Cancer Association of South Africa (CANSA)

Research • Educate • Support

Fact Sheet on Genetic Testing for Cancer

Introduction

Genetic testing, done on the deoxyribonucleic acid (DNA) found in tissue cells, also known as DNA testing, allows the genetic diagnosis of vulnerabilities to inherited diseases. It can also be used to determine a child's parentage (genetic mother and father) or in general a person's ancestry. In addition to studying chromosomes to the level of individual genes, genetic testing, in a broader sense, includes biochemical tests for the possible presence of genetic diseases, or mutant forms of genes associated with increased risk of developing genetic disorders. Genetic testing identifies changes in chromosomes, genes, or proteins. Most of the time, testing is used to find changes that are associated with inherited disorders. The results of a genetic test can confirm or rule out a suspected genetic condition or help determine a person's chance of developing or passing on a genetic disorder. Many genetic tests are currently in use while more are being developed.

[Picture Credit: Genetics]

Since genetic testing may open up ethical or psychological problems, genetic testing is often accompanied by genetic counselling.
(Wikipedia).

The Risk of Developing Cancer

Every individual has some risk of developing cancer and in most cases the disease develops by chance. However, some people are genetically predisposed to developing certain types of cancer. These people have a higher risk of developing the disease than those in the general public.

DNA is present in almost every cell in the human body and carries the basic instructions needed by cells and tissues to function properly. DNA is packaged into structures called chromosomes.

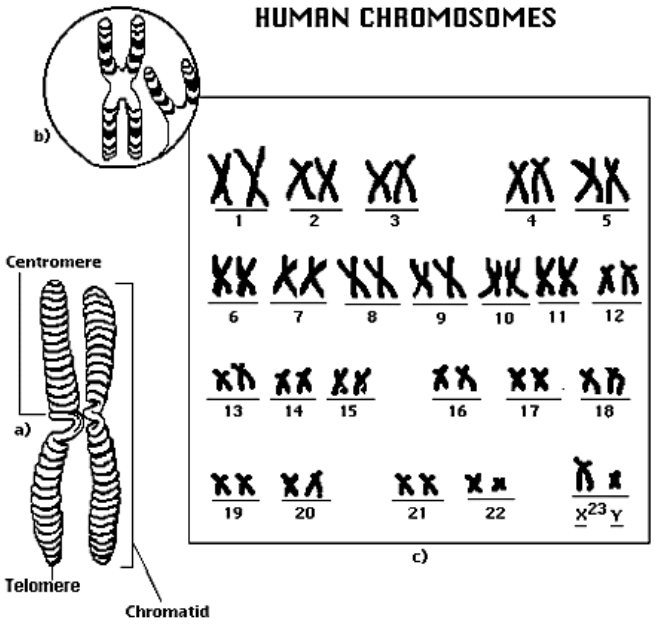
Scattered across the chromosomes are approximately 25 000 genes, which are functional units of DNA. The cell uses genes to make proteins and other substances that are

necessary for life. In some genes, changes in the DNA called mutations have been linked to cancer.
(Memorial Sloan-Kettering Cancer Center).

Genes and How Genes Works
The organs and tissues of the body are made up of tiny building blocks called cells. Every cell contains all the biological information inherited from one's parents. This information is stored in the genes in the centre (nucleus) of every cell.

Genes affect the way individuals look and how their bodies grow and work. Different genes have different functions. One's appearance such as eye colour is completely determined by one's genes. But most characteristics about living beings are the result of an interaction between genes and the environment. For example, height and weight are linked to the genes that were inherited (someone with tall parents is likely to be tall) but may also be influenced by diet, exercise, any childhood illnesses and other factors.

Genes are grouped together on chromosomes. Every cell has 46 chromosomes, arranged into 23 pairs. One chromosome in every pair comes from one's mother and one pair comes from one's father, so half of the genes come from the mother and half from the father.



[Picture Credit: Human Chromosomes]

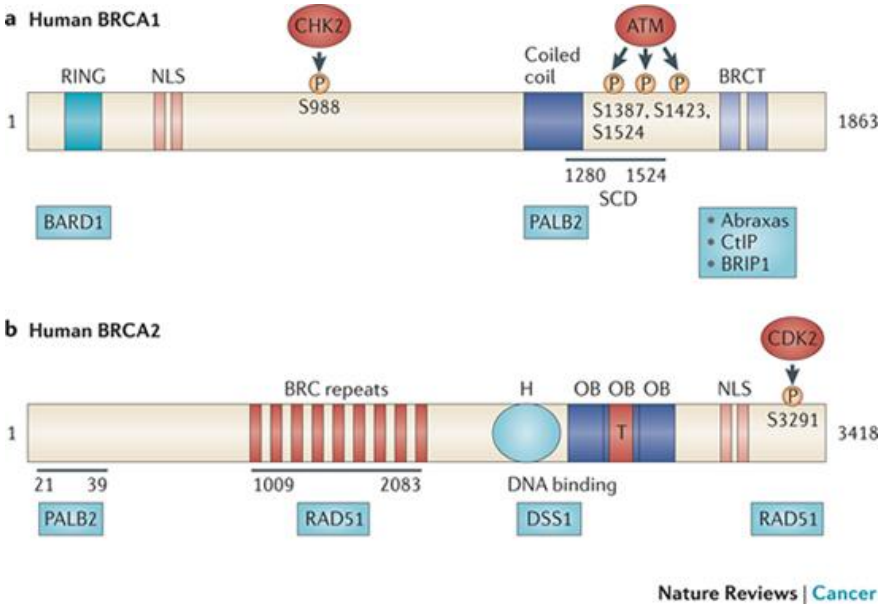
The information inside the genes is written in a 'code' made up of four chemicals (bases): adenine, thymine, cytosine and guanine (shortened to the letters A, T, C and G). These four chemicals, repeated in different combinations, contain all the information the body needs to function. This coded information is called DNA (deoxyribonucleic acid).
(MacMillan Cancer Support).

Genetic Makeup and Cancer
There need to be a number of genetic mutations within a cell before it will become cancerous. Sometimes a person is born with one of these mutations already. This does not mean they will definitely get cancer. But with one mutation from the start, it makes it more likely statistically that they will develop cancer during their lifetime. Doctors call this genetic predisposition.

The BRCA1 and BRCA2 breast cancer genes are examples of genetic predisposition. Women who carry one of these faulty genes have a higher chance of developing breast cancer than women who do not. The BRCA genes are good examples for another reason.

Most women with breast cancer do not have a mutated BRCA1 or BRCA 2 gene. Less than 3% of all breast cancers are due to these genes. So although women with one of these genes are individually more likely to get breast cancer, most breast cancer is not caused by a high risk inherited gene fault.

[Picture Credit: BRCA1 & BRCA2]



This is true of other common cancers where some people have a genetic predisposition – for example, colon (large bowel) cancer.

Researchers are currently looking at the genes of people with cancer in a study called 'SEARCH'. They also hope to find out more how other factors might interact with genes to increase the risk of cancer. In this study, the research team planned to look at the genes of 32 000 people with cancer.

The aim of this study was to:

- Find out more about the high penetrance genes already known to science
- Find new low penetrance genes
- Look at other factors that may interact with genes to increase the risk of developing cancer

(Cancer Research UK).

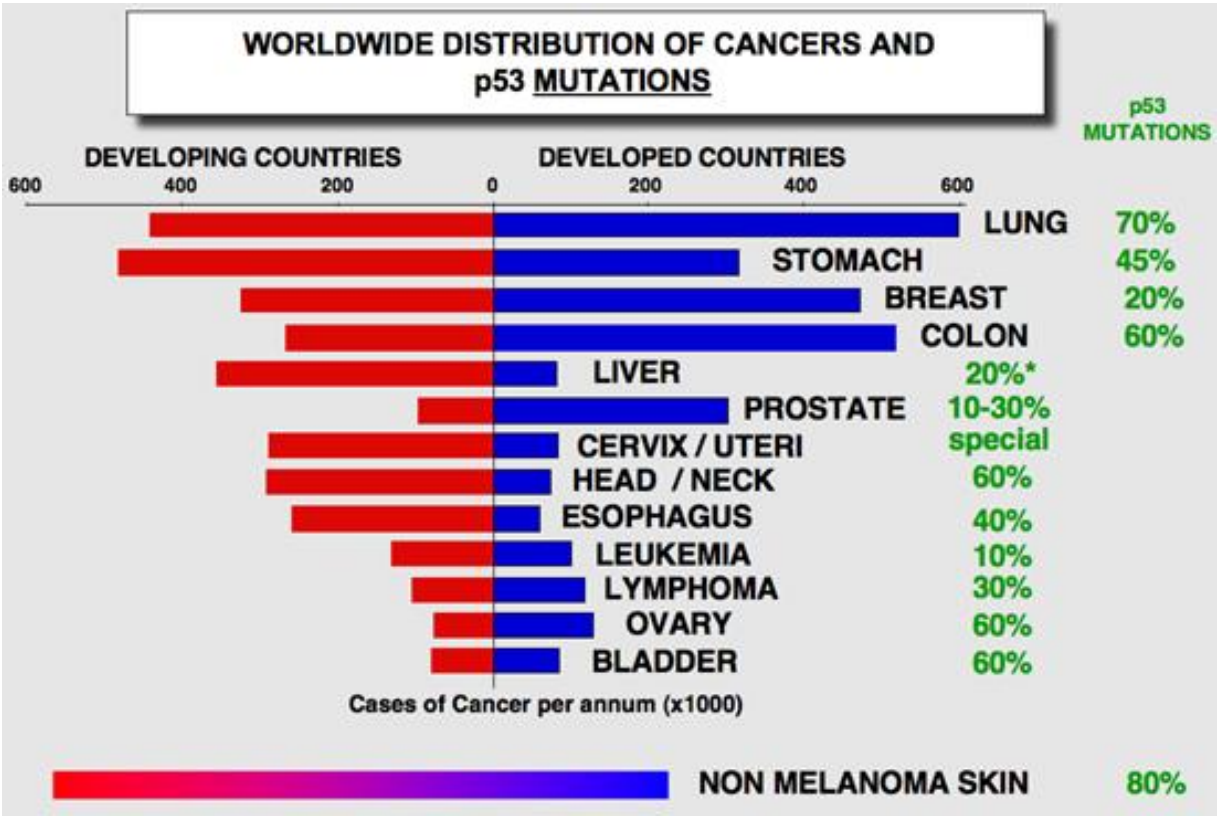
Types of genes linked to cancer

Many of the genes that contribute to the development of cancer fall into broad categories:

Tumour suppressor genes are protective genes - Normally, these genes suppress (limit) cell growth by monitoring how quickly cells divide into new cells, repairing mismatched DNA (which is often a cause of mutations), and controlling when a cell dies. When a tumour suppressor gene is mutated (from heredity or environmental factors), cells grow uncontrollably and may eventually form a mass called a tumour. *BRCA1*, *BRCA2*, and *p53* are examples of tumour suppressor genes. Germline mutations in *BRCA1* or *BRCA2* genes increase the risk for men and women to develop hereditary breast cancer or ovarian cancer in women. The most commonly mutated gene in people who have cancer is *p53*. In fact, more than 50% of all cancers involve a missing or damaged *p53* gene. Most p53 gene mutations are acquired mutations.

The p53 gene, also known as cellular tumour antigen p53 or phosphoprotein p53 or tumour suppressor p53 is a protein that, in humans, is encoded by the *TP53 gene*. The p53 protein is crucial in multicellular organisms, where it regulates the cell cycle and functions as a tumour suppressor, preventing cancer. As such, p53 has been described as 'the guardian of

the genome' because of its role in conserving stability by preventing genome mutation. *TP53* is, therefore, classified as a tumour suppressor gene.



[Picture Credit: p53 Gene]

Germline *p53* mutations are rare. Germ-line p53 mutations are associated with dominantly inherited Li-Fraumeni syndrome (LFS), which features early-onset sarcomas of bone and soft tissues, carcinomas of the breast and adrenal cortex, brain tumours, and acute leukaemias. However, carriers of germ-line p53 mutations may also be at increased risk of other cancers.

Oncogenes turn a healthy cell into a cancerous cell - *HER2* (a specialized protein that controls cancer growth and spread, found on some cancer cells, such as breast and ovarian cancer cells) and the *ras* family of genes (genes that make proteins involved in cell communication pathways, cell growth, and cell death) are common oncogenes. Mutations in these genes are almost always acquired (not inherited).

DNA repair genes fix mistakes made when DNA is replicated (copied) - If a person has error in a DNA repair gene, these mistakes are not corrected. Mistakes that aren't fixed become mutations, which may eventually lead to cancer (especially if the mutation occurs in a tumour suppressor gene or oncogene). Mutations in DNA repair genes can be inherited (such as with Lynch syndrome) or acquired.

Despite all that is known about the different ways cancer genes work, many cancers cannot be linked to a specific gene. It is likely that multiple, different genes are involved in the development of cancer. There is also some evidence that genes interact with their environment, further complicating the role of genes in cancer.

Scientists hope to still learn more about the role of genetic changes in the development of cancer, which may lead to improvements in finding and treating cancer, as well as predicting a person's risk of cancer (Cancer.Net).

Genetic Testing

There are two types of genetic testing techniques - predictive and preventive.

Predictive Genetic Testing

- Used to detect mutations associated with disorders that appear after birth, often later in life
- Identify mutations that could increase a person's risk of developing disorders based on their genetic makeup, such as certain types of cancer

Preventive Genetic Testing

- Used to identify certain gene mutations (single nucleotide polymorphism or SNPs) which are expressed in an unfavourable lifestyle environment
- SNP intervention is used to successfully treat gene mutation with lifestyle changes, proper nutrition and vitamin and mineral supplementation
- Modern genomics is based on personalised prevention. Although usually used to stop the development of age related degenerative diseases, prevention is recommended for young and old, and it is never too early to start

(8th Sense).

Genetic Testing for Cancer

Genetic testing for cancer involves checking a blood sample for gene faults (mutations) that are known to increase the risk of cancer. This is a complex process and it can sometimes take quite a long time for the results to become available.

<u>Step 1 – mutation search</u>

First, the laboratory looks for the particular gene fault (mutation) that may run in a family by testing a member of the family who has been diagnosed with cancer. This step is called the mutation search. It involves taking a blood sample, which can be arranged by a general practitioner.

Searching for a mutation in a gene is like trying to find a single spelling mistake in a big book. It involves reading the whole (or large parts) of the gene. The test looks at the order that the chemical 'letters' A, T, C and G (that make up the genetic code) are found within a gene.

<u>Step 2 – predictive testing</u>

If a gene fault known to increase the risk of cancer is identified in a family, the patient and other family members who may be at risk can be offered a test. This is called genetic screening, or predictive or predispositional testing.

Predictive testing is much faster than mutation searching, as the laboratory already know what they are looking for (the exact gene fault) and where to find it.

Results of genetic testing may show that:

- the person affected by cancer (who was tested) was not shown to have a mutation in a known cancer susceptibility gene - this is known as an inconclusive result
- there is a gene mutation in the family, but the patient did not inherit it
- there is a gene mutation in the family and the patient inherited it

(MacMillan Cancer Support).

Availability of Genetic Testing Facilities in South Africa

No genetic testing facilities are available in rural areas in South Africa. According to Kromberg, *et al*. (2013) genetic testing facilities in South Africa are available at:

- National Health Laboratory Services (NHLS)
- University of the Witwatersrand (NHLS)
- University of Cape Town
- Stellenbosch University
- University of the Free State
- University of KwaZulu Natal
- University of Pretoria
- Sefako Makgatho Health Sciences University
- University of Limpopo, Polokwane (NHLS)
- A variety of private laboratories situated mainly in the large metropolitan areas throughout South Africa, for example Ampath and Lancet Laboratories

Cancer Genetic Risk Assessment and what it Involves

A cancer genetic risk assessment helps determine individuals who may be at increased risk for developing cancer, and provides guidance with what can be done. The assessment typically involves an hour-long appointment, which can include some or all of the following:

- Personal and family history evaluation with a genetic counsellor
- Risk assessment using medical and computerized risk models
- Genetic education and counselling
- Discussion of genetic testing and its implications for the patient and their family members
- Psychosocial support
- Recommendations for screening and prevention options (e.g., breast MRI, colonoscopy, upper endoscopy, preventative medications or surgeries, etc.)

Genetic testing may be an option for some people, but is not a requirement. If and when genetic testing is performed, it will involve providing either a non-fasting blood sample or saliva sample. Results typically take about 2 weeks to come back, though can take as long as 12 weeks, and follow-up appointments are provided as needed. The genetic counselling and testing process is kept private and confidential, with the results shared only with those people designated by the patient.
(Sutter Health).

Persons Who should Consider Cancer Genetic Risk Assessment

Anyone with a personal and/or family history of cancer which suggests a hereditary susceptibility. Features of hereditary cancer susceptibility include:

- Cancer diagnosed younger than age 50
- More than one close family member diagnosed with either the same type of cancer or related cancers (e.g., breast and ovarian, colon and uterine, melanoma and pancreatic)
- Diagnosis of rare cancer or a rare tumour
- Diagnosis of two or more primary cancers in the same person
- Multiple generations affected with the same type of cancer or related cancers
- Anyone with questions or concerns about their family history of cancer
- Anyone considering cancer genetic testing
- Anyone who has already undergone genetic testing and would like to discuss the results in detail

(Sutter Health).

The Cost of Genetic Testing in South Africa

The cost of genetic services in South Africa depends on the specific type of test requested. According to available figures, the cost varies between R1 500 and R13 400 per test, depending on the type of genetic test requested.

Genetic Tests Available in South Africa

According to the Division of Human Genetics, National Health Laboratory Services (NHLS), for those genetic tests not available in South Africa, overseas testing is a possibility. The NHLS also has the Somatic Cell Genetics Laboratory which specialises in cancer diagnosis and testing.

The following genetic tests are available in South Africa:

Chromosome analysis: Blood (constitutional)
Chromosome analysis: Tissue (constitutional)
Chromosome analysis: Skin
Chromosome analysis: Amniotic fluid
Chromosome analysis: Chorionic villus
Chromosome analysis: POC
QF-PCR: Aneuploidy
Chromosome breakage: Fanconi Anaemia
FISH: Pre-natal aneuploidy
FISH: CEP X/CEP Y (XX/XY ratios)
FISH: Pallister-Killian tetrasomy 12p
FISH: Wolf-Hirschhorn Disease
FISH: Cri-du-Chat Syndrome
FISH: SOTOS Syndrome
FISH: Williams-Beuren Syndrome
FISH: Langer-Gedion Syndrome
FISH: Prader-Willi / Angelman
FISH: Smith-Magenis Syndrome
FISH: Miller-Dieker Syndrome
FISH: DiGeorge Syndrome
FISH: Phelan-McDermid Syndrome
FISH: Kallmann Syndrome
FISH: SRY gene microdeletion
FISH: "Rare abnormality"
Genetic Counseling
5-Alpha reductase deficiency
Alpha-1 antitrypsin deficiency DNA test
Andermann Syndrome
Androgen receptor insensitivity
ApoE DNA test
AR Polycystic Kidney Disease
AR Polycystic Kidney Disease linked markers
ARX
ARX sequencing

Ashkenazi Jewish Screen
Alpha-Thalassaemia DNA test
Alpha-Thalassaemia Mental Retardation Syndrom
Beta-Thalassaemia DNA test
Beta-Thalassaemia linked markers
Beta-Thalassaemia ARMS
Bardet-Biedl Syndrome
Bardet-Biedl Syndrome BBS1
Barth syndrome
Biotinidase deficiency
Bloom Syndrome (Ashkenazi Jewish)
Canavan Disease (Ashkenazi Jewish)
Cerebrotendinous Xanthomatosis
Charcot-Marie-Tooth
Colon Cancer
Congenital adrenal hyperplasia DNA test
Costello Syndrome
CPT2 Deficiency
Craniosynostoses
Cystic Fibrosis
Cystic Fibrosis linked markers
Cystic Fibrosis DF508
Cystic Fibrosis 3120
Cystic Fibrosis sequencing
Cystic Fibrosis (Ashkenazi Jewish)
Dentatorubral Palidolyusian Atrophy
Duchenne / Becker Muscular Dystrophy
Duchenne / Becker Musc Dys linked markers
Dystonia
ENaC R563Q mutation for Liddle syndrome
ENaC sequencing for Liddle syndrome
Familial Adenomatis Polyposis
Familial Adenomatis Polyposis (Family-based)
Familial Adenomatis Polyposis gene sequencing
Familial Breast Cancer
Familial Breast Cancer (Afrikaner)
Familial Breast Cancer (Ashkenazi Jewish)
Familial Breast Cancer protein truncation
Familial Breast Cancer sequencing
Familial Breast Cancer MLPA
Familial Breast Cancer HRM
Familial Dysautonomia (Ashkenazi Jewish)
Familial Hypercholesterolaemia
Fanconi Anaemia DNA test
Fanconi Anaemia (Ashkenazi Jewish)
Fanconi Anaemia (Afrikaner)
Fanconi Anaemia MLPA
Fanconi Anaemia sequencing
FMR1-Related Disorders
FMR1-Related Disorders Southern Blot
FMR1-Related Disorders linked markers
Fragile X Syndrome
Friedreich ataxia
Galactosaemia DNA test
Galactosaemia DNA test (European mutation)
Galactosaemia gene sequencing
Gaucher Disease DNA test
Gaucher Disease (Ashkenazi Jewish)
Gaucher Disease (Afrikaner)
Gaucher Disease (Black)
Gilbert syndrome DNA test
Glutaric Aciduria type 1 DNA test
Glutaric Aciduria type 1 gene sequencing
Glutathion synthetase deficiency DNA test
Glycogen Storage Disease 1A (Ashkenazi Jewish
Haemochromatosis
Haemophilia A DNA test
Haemophilia A Intron 1
Haemophilia A Exon 14
Haemophilia A sequencing
Haemophilia A MLPA
Haemophilia A linked markers
Haemophilia B DNA test
Haemophilia B linked markers
Heriditary hearing loss (Caucasian)
Heriditary hearing loss (Black)
Heriditary hearing loss
HNPP
Huntington Disease
Huntington-like type 2 disease
Kennedy's Disease
Leber hereditary optic neuropathy (LHON)
Leigh syndrome (LS) DNA test
Leigh syndrome (LS) PDHA1 DNA test
Leigh syndrome (LS) SURF1 DNA test
Lesch-Nyhan syndrome DNA test
Lipoid Proteinosis
Lipoprotein lipase DNA test type 1 hyperlip
Maternal Cell Contamination Screen
MCAD DNA test

McArdle's Disease DNA test
MELAS DNA test
MERRF DNA test
Microdeletion / duplication syndromes (MLPA)
Microsatellitle Instability analysis
Mitochondrial DNA deletion screen
Mitochondrial DNA mutation screen
Mitochondrial non-syndromic deafness (MNSD)
Mucolipidosis IV (Ashkenazi Jewish)
Multiple Endocrine Neoplasia Type I
Myoadenylate deaminase deficiency DNA test
Myotonic Dystrophy
Myotonic Dystrophy Southern Blot
NARP DNA test
NAT2 genotyping
Niemann Pick Disease type A (Ashkenazi Jewish
Oculocutaneous Albinism
OTC DNA test
OTC linked markers
Paternity Testing
PolG DNA test
Porphyria Cutanea Tarda
Porphyria Variegata
Prader-Willi / Angelman Syndr DNA methylation
Prader-Willi / Angelman Syndr linked markers
Primary Hyperoxaluria Type 1 DNA test
Pseudoxanthoma Elasticum
Pyruvate Carboxylase DNA test
Rett Syndrome
Rett Syndrome sequencing
Ryanodine receptor for AR centronuclear myopa
Sexing / Y chromosome marker
Sickle Cell Anaemia DNA test
Spinal Muscular Atrophy
Spinal Muscular Atrophy MLPA
Spinocerebellar Ataxias
Steroid-resistant Nephrotic syndrome DNA test
Subtelomeric deletions / duplications (MLPA)
Tay Sachs Disease (Ashkenazi Jewish) DNA test
Thymidine Kinase 2 DNA test
Thyroid Cancer
TPMT genotyping
Uniparental Disomy 14
Uniparental Disomy 14 linked markers
X-linked adrenoleukodystrophy (X ALD) DNA tes
X-linked mental retardation screen (non-syndr
Y-Chromosome Microdeletion
"Rare disease" DNA test
Stargardt Disease
"Rare disease" IMD test
5' Pyrimidine nucleotidase
Chitotriosidase
Fabry
Fucosidase
Galactokinase enzyme test
Galactosaemia enzyme test
Gauchers
Hurlers
Mannosidase
Maroteaux Lamy (MPS VI)
Metachromatic leukodystrophy
Morquio B (MPS IV(B))
MPS electrophoresis
Pompe's
Red cell adenosine deaminase
Sanfilippo B (MPS III(B))
Scoline apnea
Sly (MPS VII)
Tay Sachs enzyme test
Urine MPS

(easyDNA South Africa; National Health Laboratory Services; Panorama Fetal Medicine; Genediagnostics; DNA Test; Unistel Medical Laboratories; Lancet Laboratories; Ampath).

What the Results of Genetic Testing Means

Genetic testing can have several possible results: positive, negative, true negative, uninformative negative, false negative, variant of unknown significance, or benign polymorphism.

These results are described as:

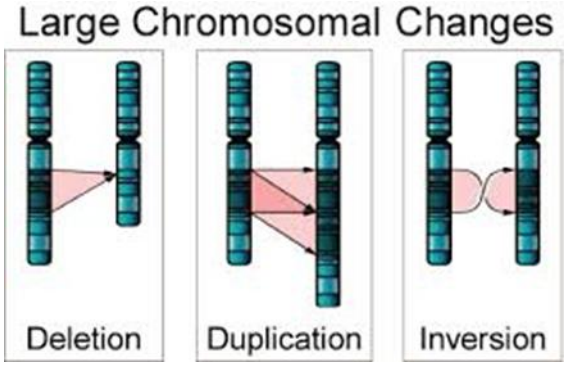
Positive test result - the laboratory found a specific genetic alteration (or mutation), associated with a hereditary cancer syndrome.

A positive result may:

- Confirm the diagnosis of a hereditary cancer syndrome
- Indicate an increased risk of developing certain cancer(s) in the future
- Show that someone carries a particular genetic change that does not increase their own risk of cancer but that may increase the risk in their children if they also inherit an altered copy from their other parent (that is, if the child inherits two copies of the abnormal gene, one from their mother and one from their father)
- Suggest a need for further testing
- Provide important information that can help other family members make decisions about their own health care
- Also, people who have a positive test result that indicates that they have an increased risk of developing cancer in the future may be able to take steps to lower their risk of developing cancer or detect cancer earlier, including:
    - Being checked at a younger age or more often for signs of cancer
    - Reducing their cancer risk by taking medications or having surgery to remove 'at-risk' tissue (These approaches to risk reduction are options for only a few inherited cancer syndromes)
    - Changing personal behaviours (like quitting smoking, getting more exercise, and eating a healthier diet) to reduce the risk of many cancers

A positive result on a prenatal genetic test for cancer risk may influence a decision about whether to continue a pregnancy. The results of pre-implantation testing (performed on embryos created by in vitro fertilisation, can guide a doctor in deciding which embryo (or embryos) to implant in a woman's uterus.

Finally, in patients who have already been diagnosed with cancer, a positive result for a mutation associated with certain hereditary cancer syndromes can influence how the cancer is treated. For example, some hereditary cancer disorders interfere with the body's ability to repair damage that occurs to cellular DNA. If someone with one of these conditions receives a standard dose of radiation or chemotherapy to treat their cancer, they may experience severe, potentially life-threatening treatment side effects. Knowing about the genetic disorder before treatment begins allows doctors to modify the treatment and reduce the severity of the side effects.



[Picture Credit: Chromosomal Changes]

Negative Test Result - the laboratory did not find the specific alteration that the test was designed to detect. This result is most useful when working with a family in which the specific, disease-causing genetic alteration is already known to be present. In such a case, a negative result can show that the tested family member has not inherited the mutation that is present in their family and that this person therefore does not have the inherited cancer syndrome tested for, does not have an increased genetic risk of developing cancer, or is not a carrier of a mutation that increases cancer risk. Such a test result is called a 'true

negative'. A true negative result does not mean that there is no cancer risk, but rather that the risk is probably the same as the cancer risk in the general population.

When a person has a strong family history of cancer but the family has not been found to have a known mutation associated with a hereditary cancer syndrome, a negative test result is classified as an 'uninformative negative' (that is, does not provide useful information). It is not possible to tell whether someone has a harmful gene mutation that was not detected by the particular test used (a 'false negative') or whether the person truly has no cancer-predisposing genetic alterations in that gene. It is also possible for a person to have a mutation in a gene other than the gene that was tested.

If genetic testing shows a change that has not been previously associated with cancer in other people, the person's test result may report 'variant of unknown significance', or VUS. This result may be interpreted as inconclusive, meaning that the information does cannot be used in decision making regarding health care decisions.
If the test reveals a genetic change that is common in the general population among people without cancer, the change is called a 'polymorphism'. Everyone has commonly occurring genetic variations (polymorphisms) that are not associated with any increased risk of disease.
(National Cancer Institute).

Genetic Counselling and Testing
Genetic counselling involves a discussion of personal or family history of cancer. It is typically recommended for individuals or families with multiple cases of cancer diagnosed at unusually young ages.

Genetic counsellors will inform about the scientific concepts that relate to genetic testing and help individuals decide what genetic tests, if any, might be useful for them.

Genetic testing involves a simple blood test and may be used to obtain a more precise estimate of your cancer risk. In some cases, genetic testing can also be done on stored tissue samples from deceased relatives.

Genetic testing is not required for a cancer risk assessment. However, it may in some cases help the physician make important decisions about medical care.

Deciding whether to undergo genetic testing is a personal choice that can be made at the time of the counselling session or at a future date. Genetic counselling does not require genetic testing, as genetic testing may not be useful for everyone receiving genetic counselling either.

The Current Status of Genetic Testing in South Africa
Serious concern was expressed recently during a combined meeting of of the National Health Research Ethics Council (NHREC) on 13 September 2016, in collaboration with the Academy of Science of South Africa (ASSAf) on the Ethical, Legal and Social Issues (ELSI) related to Human Genetics and Genomics in South Africa: Consensus Study.

It was pointed out that there is inadequate control over genetic testing, keeping of records, access to personal information of patients and over who may conduct genetic testing and

counselling. The is existing legislation in South Africa regarding genetic testing – but it is in the form of The Criminal Law (Forensic Procedures) Amendment Act 37 of 2013 (also often referred to as the 'DNA Act') which was passed into law on the 27 January 2014 in the Government Gazette, Vol. 583, No. 52, Cape Town, 27 January 2014 No. 37268.

The Act establishes and regulates the administration and maintenance of the National Forensic DNA Database of South Africa (the "NFDD") by amending the South African Police Service Act, 1995.

It provides for the use of forensic DNA profiles in the investigation of crime and the use of such profiles in proving the innocence or guilt of persons before or during a prosecution or the exoneration of convicted persons. In addition, it will assist in the identification of missing persons and unidentified human remains.

The Act makes no mention of genetic testing within civil society. This results in what has been referred to as a 'free-for-all' involved in genetic testing and engineering with very little (if any) control over the safekeeping of personal information of individuals who have been the subject of genetic testing in South Africa.

Medical Disclaimer

This Fact Sheet is intended to provide general information only and, as such, should not be considered as a substitute for advice, medically or otherwise, covering any specific situation. Users should seek appropriate advice before taking or refraining from taking any action in reliance on any information contained in this Fact Sheet. So far as permissible by law, the Cancer Association of South Africa (CANSA) does not accept any liability to any person (or his/her dependants/estate/heirs) relating to the use of any information contained in this Fact Sheet.

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Cancer.Net
http://www.cancer.net/all-about-cancer/genetics/genetics-cancer

Cancer Research UK
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http://www.cancerresearchuk.org/cancer-help/trials/a-study-looking-at-genetic-causes-of-cancer

Chromosomal Changes
https://www.google.co.za/search?q=chromosomes&source=lnms&tbm=isch&sa=X&ei=AzXzUs3FJsajhgfdyYGwBQ&ved=0CAcQ_AUoAQ#q=chromosomal+mutation&tbm=isch&facrc=_&imgdii=_&imgrc=D61Qp5KIAIbMBM%253A%3BdqJsRHAWIMtLOM%3Bhttp%253A%252F%252Fdepts.washington.edu%252Fchdd%252Foutlook%252Fimages%252FLgChromosomalChanges.png%3Bhttp%253A%252F%252Fdepts.washington.edu%252Fchdd%252Foutlook%252FOutlook_2009-Issue1.html%3B400%3B258

DNA Test
http://www.dnatest.co.za/

easyDNA South Africa
http://www.easydna.co.za/

Gene Diagnostics
http://www.genediagnostics.co.za/geneticservices/diseases.html?gclid=CMqhjpuwoLwCFZShtAodJW4Ayg

Genetic Counselling in South Africa
http://www.geneticcounselling.co.za/type-hbocs.php#BrRole

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