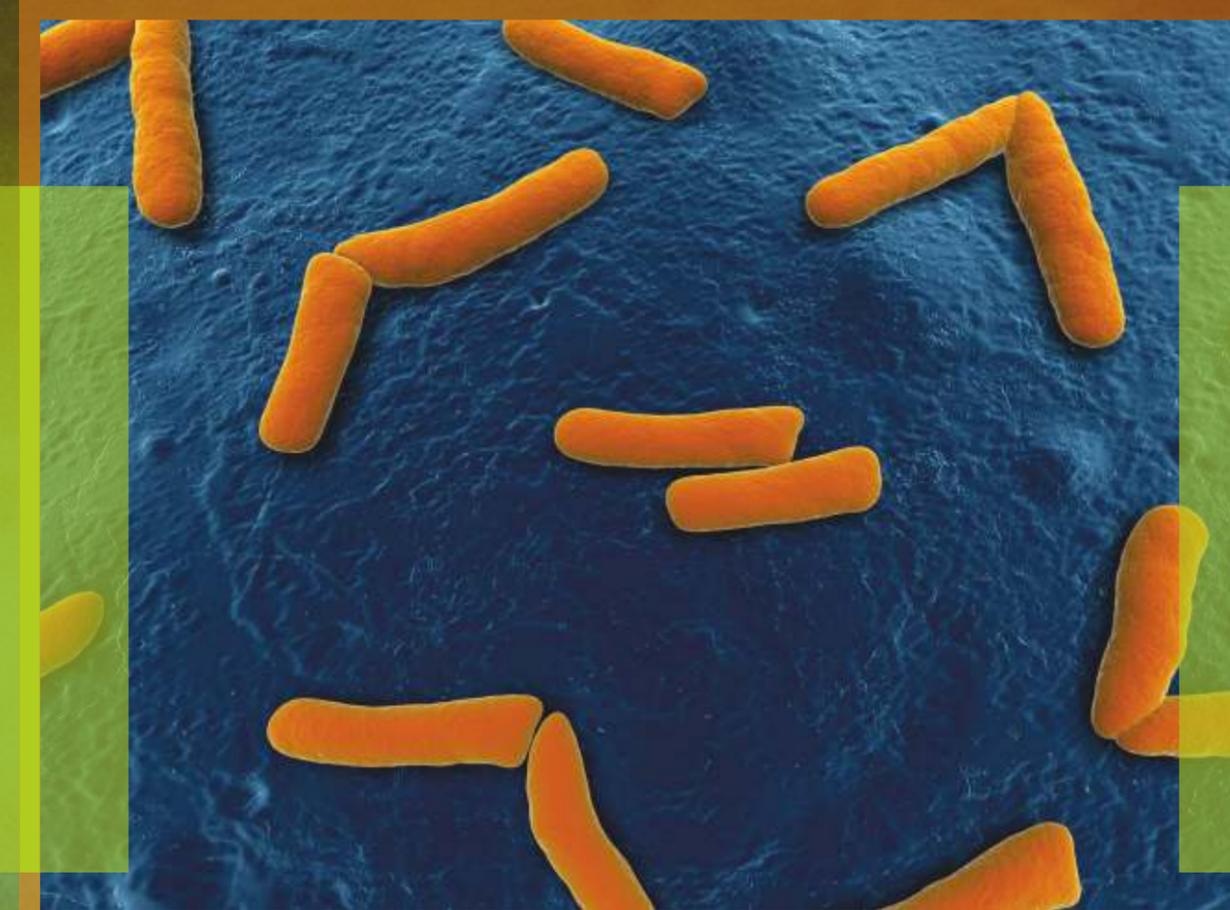


## Arthrobacter

*A ubiquitous bacteria present in genus of soil which are Gram-positive, obligate aerobes. They derive their name from Greek, which means "jointed small stick". They can metabolize a variety of very nasty chemicals. They not only grow in the presence of hexavalent chromium, but can also reduce it to trivalent chromium, which is 100 times less toxic. It can also degrade agricultural pesticides in conjunction with several strains of Streptomyces. Arthrobacter genome provides insight into the molecular basis of versatility and robustness of the strain.*

*Xcelris project on RNA Sequencing of Arthrobacter gave insight into functional characters of various genes, thereby opening new horizons for future research.*

*Xcelris Project Id: XLL\_NGS:RNA\_Arthrobacter*



1960

### 1966: MARSHALL WARREN NIRENBERG

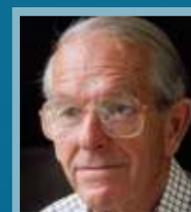
*Marshall Warren Nirenberg is best known for deciphering the portion of DNA (deoxyribonucleic acid) that is responsible for the synthesis of the numerous protein molecules which form the basis of living cells. Nirenberg's research has helped to unravel the DNA genetic code, aiding in the determination of which genes code for certain hereditary traits. For his contribution to the sciences of genetics and cell biochemistry, Nirenberg was awarded the 1968 Nobel Prize in Physiology or Medicine with Robert W. Holley and Har Gobind Khorana.*



1980

### 1975: FREDERICK SANGER

*Frederick Sanger, an English biochemist is considered to be one of the greatest and most influential biochemists in history. He received the Nobel Prize for Chemistry in 1958 for the discovery of structure of insulin. During his time, no methods existed to read the genetic code, even for the simplest of genomes. Fred and his team developed methods to allow scientists to sequence DNA. This led to the 'Sanger' DNA sequencing method, which allowed up to 500-800 bases to be read at a time. His work was rewarded in 1980 when he received his second Nobel Prize. This put Fred in a select club of people who have been awarded two Nobel Prizes in their life.*





## Kerria Lacca

*Kerria lacca* is an insect of superfamily Coccoidea which secretes Lac, a scarlet resinous secretion. On an average three hundred thousand insects produce 1 kg of lac resin. In India two strains of lac insect occur, namely, the Rangini and the Kusmi. Lac is a natural resin of great international utility. India exports about 80% of its total lac production to other countries, thereby, earning foreign exchange of an average of 85 crore rupees per year. Genomic studies have helped to enhance lac production at least by 15% of sustained lac production.

*Xcelris project on RNA Sequencing on Kerria lacca resulted in identification of genes responsible for lac production.*

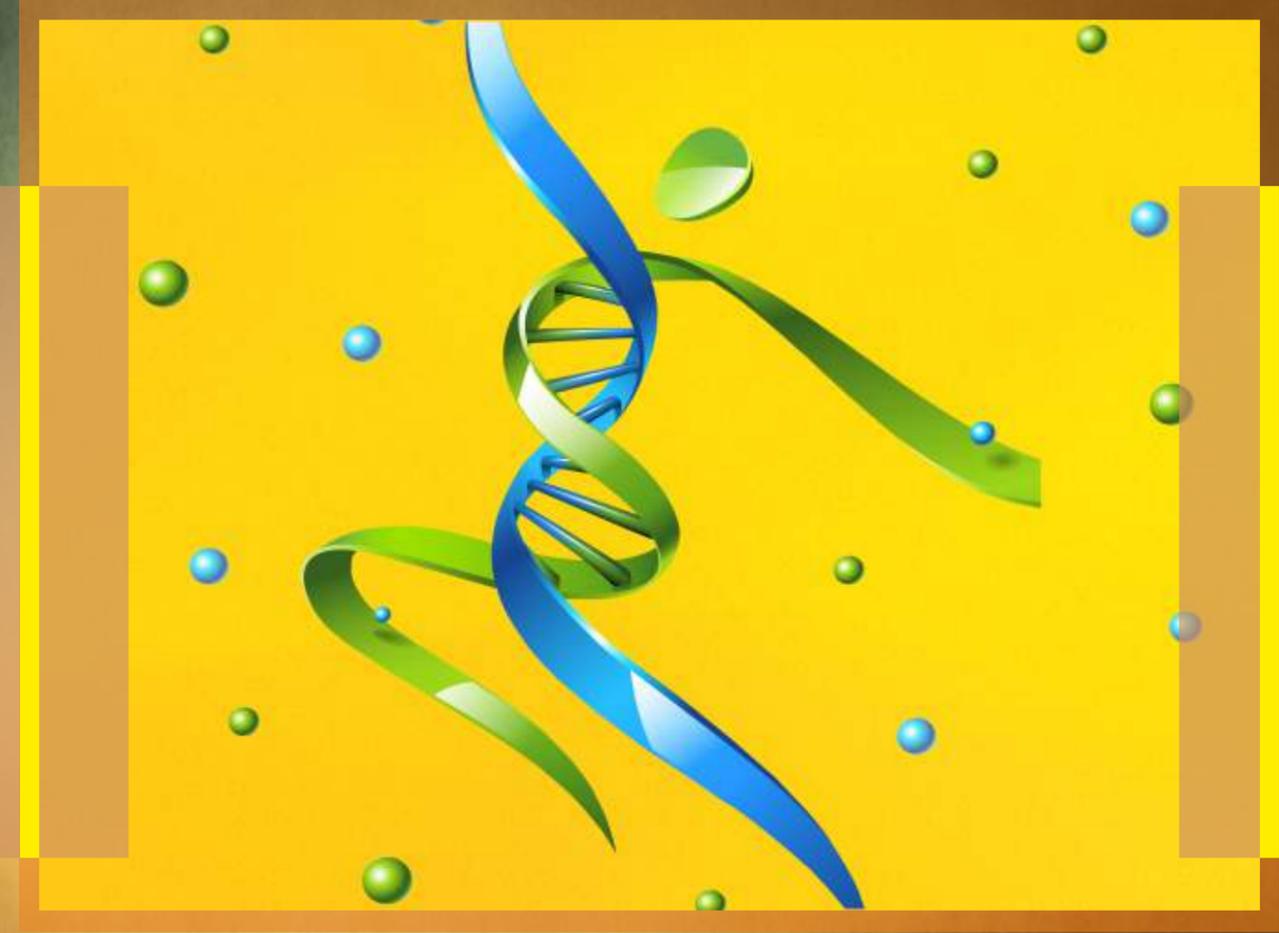
*Xcelris Project Id: XLL\_NGS:RNA\_Kerria lacca*

## Humans

*Humans are the most evolved species on earth. Two individuals share as much as 99.9% of the same genetic material and differ in only 0.1% of it. Genetic proof indicates that Sans, belonging to Southern Africa are one of oldest peoples in the world. They may well be the most ancient, and are considered to be a "genetic Adam". If you unwrap the entire DNA you have in all your cells, you could reach the moon 6000 times! Genome project improved researchers understanding on detection of genetic predispositions to disease, rational drug design, gene therapy and "custom drugs".*

*Xcelris project on SNP Discovery in Human samples resulted in knowing the common type of genetic variations and their etiology of many human diseases.*

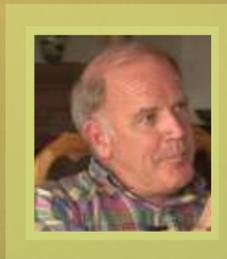
*Xcelris Project Id: XLL\_NGS:SNP\_Human Sample*



1980

### 1985: KARY MULLIS

*Kary Mullis conceived the concept of PCR technology and revolutionized molecular biology. He developed the Polymerase Chain Reaction, an elegant way to make copies of a DNA strand using the enzyme polymerase and some basic DNA "building blocks". PCR uses a thermostable DNA polymerase to amplify any given DNA segment billions of times in a few hours. Taq polymerase used in PCR was chosen as the "Molecule of the Year", by the Journal Science in 1989. Mullis was awarded "Nobel Prize in Chemistry" in 1993 for his invention and he went on to become a best-selling novelist for his book, "Dancing Naked in the Mind Field".*



### 1988: THE HUMAN GENOME PROJECT

*The Human Genome Project's goal was to provide researchers with powerful tools to understand the genetic factors in human disease. All data generated by the Human Genome Project were made freely and rapidly available on the Internet. It led to the discovery of more than 1,800 disease genes. The human genome is made up of 3 billion bases of DNA, split into 23 chromosomes. It is so big that it would take a century to recite, if we recited at one letter per second for 24 hours a day!!*

1990



## Goat

Goats were the first animals to be domesticated by man in 10,000 B.C. The goat's eye is rectangular with horizontal slits, giving them up to 340° of vision without moving. Goat's milk has an alkaline pH, so it does not produce acid in the blood or in the intestinal system. Goat genome proved useful to distinguish ruminants from non ruminant species. Genome sequence information will accelerate research on genetic regions and gene influencing phenotypes in goat. This information combined with information from other ruminant genome sequences, will serve as backbone in genetic research on ruminant species.

**Xcelris project on SNP Discovery in Goat resulted in identification of several important genes responsible for various economically important traits in Goats.**

**Xcelris Project Id: XLL\_NGS:SNP\_Goat**

## HF-Cattle

There are about 920 different breeds of cows in the world. They were domesticated about 5,000 years ago. The Holstein breed is well known for its ability to produce milk in large quantity. A Holstein's spots are like a fingerprint. No two cows have exactly the same pattern of black spots on their white body. India has the world's largest cattle herd. In 2009, genome of a female Hereford cow (*bos taurus*) was published. It is one of the largest genomes ever sequenced. The genome sequence will have a profound influence on livestock research and will lead to increased productivity, increased efficiency and smaller environmental footprint.

**Xcelris HF-Cattle Genome program aims to sequence Indian HF-cross breed to identify the variation and its association with milk and fat production along with other economically important traits.**

**Xcelris Project Id: XLL\_NGS:HF-Cattle**



1990

### 1996: DOLLY THE SHEEP

Dolly was the world's first mammal to be cloned from an adult cell. Considered as one of the most significant scientific breakthroughs ever, Dolly was named after singer Dolly Parton. Dolly demonstrated that it is possible to take a differentiated cell and essentially turn its clock back; to reactivate all its silent genes and make the cell behave as though it was a recently fertilised egg. She was cloned at the Roslin Institute, Scotland, where she lived until her death when she was six years. The sheep was originally code-named "6LL3".



### 2000: DROSOPHILA GENOME DECODED

*Drosophila melanogaster*, has been the workhorse in laboratories for the past 90 years. In 2000, a consortium of scientists released a substantially complete fruit fly genome sequence, obtained using several different but complementary sequencing strategies. The full *Drosophila* sequence allows researchers to look at multiple genes simultaneously to understand the complex signal transduction pathways that regulate cellular processes. If a *Drosophila* homology of an important but poorly understood mammalian gene is known, the arsenal of genetic techniques used in the *Drosophila* system can be applied to its characterization also.



## Bitter gourd

*Bitter gourd is known for its nasty bitter taste but despite it, they have been used in different traditional medicine practices for a very long time. They can help in many different ailments and can protect the human body from different parasites and diseases that are known to be fatal. Bitter gourd contains plant insulin, a hypoglycemic compound which is very effective in lowering blood sugar levels. They are known to increase the glucose intolerance in people suffering from diabetes mellitus. Genomic studies further aim to screen germplasm and select best varieties, high in anti-diabetic compounds along with horticulture traits.*

*Xcelris project on RNA Sequencing of Bitter gourd resulted in functional annotations of genes i.e the characterization and classification of sequences, mainly for protein synthesis*

*Xcelris Project Id: XLL\_NGS:RNA\_Bitter gourd*



## Bougainvillea

*Bougainvillea is a spectacular climber of Nyctaginaceae family. They derive their name from Louis Antoine de Bougainville, a French explorer. There are about more than 300 varieties of Bougainvillea. An interesting fact about them is that their flowers aren't flowers at all! The bright pink petals, which are confused as flowers are actually 'bracts' (a leaflike structure located below the flower). Bougainvilleas is the official flower of countries like Grenada, Guam and cities like Ipoh in Malaysia. Genomic studies have revealed the phylogenetic relationship between different cultivars of Bougainvillea.*

*Xcelris project on genome wide SSR Discovery in Bougainvillea resulted in molecular markers will be useful for detection in further studies.*

*Xcelris Project Id: XLL\_NGS:SSR\_Bougainvillea*



2000

### 2002: MOUSE GENOME DECODED

*International Mouse Genome Sequencing Consortium announced their publication of a high-quality draft sequence of the mouse genome. For the first time, scientists were able to compare the human genome sequences with those of another mammal. This milestone is significant because of the widespread use of the laboratory mouse as an animal model for studying human disease. Among other informative discoveries, researchers reported that more than 90 percent of the mouse genome could be aligned with corresponding regions of the human genome, and each of the two genomes seemed to contain close to 30,000 protein-coding genes.*



### 2007-2012: 1000 GENOME PROJECT

*The 1000 Genome Project is an international collaboration to produce an extensive public catalog of human genetic variation, including SNPs and structural variants and their haplotype contexts. It aims to use the knowledge of human genome sequence variation and study its relation between genotype and phenotype. The first study to break the '1000 genomes barrier' will enable scientists to begin to examine genetic variations at the scale of the populations of individual countries, as well as guiding them in their search for the rare genetic variations related to many diseases. This resource will support genome-wide association studies and other medical research studies.*

2013