MEDGENOME

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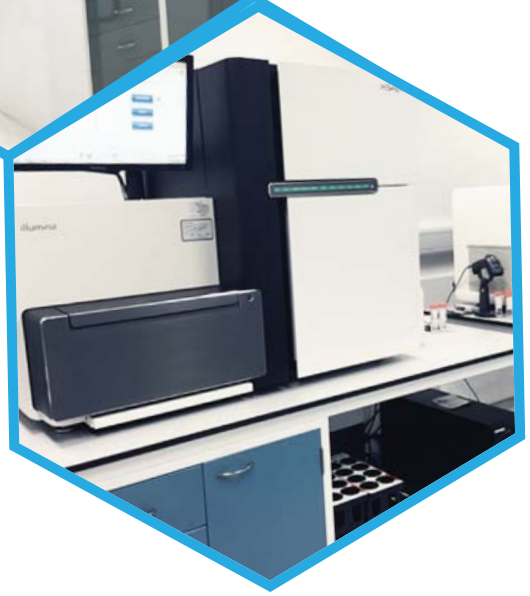
Internal Quarterly Newsletter



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Management speaks

Rohit Gupta
Chief Information Officer

Dear Colleagues,

Greetings and wishing you all a very Happy New Year 2018!

First let me take this opportunity to congratulate everyone on our last year's performance. We are now a CAP accredited lab in Bangalore with many tests under one roof. Several new diagnostic tests such as liquid biopsy, carrier screening were launched with end-to-end in-house developed methods. On the research and services side of the business, lab capabilities and capacity has been increased in both India and the US lab, disease-focused research programs have been accelerated with revamping of the Scientific Affairs Committee (SAC), new genomic tools specially in the area of cancer immunotherapy and clinical knowledgebases in Diabetes and Ophthalmology have been created, publications and patents have been filed.

With all this hard work and past achievements, I believe MedGenome is now at a tipping point and therefore 2018 will prove to be a very important year. We are committed to use genomics at a deeper level for both clinical diagnostics and research which is clearly reflected by investments in setting up disease - focused research centers across the country in collaborations with the leading institutions. While diagnostics business will continue to grow in India and few other countries with increase in awareness and adoption, the time is ripe for us to leverage all the past work and use rich clinical and genomics data collected from collaborating institutions to enable drug discovery and grow up the value chain. The advantages of using the data from Indian population to research complex diseases, find novel biomarkers, validate known drug targets, conduct drug repurposing studies, and provide support in running clinical trials, appears to be a good proposition for the company.

We are also strategically very suitably placed to make significant headway into developing Artificial Intelligence and Machine Learning techniques in-house for analyzing multi-modal clinical and genomics data. These advances can play a crucial role in solving bigger and more complex problems like prediction of complex diseases and associated complications at an early stage, role of genetics in response to drugs and predicting adverse events, identifying the disease sub-types, segmentation of patients based on their genetic profile for risks and clinical trials, etc. Our understanding in these areas will also help us to reach the consumer market directly which is one of the important segments that company would like to develop going forward.

Finally, we should realize that success comes with even bigger responsibility. Therefore, while celebrating our past achievements is gratifying and fulfilling, we need to be more focused now and strive for quality to make MedGenome a globally known company solving complex problems that improve peoples lives worldwide. Clearly, people are the pillars of any organization and with the kind of enthusiasm, skills and dedication we have as a team, I have no doubt that this will happen rather soon. Most importantly, let us have fun doing it!

Best wishes,
Rohit

Highlights

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MedGenome in news

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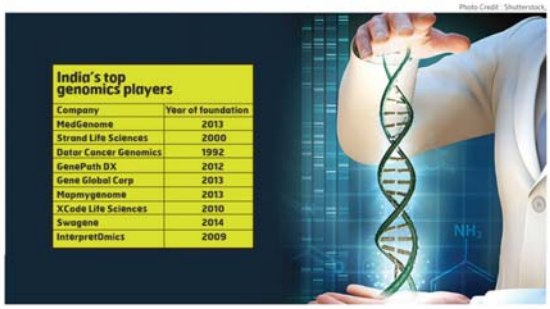
Genomics: Cracking The Code

Why only a handful of new-gen startups are venturing into the genomics research landscape in India



07 November, 2017 by C H Unnikrishnan

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Imagine this: what if you could predict your future illnesses and nip them in the bud or if you could prevent the possibility of becoming a cancer victim? Or what if, you could know how well you respond to a medicine before you decide to take it, or what if, you could save your baby from hereditary disorders for his/her entire life at the foetal stage?

This is not a script from any sci-fi movie. Genomics, the science that can define the health and heal of each individual in a precise way by closely looking at the genetic make-up or DNA, is forecasted to surpass $23 billion in market value by 2024 globally. However, India, the land of maximum genetic diversity, hasn't been able to achieve much in this field, at least not yet.

A 2017 report from a London-based genomic initiative confirms that genetic data from India accounts for just about 0.2 per cent of what has been collected till date. India, known as 'pharmacy of the world', with its pharma and biotech prowess, is yet to explore its vast genetic diversity to be part of an imminent healthcare revolution — the precision or personalised medicine.

Making Inroads

Surprisingly, only a handful of startups are taking the lead in this life science revolution in India. Genomics, the most promising area of bio-technology, is yet to get adequate industry backing, especially from the large and established pharma and biotech players. Even the government organisations have not shown efforts to provide the much needed boost to the sector, which is in complete contradiction with the trends in the West and even countries like China and Korea in Asia.

New generation companies, along with half a dozen diagnostics providers, have already started making waves in the Indian market. New generation companies such as Bangalore-based MedGenome Labs and Strand Life Sciences, and Mumbai's Datar Cancer Genetics and Pune's Genepath DX are into the fully integrated play ranging from genetic research to DNA sequencing and diagnostics solution development. The genetic research by the top players among these entities have also made significant progress in gene mapping with about 50,000 Indian samples.

Of course, the entry for the start-ups were not easy. The initial investment for setting up a good genomics lab will be in excess of $10 million, a tall order for startups, but not a barrier for large pharma or life sciences companies, say industry experts.

"It is indeed surprising that only a few companies are leveraging genomics in India. It is also sad that neither the Indian government nor the domestic pharma and biotech leaders are paying much attention to the potential of genomics," says Sam Santhosh, founder and Chairman of MedGenome.

Experts also stipulate the lack of interest due to a combination of factors such as absence of interdisciplinary skills and general aversion to risk taking among the large pharma and biotech companies.

"Genomics is not a pure biology or life sciences domain. Considerable software and bioinformatics skills are needed, which has been traditionally not available in the life sciences industry," reasons Santhosh.

"It would have been great if there are big names to back the initiatives like genetic studies, sampling, clinical trials, etc., to scale up the discovery process and market development in India," says Strand's CMD Vijay Chandru.

Collaborate and Grow

Low awareness among people and lesser initiatives at the government and organisational level to create an ecosystem are the initial challenges that kills the commercial interest among industry players.

"In the West, there is active collaboration among educational institutions, government and the industry, which ensures that scientific discoveries are translated quickly to benefit society and create wealth. In India most academic institutions do not collaborate with the industry and remain secluded in their glass towers," says Santhosh.

Many in the industry also believe that Indian pharma, which did a commendable job in the generic drug industry by focusing on manufacturing APIs and drugs of high quality at low price and capturing the global market, has become a victim of their own success. This success made the local pharma players wary of taking risk in new areas since the same investment would give them better short-term returns.

"Also, a lot of them had become public and the investment community would also give better rewards for quarterly progress," points out Santhosh.

A senior executive from a top biotech company, who did not want to be identified, agrees. "Taking new risks, that too in an area where fresh skills and investments needs to be created, is often a taboo under the quarterly appraisal system," he says

At The Tipping Point

The industry is currently at a point where the technology is available, costs are coming down and people awareness and medical community acceptance are increasing. Going by the current pace of growth, the $10 million worth market for genomics-driven diagnostics (cancer mapping, liquid biopsy, parental screening, etc.) in India would touch $100 million in the next two years. The targeted size of genomics-based diagnostics market in the country is to the tune of 3 lakh tests at present and each test costs about Rs 20,000 on an average.

The total venture capital investment in Indian genomics industry has been around $100 million and it is growing. Most of the companies have now started raising second round of funding from the same investors.

While, genetic sampling on Indian population is also expanding with several international research initiatives, including GenomeAsia 100K and London-based Three Nation (Britain, India, Singapore) initiative Beacon, among others, actively involved in India.

"The next few decades will belong to genomics and precision or personalised medicine and we expect India to be a significant part of this revolution," says Chandru.

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Last Published: Mon, Oct 09 2017. 11 09 PM IST

MedGenome to fund its own research on DNA sequencing, precision medicine

MedGenome aims to licence the findings to bio-technology firms and drug makers

Yuvraj Malik

New Delhi: Sequoia-backed MedGenome, a start-up that conducts genomics-driven research for large pharmaceutical companies, is planning to fund its own research in the area of DNA sequencing and precision medicine, with an aim to licence the findings to bio-technology firms and drug makers, a top executive said.

Launched in 2013, San Francisco- and Bengaluru-based MedGenome Labs Pvt. Ltd has a network of Next Generation Sequencing (NGS) laboratories in India, Singapore and the US.

Launched in 2013, San Francisco- and Bengaluru-based MedGenome Labs Pvt. Ltd has a network of Next Generation Sequencing (NGS) laboratories in India, Singapore and the US. In August, it raised $30 million from Sequoia and Brussels-based Sofina SA.

"Currently, a lot of it (research) is done on project basis, but we are also creating our own IP (intellectual property), so that in two-three years' time we can license some of the knowledge," said Sam Santhosh, founder and chairman, MedGenome. Its research is in four main areas: cancer immunotherapy, inherited diseases, diabetes and ophthalmology.

About 70% of the company's revenue is earned from project-based research mainly for US-based pharmaceutical clients, while the rest is from consumer diagnostic tests in Asia. Its labs combine state-of-the-art testing equipments and powerful computers to perform DNA sequencing that is used for a wide

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1 **Industry story on Genomics in Business World magazine**
http://businessworld.in/article/Genomics-Cracking-The-Code/07-11-2017-130796/

2 **MedGenome story on its research front in Mint**
http://www.livemint.com/Science/7hCGqR7b1pX92tJmdYPYUI/MedGenome-to-fund-its-own-research-on-DNA-sequencing-precis.html

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Pune-based Nalini Nivangune (seated, right) and her family say that genetic profiling has helped them to prepare for any eventuality

Tracing their fear

Mirror meets families who have been part of genetic tests for cancer to find stories of hope, anxiety and stigma

Lalitha.Sukasini@timesgroup.com
TWEETS @BangaloreMirror

Two years ago, Pune-based Nalini Nivangune, who is one of six sisters, was diagnosed with breast cancer. In 2002, the 62-year-old's younger sister, Alka Parulkar, succumbed to the disease at 46.

"My mother and father lived up to 80 and were able-bodied until the end," says Nivangune. "This was the first time someone in the family got cancer, and none of us knew anything about the disease then." two months after Nivangune's diagnosis, her younger sister Savita Sharma, 56, complained of severe stomach ache. One doctor dismissed it as fear psychosis as a result of her sister having been recently diagnosed with cancer. But an alert Sharma went to another physician who advised a sonography and scan that revealed that she too had cancer, of the ovary. The female members of the family are a classic case of the Hereditary Breast and Ovarian Cancer (HBOC) genetic condition.

"Tests should only be conducted in families that have a history of a particular disease. At the same time, emotional counselling is required to ensure that patients are able to cope with stark diagnoses
–Dr Shishir Shetty

Nivangune's family, including her sisters, son, nephews, nieces and eight-year-old granddaughter, have taken the Gemh Line Cancer Test, usually performed on a blood sample, to determine which of them were carriers of the mutated gene. Only two of her siblings have tested negative for carrying the mutated BRCA1 gene that causes cancer. Her son Nandan, 38, and sister Asha Kadu, 50, have both tested positive. This puts Nandan at the risk of male breast and prostate cancer and Kadu at the risk of breast and ovarian cancer, but the family that has lived with the disease says that there is no more fear, just a desperate need for more information. "No one knows how cancer can be cured unfortunately," says Nandan, who works in an electronic leasing and financing company in Pune.

But there is an important distinction to be made when it comes to cancer, says Dr Shona Nag, oncologist at Pune's Jehangir Hospital, who has been treating Nivangune. "Hereditary and genetic are not synonyms," says Dr Nag. What Nag means is that genetic mutation need not necessarily be hereditary. "Only 5-10 per cent of cancers are hereditary. Hereditary means when a is passed on from one generation to the next and at least one of the offspring is carrying that train and is passing it on to the next generation."

Sharma says that the bond between her family members has grown stronger ever since they were diagnosed. "Can you tell we have cancer?" she smiles. Her thinning scalp, a result of chemotherapy, is indeed the only giveaway. "If you have family support, nothing can be daunting." Her 29-year-old son, an IT professional, does not want to disclose the results of the test, or even his name for fear of being stigmatised at his workplace. His sister, who is based in Aurangabad, has tested positive. Kadu, who runs a provision store, also lives in fear of customers boycotting her store because cancer runs in the family. The gene has become an identity marker for the family. "There has been so much stigma that those who have been close to us have distanced themselves," says Nandan. "Some of them act as if cancer is contagious." His cousin, who wishes to remain anonymous, adds, "I don't want my actions to be judged in the office because someone in my family has cancer."

Nag says that the tests can help guide further treatments. "Preventive surgeries for breast or ovarian cancer

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can provide 95 per cent protection," she adds. Treatment, however, can be expensive. Sharma has spent close to eight-to-10 lakh on treatment and her older sister, Nivangune, who has undergone 18 rounds of chemotherapy besides mastectomy, has spent approximately 25 lakh, and is still being treated for cancer. Nandan says that the disease has made them put away money in a more systematic manner. "My wife is a nurse so she understands the situation. We are saving so that our two-year-old daughter's future is secured," he says, "It has also made us realise how important medical insurance is. It is why we could afford all of these expenses."

In a village called Godesu, some 100km from Bhavnagar in Gujarat, Anvarali Manjiyani is awaiting the results of a test that, he says, is extremely vital for the future of his children

Genetic testing, or an awareness of the insights that genetic material (chromosomes) can provide into our biological destinies, so to speak, has been around for long or than you think. In fact, inherited diseases were linked to chromosomes as far back as the early 1900s, and by the 1950s scientists had developed tests for Down syndrome, among others. Genetic testing is now available for more than 2,000 conditions, and the tests available include, among others, diagnostic testing, pre-natal testing and even pharmacogenomic testing, which focus on matching medicines with a person's genetic make-up. Hollywood actor Angelina Jolie's pre-emptive double mastectomy in 2013 acted as a catalyst, especially among women across the world, in furthering genetic diagnoses, and today, awareness about it has also percolated to smaller towns in the country.

Earlier this month, again in Pune, Ashok Gholap, 66, invited his extended family over to his home. His relatives came from across Maharashtra. Gholap told a newspaper that he wanted his relatives to undergo a Germ Line Cancer test that would help flag vulnerabilities. And, in a village called Godesu, some 100 km from Bhavnagar, Anvarali Manjiyani is awaiting the results of a test that, he says, is extremely vital for the future of his children. Two months ago, the cloth trader's wife, Yasmin, succumbed to breast cancer. Yasmin's sister, too, was afflicted with breast cancer – as well as ovarian cancer – but she survived, says Manjiyani. He is now waiting for the results of the genetic tests conducted on his wife when she was alive. These, he says, will determine whether he needs to get his three daughters tested.

"We got to know about the tests only after my wife fell ill," says Manjiyani. "We were advised that on the basis of Yasmindben's sex reports, doctors will suggest whether I should get my daughters tested or not.

Gadesu-based cloth trader Anvarali Manjiyani is getting his daughters tested after his wife Yasmin succumbed to cancer two months ago

Bengaluru-based MedGenome is a market leader in genomic diagnostics

Sheny's patient is convalescing at the moment, but she is also worried about her sons. "She has already lost her two elder sisters and a younger brother to colon cancer, and the chances of other younger members in the family too being affected with it is very high. So, the lady's extended family is now undergoing tests to determine whether they have the genetic condition," says Sheny. The woman's younger son has been diagnosed with the same gene, and has been advised by Sheny to get his large intestine removed. The son, who are 32 and 30, are wary of what the future holds for them. "I'm not sure if I want to go in for the surgery, but I'm periodically undergoing tests to rule out colon cancer," says the younger son. His elder brother would rather focus on his career at the moment. "I'm a bit unnerved by my brother's diagnosis, but at this moment, I have a career to think of," he told Mirror.

Over the years several private laboratories offering personalised individual DNA readings and genetic tests have come up in India. ACTREC, the R&D arm of the Tata Memorial Hospital, has been conducting genetic analysis of hereditary cancer since 2007, a project funded by the Indian Council of Medical Research. Yet others include Chennai-based XCODE, which offers predictive genetic tests for obesity, stroke, diabetes and cardiovascular diseases, Gurgaon-based Super Religare Laboratories and Hyderabad-based Map My Genome. But Dr Sheny says that while genetic testing is now more accessible, there are still concerns that need to be addressed. "First of all, tests should only be conducted in families that have a history of a particular disease, and more often than not, it is cancer. At the same time, emotional counselling is required to ensure that patients are able to cope with stark diagnoses." Other experts echo his concerns.

"We have discussed genetic testing with many families, but these pertain to only hereditary cancers, so we whether the family has a high risk or not. These cancers mostly include breast, ovarian, and gastro-intestinal," says Dr Prasad Narayanan, chief medical oncologist at Bengaluru-based Cytecare Hospitals, but one needs specific indications as to why one want to get tested, he clarifies. "When you have a first-degree relative who has either one of these cancers, or if there is a male patient who has breast cancer, it makes sense to get the test done to understand whether you have a high risk of passing on the disease genetically," he adds.

"When it comes to Germline Genetic Testing, it is necessary only if someone within the family – a blood relation has already been diagnosed with any of the cancers. However, what is more important is testing and analysing the patient's blood first. If it's a somatic or acquired disease, then there's almost no chance that the person will pass on the cancer to the family. However, if the germ line test reveals that the person's cancer was inherited (for example BRCA1 gene mutation for breast cancer), it is important for the family to get tested to see if they are carriers as well, or not," says Sam Santhosh, founder and chairman of MedGenome, a market leader for genomic diagnostics in South Asia and a leading provider of genomics research services globally. Santosh does not recommend recreational genetic testing. "Recreational genetic testing – called so because it's not necessarily recommended by a physician – is where a family goes in for an ad hoc genetic screening for diseases, and it is unlikely to be beneficial because we don't possess enough technology or data as yet to come to conclusions whether a person is genetically pre-disposed to complex diseases such as cancer."

With inputs from Lata Mishra, Alok Deshpande and Priyadarshini Nandy

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Telangana Today

Edition: Hyderabad

Virinchi Hospitals, MedGeome tie up

Y V PHANI RAJ
Hyderabad

Hyderabad-based Virinchi Hospitals, a subsidiary of IT company Virinchi has entered into a strategic collaboration with MedGenome, a genomics-based diagnostics and research company for molecular diagnostics.

As part of the collaboration, Virinchi will offer MedGenome's tests in the cardiology, ophthalmology, oncology, neurology, nephrology, diabetes, dermatology and haematology besides other conditions. It will also include non-invasive prenatal tests, which will define genetic health.

MedGenome offers over 400 genetic tests across disease areas. It is connected to 500 hospitals for diagnostics and has established more than 50 research collaborations. Virinchi is a 600-bed tertiary healthcare provider.

Dr Chirantan Bose, V-P, Clinical Services, MedGenome, said, "We are looking forward to this partnership for bringing affordable and high quality genetic testing to the patients of Virinchi hospitals.

MedGenome is helping in reduce the costs of previously expensive genetic tests, and empowering clinicians with actionable insights to provide better outcomes for their patients."

He told *Telangana Today*, "Virinchi wants to use molecular genomics as part of its overall treatment protocol. From early stage, patients will be able to take advantage of the tests available. We want to create a molecular genomics clinical lab which will significantly improve the patient interface. While on one hand the prognosis and treatment can be specific and accurate, on the other hand it brings down the overall treatment cost using advanced technologies. We are a reference lab with clinical expertise in genomics and our collaboration with Virinchi will be continual."

JOINING HANDS: *Virinchi Hospitals medical director Dr Murty Nekkanti (centre) and MedGenome V-P Dr Chirantan Bose (right) announcing the partnership in Hyderabad.*

Commenting on the partnership, Dr Murty Nekkanti, medical director, Virinchi Hospitals, said, "The aim of this collaboration is to help the clinician with molecular information for accurate as well as precise diagnosis, prognosis and management of multitude of diseases that have genetic basis."

"And, genetic testing has gradually been gaining prominence and significance in terms in effectively diagnosing and managing many rare to common diseases such as Spinal muscular atrophy, Huntington's disease, and Inborn errors of metabolism. Our collaboration with partners like Medgenome shall certainly keep us in a favourable position to offer molecular testing services more competently to our patients," he said.

5

MedGenome receives accreditation from College of American Pathologists

The CAP laboratory accreditation programme i globally recognised and is the only one of its kind that utilises teams of practicing laboratory professionals as inspectors

BENGALURU,13 DECEMBER

MedGenome, a major player in genetic diagnostics, announced today that its next generation sequencing technology based clinical laboratory in the IT capital , has been awarded accreditation from the College of American Pathologists .

The CAP laboratory accreditation programme is globally recognized and is the only one of its kind that utilizes teams of practicing laboratory professionals as inspectors.

It is designed to go well beyond regulatory compliance.

A company release here said that during the accreditation process, inspectors do a detailed check of the laboratory's records and quality control procedures besides assessing the laboratory's staff competency, qualifications.

This accreditation is awarded to facilities meeting the highest standard of excellence in clinical laboratory practices. With this accreditation, MedGenome's ,India laboratory joins the ranks of the most elite laboratories in the world. Dr Ramprasad, coo, MedGenome, said that having launched India's first validated liquid biopsy and the carrier screening tests, "we are trying to find answers to some of the most complex diseases.

SNS

3 **Story on genetic testing in Bangalore Mirror**
http://bangaloremirror.indiatimes.com/opinion/sunday-read/tracing-their-fear/articleshow/61799652.cms

4 **MedGenome collboration with Virinchi Hospital in Telangana Today**
https://telanganatoday.com/hyderabad-based-virinchi-hospitals-ties-up-with-medgenome

5 **MedGenome CAP accreditation news in Statesman**
https://diagnostics.medgenome.com/pdf/2017/13thStatesman2017.pdf

MedGenome connect

ACTIA

Rasopathy (Kochi)

In this quarter i.e. between Oct-Dec 2017 we participated in 4 conferences, 5 CMEs & relationship meetings in 8 cities. These events covered various aspects of Neuro and Nephrogenetics to promote our services among Key Opinion Leaders (KOLs) and clinicians.

The aim was to reach out to more than 850 clinicians with a special focus on Renal and Neurological Disorders with genetic origins and the utility of genomics in helping their patients with these disorders. Dr. Sheetal Sharda and Dr. Gaurav Verma were the speakers for these CMEs. One of the major events wherein we participated was ISPNCON, the annual event of Pediatric Nephrologists of India from 14th to 15th October. Nearly 300 doctors attended this annual event 2017.

This quarter also saw our foray into other important specialties like Ophthalmology and Cardiology by participating in RTM at Kolkata and RASopathy conference at Kochi. The next 2 months are promising as we have plans to connect with leading clinicians thus providing us enhanced visibility, with some of the important events of geneticists and Pediatrics, Neurology and Nephrology lined up during this period.

PRIMA

In the last quarter we participated in two key events:

- 2nd Indian Cancer Congress 2017, 8th to 12th Nov, held at Bangalore

  At the Indian Cancer Congress we had a stall where we could showcase our expertise and interact with customers. We had 2 sessions on Molecular oncology by Dr. Ramprasad and Dr. Chirantan Bose. About 250 plus doctors visited our stall during the event.

2nd Indian Cancer Congress 2017, held at Bangalore

- Genetics Conference at Kochi from 10th to 12th Nov 2017

  In this event MedGenome showcased its capabilities in the field of genomics with active participation and collaboration with the genomics department of TMH (Tata Memorial Hospital) Mumbai. Dr. Ramprasad participated as a Panelist in one of the important sessions on genomics .

CLARIA

Dr Kamini Rao at the MedGenome stall at Life conference in Bangalore

October was a month of conference for Claria. We were at three conferences and presented at one of them, the Asia Pacific Institute of Embryology conference in Mysore. Our stall at the CIMAR PERICON attracted a lot of attention thanks to the quiz competition, the winner of which received an Amazon Kindle. November was relatively quiet with just one conference and two CME's where in Dr. Priya showcased our NIPT capabilities at a CME conducted for CloudNine Gurgoan. Dr. Sam Balu presented our NIPT capabilities at the 39th annual Association of Obstetricians and Gynaecologists of Delhi (AOGD) conference in New Delhi. His talk was very well received with a lot of audience interaction.

There was also a public endorsement of our service from one of the panellists at the conference. In December we did 3 conference in Delhi, Trivandrum and Bangalore and 1 CME in Kolkata .

Introducing The Claria Webinar Series

The Claria Webinar Series initiative is designed to make genomics-guided clinical treatment strategies more accessible to clinicians. Till date we have conducted three webinar's on PGS/PGD, Micro-deletion detection using NIPT and the Importance of Carrier Screening Testing in India. The recordings of these webinar are available on providers.medgenomeclaria.com/events.

Making a difference

Embryo biopsy with presence of Partial trisomy & monosomy in chromosome 16 detected by VeriSeq NGS method:

A Case Report

Introduction

A couple, 35-year-old wife with history of multiple spontaneous abortions and 39-year-old husband underwent IVF procedure. The karyotype results of the mother showed presence of balanced chromosomal translocation t(16;19) (q11.2;p13.3) whereas the father was completely normal. We received a high grade embryo biopsy (Two day 5 trophectoderm biopsies) for the above case to perform "Pre-implantation Genetic Screening/Diagnosis" (PGS/PGD) procedure in order to look for chromosomal aneuploidies in the embryo prior to implantation.

Alternatively, based on karyotype data from the father and mother we predicted the probability of possible outcomes w.r.t. t(16;19) (q11.2;p13.3) in the embryo (Figure1).

Figure 1: Diagrams to predict the probability possible outcomes w.r.t. t(16;19) (q11.2;p13.3) in the embryo

Making a difference

Scenario I and IV – Cannot differentiate between the normal and balanced translocation by VeriSeq PGS as both will appear normal (limitation of the technology used)

Scenario II and III – Can be detected by Veriseq PGS, Scenario 2 is a case of partial trisomy 16 (gain> 40 mb for chr16:). And scenario III is a case of monosomy 16 (loss> 40mb for chr16) {Size of Gain & loss confirmed by Ensemble Genome browser}

Based on the above findings, the following observations were made:

- ✓ 25% chances for the presence of cases with balanced translocation
- ✓ 25% chances for normal cases
- ✓ 50% chances for presence of unbalanced translocation

We performed PGS screening by Next Generation Sequencing method using Veriseq library preparation method. The DNA obtained from trophectoderm cells was subjected to whole genome amplification procedure (SurePlex method) which ultimately was used as a starting material for NGS library preparation. Data was generated using Nextera based library preparation method on the MiSeq sequencer for screening of all 23 pairs of chromosomes for aneuploidies.

The highlights of this method are: it uses an engineered transposome to simultaneously fragment and tagment DNA which is obtained from single or few cells after whole genome amplification. The technology assists in selection of euploid embryos for implantation.

The PGS data generated for this case showed the Gain in Chromosome 13 (Mosaic) and partial trisomy in chromosome 16 whereas another embryo from the same couple showed the presence of monosomy in chromosome 16 in embryo DNA i.e. A case of unbalanced translocation (Figure 2A & 2B). Consequently, both the embryos were reported as "Not recommended for implantation".

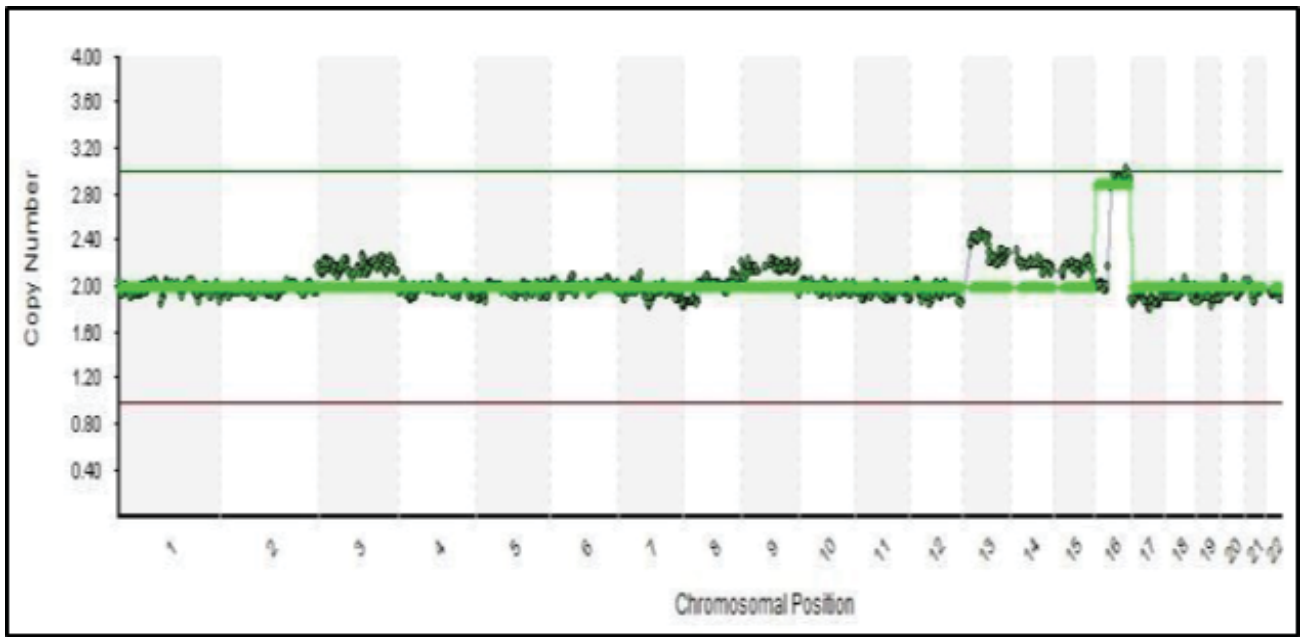

Figure 2A: CNV chart for embryo biopsy showing "Partial Trisomy 16"

Making a difference

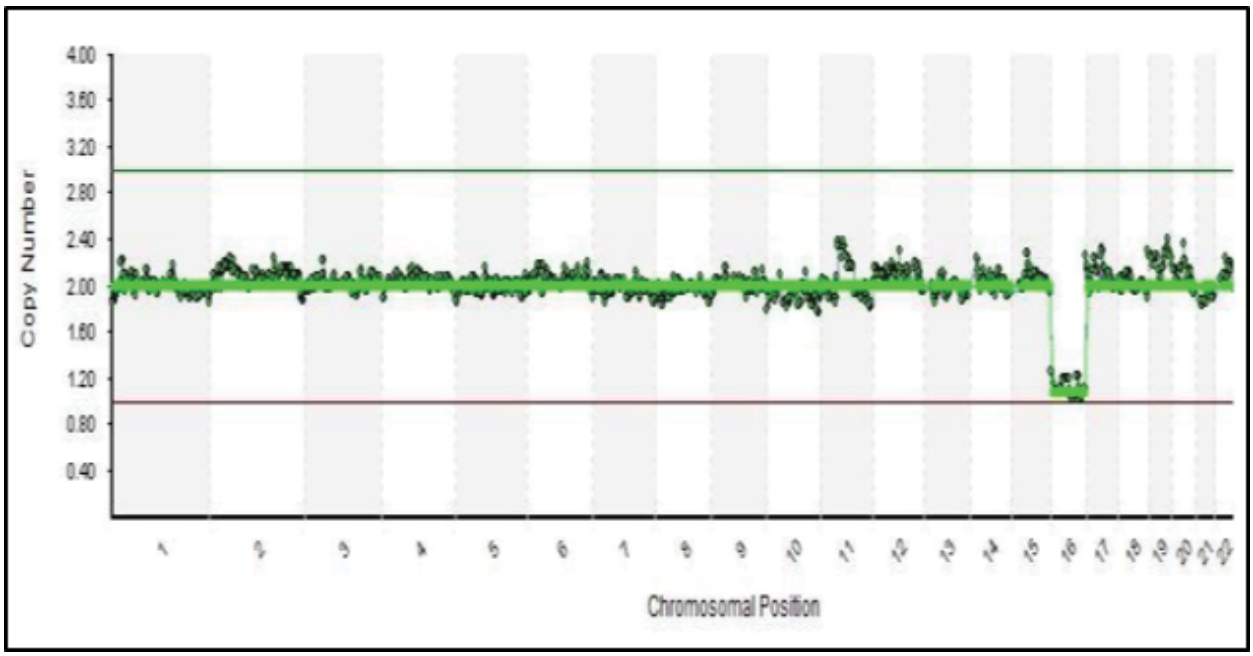

Figure 2B: CNV chart for embryo biopsy showing "Monosomy 16"

In conclusion Pre-implantation genetic screening using NGS can be used to detect chromosomal abnormalities in the embryo. In the present case, implantation of genetically abnormal embryo could have led to either selective pregnancy termination or birth of an abnormal child. Therefore, Pre-implantation genetic screening procedure is very much helpful for the clinicians, in better decision making which is also a preventive measure for physical as well as emotional trauma for the patient.

From our US office

This quarter we attended few key conferences which provided us an opportunity to showcase our lead products OncoPept and Diabetome.

At the recently held International Diabetes Federation event in Abu Dhabi - our product Diabetome was presented to an elite group of scientists and academicians. Diabetome is a novel clinical knowledge base/analytic platform designed based on 320,000 individuals with diabetes. It provides data and tools to promote continued understanding of diabetes, its risk factors and complications for research, development and clinical diagnosis.

The event included more than 200 speakers, both world-renowned and newcomers, 230 national diabetes associations from 170 countries and high level participation from the Health Authority Abu Dhabi (HAAD) and other health organisations.

We also took part in the Neoantigen Summit 2017, where our tumor microenvironment analysis and neo-epitope prioritization solutions were presented to the scientific community. This event is considered to be the premier platform to benchmark against the industry and network with the crème de la crème of neoantigen therapy developers.

We also presented OncoPept at other conferences namely: Society for Immunotherapy of Cancer (SITC), Impact Immunotherapy Progress & Clinical Trials and World Vaccine Congress.

At ASHG, we had an opportunity to present a poster on Diabetome that involved a case study depicting how Diabetome can be applied in disease management and treatment strategies.

The sales team in US had a team meeting in MedGenome Foster City office and discussed our offerings with our scientists in-depth.

This involved a deliberation on critical customer feedbacks that would allow MedGenome to scale up our offerings in the US market.

On October 30, 2017 - our chairman Sam Santhosh addressed the Staff at Foster city – delving deep in defining the vision and mission of MedGenome Inc. He also took part in a Radio Interview organised by Wharton Business Radio – where he provided insights into the future of MedGenome and elaborated on how MedGenome is playing a major role in tapping the genetic diversity of India which has a huge bearing on Global Genetic Research programmes/studies. The below link provides the recording of the interview

https://soundcloud.com/user-414944777/sam-santhosh

As we enter the New Year, we have an opportunity to position ourselves as a global player in biomarker discovery services and solutions across various disease areas including Oncology and Diabetes.

We wish you a happy new year and a great year ahead. Thank you for all your support and at the turn of the New Year we hope to bring some more exciting news.

Sneak peek into the world of science

Cancer Vaccine: Promises, Challenges and MedGenome Solution

by Ravi Gupta, PhD, Associate Director - Bioinformatics

Introduction

High-throughput sequencing of cancer patients has enabled rapid identification of somatic coding mutations that could generate neoantigens[1,2]. The tumor neoantigens are ideal targets for immunotherapy because they are expressed only by the tumor cells[3]. Several studies have suggested that neoantigens are important targets for effective antitumor immune response and their use for developing personalized vaccines[4-6]. Many studies have been published that showed that higher mutation burden is linked to stronger T-cell responses and better survival of the patients[7,8]. Associations have been reported in endometrial cancers, melanoma, non-small cell lung cancer (NSCLC) and colorectal cancer[9-12].

The neoantigens-specific T cell population have also been found to be expanded in effective antitumor immunity[9,10]. Both animal and human studies the tumor cell presenting immunogenic peptides can be selectively targeted by T cells which leads to complete or partial regression of tumor[13-15].

Challenges in developing cancer vaccine

The vaccine has to be designed such that the patient's immune cell (T cells) selectively hunts and kills only those specific tumor cells that present the targeted neoantigens. Finding a solution to train patient's immune systems to specifically target and kill cancer cells has proven to be a difficult task. The first success of molecular identification of neoantigen was reported by *Plaen et al.* in 1998[16].

Identification of right immunogenic neoantigens is one of the central problems in the successful development of cancer vaccine. A patient's tumor contains candidate neoantigens ranging from few hundred to several thousand. The real challenge is in selecting the candidate that would be best for stimulating the patient's T cells. Computational algorithms have been developed but these programs suffer from lack of sensitivity and specificity because they rely heavily on features associated with antigen presentation alone, without considering features required for T cell receptor (TCR) binding. A recent paper describes a novel approach of quantifying neoantigen fitness in tumors to predict immunogenic peptides, in which both HLA presentation and TCR recognition are used as fitness components[17]. The neoantigen fitness model predicts immunogenic epitopes without examining structural features in a peptide that enables interaction with TCR. The model was used to predict long-term survivors of pancreatic cancer in a recent study[18].

MedGenome solution

MedGenome computational group has developed a highly accurate new method (IPepPredicT) to select immunogenic peptide[19]. IPepPredicT applies ensemble voting-based machine learning approach to identify immunogenic peptides from patient's somatic mutations.

Our method is the first in-silico model that combines physicochemical properties of amino acids favorable for TCR binding with features relevant for antigen presentation and processing. IPepPredicT is trained on MHC Class I HLA-A*02:01 9mer peptides present in IEDB data. Our analysis revealed enrichment of helix/turn features at TCR contact residues along with hydrophobicity features enriched at the HLA-binding anchor residues. Our analysis also provides a feature spatial enrichment map that provides a guideline for selecting immunogenic peptides. While developing the method we also analyzed MHC-peptide-TCR complex crystal structures. Our analysis revealed that many of the features selected by our prediction algorithm are in agreement with finding from crystal structure analysis. Performance evaluation on unseen peptides provided sensitivity and specificity of 90.23% and 99.14% respectively.

Promising results from recent clinical trials

Recently, two clinical trials reported have shown encouraging results. The first study was conducted at Boston's Dana-Farber Cancer Institute on six melanoma patients[4]. The cancer vaccine targeted 20 neoantigens. Of the six patients given cancer vaccine, four of them are disease free for 25 months. For the remaining two patients, the disease reoccurred and was treated with anti-PD-1 therapy. The neoantigen specific T cells was found to be expanded that lead to complete tumor regression. The second clinical trial was conducted on 13 melanoma patients by Biopharmaceutical New Technologies (BioNTech) in Germany[5]. The cancer vaccine in this trial targeted 10 neoantigens for each patient. Eight patients were disease free for 12 – 23 months. These studies clearly indicate that the personalized vaccine has the ability to make cancer patient disease free.

By accurately predicting neoantigens, we believe **IPepPredicT** could help in effective personalized cancer vaccines.

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Product of conception testing – Implications and Methods

by Sakthivel Murugan SM, PhD, Associate Director - Diagnostics

Introduction

Recurrent Pregnancy Loss (RPL) is defined as two or more consecutive spontaneous abortions. RPL affects about 1 percent of the child-bearing population and it is estimated that 15–20% of clinically recognized pregnancies end in miscarriage. Although a few cases of RPL are sporadic, most have a genetic basis. The proposed causes of RPL are parental chromosomal abnormalities, uterine anatomic anomalies, endometrial infections, endocrine etiologies (leuteal phase defect, thyroid dysfunction, uncontrolled diabetes mellitus), antiphospholipid syndrome, inherited thrombophilias, alloimmune causes and environmental factors as mentioned in the table 1. Among the various proposed etiologies, genetic factors appear to be highly associated with reproductive loss.

The single most common cause of early (first-trimester) pregnancy loss is the presence of a major fetal chromosomal abnormality, which is responsible for 50 to 80 percent of losses in the first trimester, depending on maternal age and gestational age at the time of the loss. Cytogenetically abnormal embryos are usually aneuploid because of sporadic events, such as meiotic nondisjunction, or polyploid from fertilization abnormalities. Incidence of numerical and structural chromosome abnormalities in spontaneous abortuses is reported to be almost half (47.9%), 9.8 percent, polyploid (mostly triploid) 8.6 percent 45, X, and 26.8 percent trisomic for one or another chromosome. Fetal chromosomal abnormalities account for approximately 8–10% of intrauterine fetal deaths occurring after 20 weeks of gestation and/or stillbirths occurring in the second or third trimester. The etiologic analysis of pregnancy loss can provide important information for medical management, reproductive counseling, and supportive patient care.

Table 1: Etiologies of pregnancy loss

Genetic Causes	Anatomic Causes	Immunologic Causes	Infectious Causes	Endocrine Factors
o Aneuploidy o Somatic o Sex chromosome o Mendelian disorders o Multifactorial disorders o Parental chromosomal abnormalities (translocations) o Chromosomal inversions. o Thrombophilia	o Alloimmune causes o Uterine mullerian anomaly o Uterine septum (the anomaly most commonly associated with pregnancy loss) o Hemiuterus (unicornuate uterus) o Bicornuate uterus o Diethylstilbestrol-linked condition o Acquired defects (eg. Asherman syndrome) o Incompetent cervix o Leiomyomas o Uterine polyps	o Autoimmune causes o Alloimmune causes Listeria monocytogenes, Toxoplasma gondii, rubella, herpes simplex virus (HSV), measles, cytomegalovirus and coxsackieviruses	o Smoking o Excessive alcohol consumption o Caffeine	o Diabetes mellitus o Antithyroid antibodies o Luteal phase deficiency

Table 1: Etiologies of pregnancy loss Continued

Genetic Testing Methods

Several methods have been used for POC testing. Conventional karyotyping is the gold standard in genetic testing and effectiveness of new methods was proven in comparison with GTG karyotyping results. Conventional G-banding karyotyping enables direct visualisation and assessment of the number and structure of all chromosomes under a light microscope during metaphase. After embryonic or fetal demise, culture failure is common and the results may be unavailable in up to 10–40% of samples. Moreover, conventional karyotyping is time consuming and expensive as it requires a highly qualified staff. The resolution is usually 5–10 Mb but when structural aberration occurs in atypical bands or the quality of digestion or dyeing during chromosome preparation is insufficient, segmental changes exceeding 10 Mb may be missed.

Other methods include whole genome approaches like Comparative Genomic Hybridization (CGH), Array-CGH, Chromosomal microarray (CMA), BAC (Bacterial artificial chromosome) on Beads (BoBs) and NGS and Targeted approaches like Fluorescence in-situ hybridization (FISH), Quantitative Fluorescence- PCR (QF-PCR), Multiplex Ligation-dependent Probe Amplification (MLPA) etc. A comparison of the advantages and limitations of the methods used in miscarried tissue analysis is presented in Table 2.

Selection of Miscarriage Tissue for Genetic Testing

The most reliable material for genetic analysis is the fetus (embryo), but its separation from the remaining miscarried tissue may be difficult or even impossible, especially in early pregnancy. Moreover, the fetus is often spontaneously evacuated from the uterus, its tissue is lost and an alternative material has to be collected.
Although chorionic villi may be easily separated from the remaining tissue, in the clinical setting, improper preparation of the sample severely affects the reliability of molecular testing in over 40% of first trimester miscarriages. To prevent maternal cell contamination (MCC), miscarried tissue should be cleaned in saline solution directly after evacuation from the uterus, and white tissue (villi) should be separated from the remaining maternal decidua and blood clots and placed in sterile saline solution. Chemical contamination (such as contact with formaldehyde) should be avoided to prevent DNA degradation.

The sample should be collected either in RPMI culture media, saline or PBS with antibiotics in a sterile container. Store the sample at 2-8 degree until transport. Transport the sample with cool packs.

Table 2: Comparison of methods used in POC testing

Karyotyping	FISH	QF-PCR	MLPA	BAC on Beads (BoBs)	CMA
Screens all 46 Chromosomes	Quick screen for 13, 18, 21, X & Y chromosome	Quick screen for 13, 18, 21, X & Y chromosome	Screens all 46 Chromosomes	Screens all 46 Chromosomes	Screens all 46 Chromosomes
Can detect balanced translocations	Can detect balanced translocations	Cannot detect balanced translocations	Cannot detect balanced translocations	Can detect unbalanced translocations	Cannot detect balanced translocations
Cannot Detect Micro deletions / duplications	Can detect deletion & duplications only in targeted probe regions	Cannot Detect Micro deletions / duplications	Cannot detect telomeric deletion / duplications	Cannot detect Microdeletions/ duplications	Can detect Micro deletions / duplications
Very Low Resolution	Intermediate Resolution	Intermediate Resolution	Intermediate Resolution	Moderate Resolution	High Resolution: 1 MB for losses, 2 MB for gains, and 5 MB for LOH/AOH (Loss/Absence of Heterozygosity)
Higher failure rate due to dependence on cell culture	No Cell Culture Required	No Cell Culture Required	No Cell Culture Required	No Cell Culture Required	No Cell Culture Required
Suitable for mosaicism	Suitable for mosaicism	Not Suitable for mosaicism	Not Suitable for mosaicism	Suitable for low level mosaicism (>20%)	Suitable for low level mosaicism (>20%)
Poor Genome Coverage	Poor Genome Coverage	Poor Genome Coverage	Intermediate Genome Coverage	Moderate Genome Coverage. Array detects aneuploidies and also analyses 143 chromosomal regions of known clinical significance [5].	High Genome coverage leading to improved identification of chromosomal changes (25 markers / 100 kb of the genome). Covers 396 clinically relevant regions in the genome, especially those which are implicated in prenatal complications
Cannot rule out maternal cell contamination	Can rule out maternal cell contamination	Can rule out maternal cell contamination	Can rule out maternal cell contamination	Cannot rule out maternal cell contamination	Cannot rule out maternal cell contamination
Low Throughput	Low Throughput	High Throughput	High Throughput	High Throughput	High Throughput

Maternal cell contamination (MCC)

The separation of the chorion from the uterine wall through the stratum spongiosum inadvertently causes rupture of the uterine vessels and high contamination by the maternal blood cells. The reported MCC of the miscarried tissue rate ranges between 4% and 47% for different centers, probably reflecting the tissue preparation process. Chromosomal abnormalities are detected in 61% of samples where first trimester villi are separated and cleaned directly after evacuation from the uterus, compared with 36% in samples routinely prepared (i.e. separated in the laboratory).

Moreover, the percentage of 46,XX results is much lower in well prepared samples, which indirectly demonstrates a lower level of MCC as nearly 60% of 46,XX results of miscarriage product testing are maternal in origin. Proper preparation of the sample decreases the rate of MCC. Nevertheless, MCC should be excluded in every case of a 46,XX result, for example, by the analysis of maternal-fetal DNA pairs with the use of polymorphic microsatellite PCR markers.

Placental mosaicism

The chorion consists of two layers: an outer formed by the primitive ectoderm or trophoblast and an inner formed by the somatic mesoderm. The trophoblast is made of an internal layer of cubical or prismatic cells, the cytotrophoblast and an external layer of richly nucleated protoplasm devoid of cell boundaries, the syncytiotrophoblast. The chorion undergoes rapid proliferation and forms the chorionic villi. In nearly 2% of cases, two or more different cell lines are present in the placenta (confined placental mosaicism). When the uncultured villi are tested, trophoblastic DNA is predominant as a result of the richly nucleated syncytiotrophoblast, while in the culture the mesoderm grows more rapidly, leading to domination of mesodermal DNA. This phenomenon explains a possible discordant result of molecular testing of short and long-term cultured villi and the fact that in direct molecular analysis, some fetal abnormalities may remain undetected. In a study by van den Berg et al., abnormal fetal karyotype was discordant with short-term cultured villi in 0.42% of cases (false-negative results) compared with only 0.08% with long-term culture.

Conclusion

First trimester miscarriage is the most frequent complication of pregnancy. Chromosomal abnormalities incompatible with life are the only undisputable cause of pregnancy loss, as opposed to maternal factors (e.g. mild endocrine abnormalities), whose role remains questionable, especially in secondary sporadic cases. The detection of numerical abnormalities allows the establishment of the cause of miscarriage and influences genetic counseling, especially in recurrent cases. Moreover, genetic testing of the miscarriage enables the detection of the causes of otherwise unexplained recurrent pregnancy loss and decreases the prevalence of unexplained cases to less than 25%, which is important for psychological reasons as well as for clinical evaluation.

Conventional karyotyping is the gold standard for genetic testing. However, its clinical usefulness is limited by possible culture failure, poor metaphase chromosome quality, maternal cell overgrowth, and time and labor consumption. Array-CGH and chromosomal microarray are becoming the most efficient method of testing nowadays. They overcome the necessity of tissue culture and allow for the rapid detection of aneuploidies, unbalanced structural changes and submicroscopic abnormalities. However, the clinical significance of some of these abnormalities is unknown, while others may be benign, making the interpretation of the results challenging. Furthermore, female polyploidies, tetraploidies and balanced changes remain undetected and other methods are needed (e.g. flow cytometry for polyploidy detection).

Next generation sequencing may contribute more to the knowledge of the genetic pathogenesis of miscarriage, but it is currently only used experimentally, mainly because of its high costs. The efficacy of chromosome region specific molecular methods like MLPA, QF-PCR, FISH etc is limited and none can be used alone as a diagnostic tool. However, they are valuable screening methods, as a great majority of genetic abnormalities in miscarriage tissue are simple aneuploidies.

Genetic diagnosis should be offered in first trimester pregnancy loss, especially in recurrent cases. The material for testing should be properly prepared. Knowledge of the pathogenesis of a miscarriage, as well as advantages and limitations of diagnostic methods, is necessary for appropriate genetic counseling.

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From our Colleague

A trek into the divine serenity of Himalaya!!

by Udita Mahadevia, Scientific Communications

Trekking for me is an art of walking amidst lush greenery, rocky roads and snow-covered mountains. Trekking can be quite an exciting and thrilling experience as it inculcates a sense of adventure, value of physical exertion, sometimes to the limit of endurance, a spirit of comradeship and realization of one's responsibilities towards the cleanliness of the nature.

This is from my recent trip to a spiritual place called Sri Narayan Ashram (SNA), an ashram built by my Guru, in the Kumaon Himalaya, close to Nepal border and on the way to Kailash-Mansarovar. The ashram is located at a height of ~9,000 ft above the sea level.

This was my 8th visit to the place. I still have vague memories of being carried by my father on his shoulders during my first ever-trekking trip. I used to hold his hand and walk around the mountains with baby steps. From then to now, 24 long years and I was back to the same place with my parents, but this time it was my turn to take them around the place.

We had taken up 2 treks from SNA in a span of 3 days; one was a 7 kms trek in the mountains to the nearest villages-Sirkha and Sirdang which took us about 3 hours. This was only a warm up for our actual trek scheduled the next day to the place called Narayan Peak, situated at a height of ~11,000 ft above the sea level.

The trek path all through was narrow, had slippery grass, stones and was filled with moss-coated rhododendron trees, which made it tough to walk. Walking along the mountain ridge, at the height of 11,000 ft in the Kumaon Himalaya, Uttarakhand was by far the best experience of my life. Even at that height we were still in a valley, surrounded by the sun-kissed snow covered peaks of Nanda Devi, Panchachuli, Api-Nampa, Om parvat, etc.

It took us about 5 hours to reach close to the peak, and that last slope before we could actually experience pure bliss, seemed the toughest as we were tired, exhausted and drained. After taking a halt for a while, few of us headed towards the peak. Finally, after so many years, standing on that peak, surrounded by other snow-covered mountains gave a sense of satisfaction, thrill and joy. A sense of being away from the hassles of the world, breathing the purest form of nature in absolute silence and feeling alive in the true sense.

I joined MedGenome recently and was very excited to know there are people who have the same passion for trekking as me. Here are some of their experiences.

Sneh: "Located around 125 kilometres from Bengaluru, Ramanagara is a perfect getaway from the bustling cities, breathe in the fresh air away from the stifling city crowds and revel in the peacefulness of the mountains. Enriched with a history connecting it to the famous Hindu stories of Mahabharata - the Pandavas and their mother Kunti, after whom the village and the rocky hills have been named, this trek becomes even more appealing and fascinating.

The trek starts from Kunti Betta base, a trail through the rocks, boulders and shrubbery growth that lies towards the base of the hill. The night is pretty exciting as you sit next to the bonfire sharing stories, it's a breathtaking visual to feel the height unravelled when the dawn sets in, the difficulty level is a bit higher for first timers but it is definitely a next door getaway for rugged adventurers. Light weight-baggage, trekking shoes, chilly breeze, lush bouldering mountains, night sky, and twinkling stars accessorize your making it a thumbs up adrenaline rushers...."

Susan: "Avalanche forest, Ooty is 30Km further from Ooty and is an amazing forest area. I and my group had the pleasure of trekking way inside the forest and pitching our tents in the camp site which was in the middle of the forest. There was a mixed feeling of anxiety and excitement. Anxiety because there were only 4 people who knew the trekking trail way inside and out from the camp site and so in case of wandering away from the group, means we are lost in that thick forest. And excitement because there were adventurous activities that we were going to do along with our friends. We got to do kayaking, archery, abseiling and gorge walking. These were so helpful in making ourselves to go past our fears and limitations. Our fear of water and heights were challenged to its maximum. But there was a joy in overcoming them. The beautiful Avalanche lake where we did the kayaking was surrounded by mountains and tall trees. Sitting in the kayak you would want nothing more than staying in that place forever, away from the regular busy city life. We also did a night trekking with just the stars leading our path and some of us were lucky enough to see shooting stars. Sleeping inside the tent was another exciting thing. We could see shadows of wild boars and creepy crawlies near our tents. Surely there were tiger roars heard, probably they were enjoying a surplus meal in the dark of the night. It was cold inside the tent still we slept because of the long tiring activities we did everyday. Returning back there were lessons that were learned. Learnings that the best team player is the one who walks with the slowest and weakest person in the team, including them and helping them in the strenuous way and also that if we do not take up challenges we will never know how best we can perform. It was one of the best experiences of life reminding me personally again that we need just the basic necessities of life to be happy. The rest everything complicates our lives. Simple life is the most content life"

From our Colleague

Exercise at workplace

by Malaichamy Sivasankar, Genome Analyst

The ergonomics process identifies and controls risk factors related to the workplace. Stretching and warm-up exercises is one of the elements which is crucial to reduce the fatigue caused by long hours of work. But this does not replace an ergonomics improvement process – they enhance it.

Ergonomics is the science of designing the workplace to fit within the capabilities and limitations of team members. The goal is to make sure the work fits the worker, thereby reducing injury risk and promoting safety, productivity and quality of work.

Sitting at a desk or computer or standing at your work station for extended periods of time can cause muscle tension, stiffness and strain in the neck, arms, wrists, hands, back and legs. Inactivity or being sedentary increases the pressure on spinal discs by about 40 percent more than standing. As a result, the pelvic muscles become tight and when a person stands after sitting for long periods of time, the body is off balanced, causing stress to bones and muscles.

"Benefits of stretching at workplace," include:

The ergonomics process identifies and controls risk factors related to the workplace. Stretching and warm-up exercises is one of the elements which is crucial to reduce the fatigue caused by long hours of work. But this does not replace an ergonomics improvement process – they enhance it.

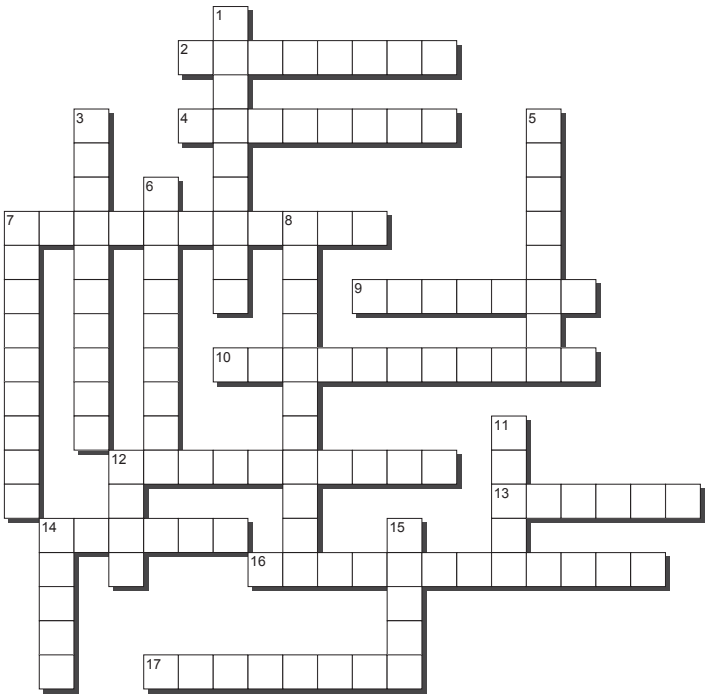
It is recommended to take short stretch breaks at least once per hour. Taking frequent, shorter breaks where you can regularly relax and stretch your muscles is preferable. If your job is system based, you should try taking a 5 minute break every 30-40 minutes spent on the computer. Spontaneously stretching any area of the body that feels tense will also help reduce pain and stress on your muscles.

- ✓ Reduced risk of cumulative trauma disorders, such as rotator cuff injuries, tendonitis, tennis elbow and "Blackberry" thumb
- ✓ Reduced workplace stress
- ✓ Improved worker productivity
- ✓ Frequent stretching keeps a proper blood and nutrient supply to the working muscles and tissues throughout the workday and prevents fatigue and discomfort and reduces the risk of MSD injuries while reducing stress and increasing energy
- ✓ It stimulates the formation of synovial fluid in the joints, which acts to make the joints easier to move, thus reducing pain and stiffness

Making sure your team members are physically fit is essential in order to promote a healthy and safe work culture

Genomics puzzles

1. Mendel puzzle



[Across]

2. The genetic makup of a living thing.
4. The field of biology that studies how genes control appearance.
7. The likelihood that an event will happen.
9. Different versions of a gene.
10. Long molecules made of DNA that hold genes.
12. All the individuals born at the same time.
13. The part of the flower that creates pollen.
14. A monk who experimented with pea plants.
16. Two different alleles for a trait.
17. The trait that is visible when other traits are present

[Down]

1. The trait that is hidden when other traits are preset.
3. Two copies of the same allele.
5. Separate units.
6. An image of chromosomes.
7. The physical appearance of a living thing.
8. Genetic traits are _____ from a parent.
11. Stores female reproductive cells.
12. Region of DNA where instructions for one trait are kept.
14. Paired male and female cells for reproductive purposes.
15. Characteristic like hair freckles or dimples.

2. Find the word

Genetics and Adaptations

S	P	N	R	M	O	P	D	O	E	O	G	A	I
C	D	S	S	E	G	G	O	G	S	P	O	L	P
H	M	U	U	R	N	E	M	E	S	S	S	L	H
R	S	B	O	O	O	N	I	N	U	N	I	E	E
O	T	M	G	F	H	O	N	E	O	O	E	L	N
M	R	G	Y	F	E	T	A	T	G	I	N	E	O
O	U	N	Z	S	R	Y	N	I	Y	T	S	O	T
S	C	I	O	P	E	P	T	C	Z	A	O	A	Y
O	T	D	R	R	D	E	T	S	O	T	Z	Z	P
M	U	E	E	I	I	S	R	I	M	P	S	O	E
E	R	E	T	N	T	N	A	P	O	A	S	E	S
I	E	R	E	G	Y	U	I	T	H	D	S	O	U
Z	I	B	H	I	T	P	T	A	I	A	M	P	U
T	E	H	O	R	M	I	S	A	E	D	F	T	N

STRUCTURE
GENOTYPES
HEREDITY
CHROMOSOME
DOMINANT TRAITS
OFFSPRING
HETEROZYGOUS
ADAPTATIONS
PHENOTYPES
HOMOZYGOUS
GENETICS
ALLELE
BREEDING

Kindly mail your answers to editor@medgenome.com. The first two people to answer the puzzles correct will be featured in the next edition of our newsletter.

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Wishing you a happy, healthy and prosperous 2018
&
Happy Sankranti

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