Genomics for clinicians

DNA sequencing technology has transformed genomic research globally

BY DR RAM PRASAD

1. The science of genomes is dedicated to the determination of DNA sequences.

Genomics refers to the study of the genome, which is the complete set of DNA, the blueprint of an organism and includes all its genes. Nucleotide bases, A, C, G and T, in a specific order make up the DNA sequence of an organism. Human genomes include both, protein-coding DNA genes and non-coding DNA. Every piece of genomic information sets the pace for detailed studies of the genome.

Next Generation Sequencing (NGS) is a DNA sequencing technology which has transformed genomic research globally. This potent technology helps in sequencing an entire human genome within a matter of 24 hours. The human genome is made up of more than 3 billion genetic letters and hence sequencing the genome is a pre-requisite to understanding it. However, hi-tech machines are required for all large scale ambitious projects of sequencing genomes. Though a genome sequence helps scientists find genes effortlessly and speedily, scientists are still learning how to recognise, interpret and analyse these clues.

Scientists have progressed from the analysis of a single gene to the investigation of thousands of genes. The science of genomes is dedicated to the determination of DNA sequences. Genes are the building blocks of heredity. They are passed from parent to child. Sometimes there is a nucleotide base change, mutation, in the gene or genes. This mutation in the gene can cause a medical condition called genetic disorder.

Some complex genetic disorders:

Down syndrome or Trisomy 21 is a chromosomal disorder caused because of an error in cell division resulting in an extra copy or a part of the copy of chromosome 21. It is one of the most commonly occurring chromosomal disorders in newborns, which

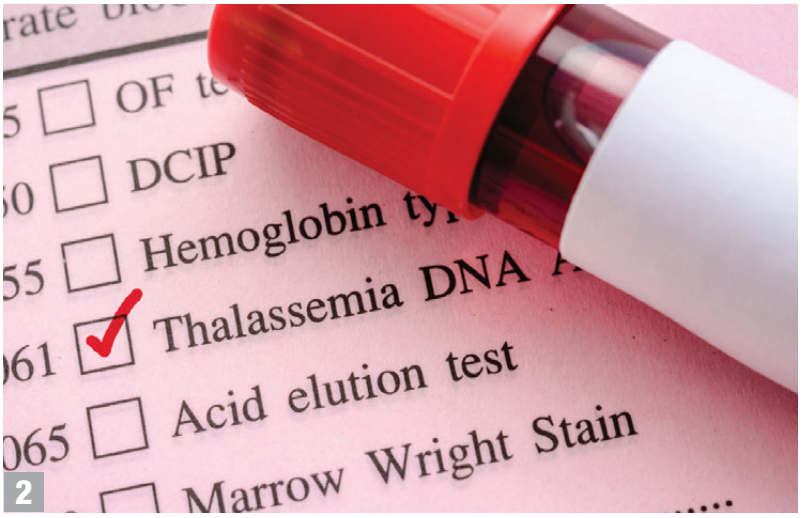
leads to intellectual and developmental disabilities and other medical conditions.

Thalassemia is a genetic disorder caused by deletions in the HBA1, HBA2 and mutations in the HBB genes and results in reduced haemoglobin production, impairing oxygen transport to the body tissues. This makes a person exceedingly anaemic, resulting in pale skin, lethargy, and a host of other serious complications. There are two types of Thalassemia viz; Alpha Thalassemia and Beta Thalassemia, the latter being of a more serious nature and also referred to as Cooley's Anaemia.

Sickle Cell Anaemia is an inherited disease which affects the red disc-shaped red blood cells. Once affected these cells take on an abnormal shape - that of a sickle / crescent which split with ease resulting in anaemic conditions. Their shape hinders their movement through small blood vessels. As a result, they get stuck in the small blood vessels and prevent the flow of blood from reaching the different parts of the body.

The life span of these cells varies between 10-20 days which is a huge departure from the normal lifespan of 120 days. This state of a limited life span causes the person immense pain and results in permanent harm to vital organs.

Cystic fibrosis: This is a transmitted genetic disorder hereditary by nature and is caused in a single gene on Chromosome 7. The CFTR gene contains building information for cystic fibrosis transmembrane conductance regulator (CFTR) protein but mutation hinders the same, affecting the sodium channels in the body, causes unrelenting respiratory problems like lung infections and, over a period of time, weakening a person's ability to breathe. Cystic fibrosis occurs in both, males and females. Chronic lung infections, digestive and reproductive issues and breathing problems are its most common symptoms. An incurable disease, its progression can be slowed down with timely treatment.

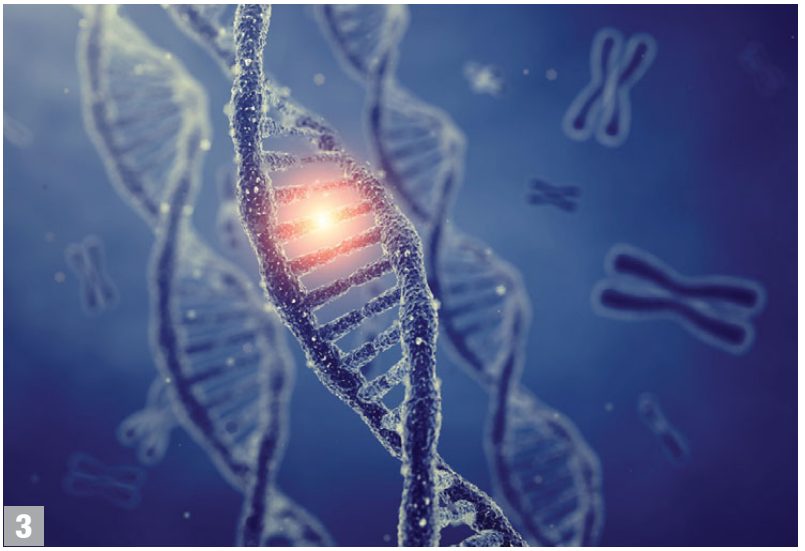


Tay-Sachs is a rare genetic disorder which affects the nervous system. Though its progress cannot be hindered, genetic testing conducted in a child, while he/she still in a mother's womb, helps understand whether the child is affected or not. Tay-Sachs can be diagnosed in the early stages of pregnancy either through amniocentesis or through blood tests.

Precision medicine focuses on understanding individual variability in disease prevention, care, and treatment. Precision medicine education helps people by providing the public with summaries of genetic conditions and their associated genes. Former President of the USA, Barack Obama, initiated precision medicine on the premise that it offered immense potential for improvisation of health. Genetic testing helps the doctor to decide upon your treatment and take appropriate precautions. This testing also helps in pre-natal testing. This also helps in educating the patient and his/her family to make an informed choice. At the same time, it can help scientists create cures and medicines.

With new technology, clinicians can now examine the whole of a person's DNA. This is done in a speedier and inexpensive technique compared to the old days. Based on the study, the clinician can choose the best treatment depending on the situation.

2. Thalassemia is a genetic disorder, caused by deletions in the HBA1, HBA2 and mutations in the HBB genes.



3. Genome sequencing and various other constituents of genomics are being utilised in medical treatment.

Application of genomics in medicine

Genomic medicine has become a much acknowledged aspect of medical treatment in patients with genetic defects and chronic/complex diseases. While most of genomic medicine constituents are still being researched upon, a few are being applied in medical world to make a difference to patients. Next generation sequencing is a breakthrough technology being utilised in cancer pharmacogenomics, the treatment of rare diseases and the diagnosis of rare disorders. It is also effective in identifying the outbreak of infectious diseases. This will aid medical researchers to further effect the manner in which they foresee and make diagnoses. Many different solutions are being sought from the application of genomics in medicine. However, there still persist a few challenges like establishing awareness and promoting the same to clinicians, educating individuals and also dealing with the ethical aspects.

Education for clinicians

Genome sequencing and various other constituents of genomics are being utilised in medical treatment but there are many clinicians who are still living in the dark. With the increasing number of chronic as well as genetic defects and diseases, clinicians need to be aware of genomics, from the basics to ongoing research and latest developments. They need to be given in-depth and intensive training and given numerous opportunities to practice their acquired skills. Genomics should become an integral part of daily practice of disease management and caregiving to the extent that clinicians and patients better understand the intricacies of their medical situation and effectively utilise the genomic information.

The benefits of genomics

The benefits of sequencing could be humongous but genomics is likely to benefit the world of medicine in a large way. Genome sequencing may reveal details to the causes and solutions on diseases which have baffled the medical world today. As a result, patients will be able to better understand the risks involved with the diseases. Addition of genetic testing to standard medical tests and specified prescription and advising a genetic risk compatible regimen could lead to improvised health of the patients. Precision medicine will be the norm of the day, leading to specific and speedy treatment. It will also save time and unnecessary tests and medication associated with only symptom-based diagnosis and genetic ignorance.

Genomics could help identify genetic traits/defects in the embryonic stage, thus alerting both the prospective parents and the doctors about what preventive measures and precautions need to be taken. The benefits could be numerous and the right methodology could revolutionise the world of medicine, offering numerous benefits to us at large. HR

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