GENETICS and YOU

By

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An Inaugural Lecture

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PREFACE

Today, it is my singular honour and privilege, by the "Grace of God" that I shall be presenting my inaugural lecture as a Professor of Plant Genetics in God's own university "Nnamdi Azikiwe University, Awka". Great UNIZIK- Great! First, I shall like to give a brief resume of my profile. I was appointed Assistant lecturer in 1983, having obtained an M.Sc degree in Botany from Ahmadu Bello University Zaria. By special grace of God and dint of hard work, I rose through the ranks after obtaining a Ph. D Degree in Plant Genetics in 1989 to the rank of professor in 1998. I wish to express my profound gratitude to Professors Gilbert Uwahamaka Okereke, F. A. Nwako Pita Ejiofor and J. O. Uzo, for their encouragements.

I shall like to acknowledge the invaluable help rendered to me while preparing this manuscript by Professor R. I. Egwuatu, Mrs. Virginia Nzegwu. I also acknowledge illustrious professors of this University including Professors E. U. Obienu, E.C.L. Nnabuife, Ogum, Ekejiuba, I. E. Nwana, Sam Omenyi, Nze, F. J. C. Odibo, F. O. C. Ndu and to brothers Dr. J. C. Okoye, Dr. Emma Okoye, Brother, David Enweremadu, Sam Ufo, Dr, Nath Nwankpa, Bro. Goddy Umerie, Prof. Tony Ogbalu, Bro. Tim Umeasiegbu, Dr. Mike Ezeama Bro. Akabogu and Prof. J. I. Igbokwe for their moral support. I salute you all, and may God's abundant mercy overtake you all in Jesus name. Amen.

Finally, I sincerely acknowledge the invaluable help both in cash and kind rendered to me by my beloved

wife Mrs. Elizabeth Nkiruka Anaso-yes behind every successful man is a woman. My brothers Prof. Akachukwu Anaso, Dr. George Anaso and Mr. Sigismund Anaso and my sisters Mrs. Doris Egwu, Mrs. Grace Arubalueze, Mrs. Patricia Obiokpala and Mrs. Edith Igwealor. I also appreciate the help rendered by my children Chinelo, Ifeoma, Ugochinyere, Ogechi, Emmanuel Chinonso and Prosper Kenechukwu.

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GENETICS AND YOU

Introduction

Genetic is that discipline that deals with the study of hereditary characters and variation in organisms and how these characters are transmitted from generation to generation. Man's exploratory attitude which manifested when he started to live a settled life made him to notice individual differences between and among organisms which persisted from prehistoric times. This persistence of individual differences among organisms suggested that some differences or traits are heritable.

Myriad of distinction could be drawn between living and non-living things, plants and animals, human beings and lower animals, as well as higher and lower plants. As a result of these distinctions, one is able to say with some degree of certainty that "like begets like". In other words man beget man, lower animals like cattle, sheep and goat beget organisms of their own species, plants also beget plants and not otherwise.

Even among organisms of the same species there are physical diversities as noted in heights, size, girth and modification of pendactyl limbs. Also among plants there are differences in heights, fruits, flowers and plant habits. This lecture therefore deals with heredity and variations and some aspects of evolution, and how characters are transmitted from parents to offsprings of generation. The

lecture also deals with the application of genetics for bettering human stock and breeding of animals and plants to get better stock. Included in this text are basic terminologies used in the text for better understanding of genetics by prospective students of genetics.

Brief History of Genetics

The discipline "Genetics" was formerly given an insignificant place in Nature study now called "Biology". It became fully established as a discipline of its own after the "Renaissance", when some early scholars became aware of flaws in the reasoning of early Greek philosophers like Hippocrates (400BC) and Aristotle (350BC) about the nature of hereditary material. Hippocrates (400BC) suggested that the reproductive materials called gametes came from all parts of the individual's body, hence that characters were handed down directly to the progeny from various parts of the body. Hippocrates made reference to a race of mankind called Macrocephali, who immediately after a child was born fashioned its head by hand to give it an elongated shape (White House 1973). Our people still practice that today; young mothers are advised to rub olive oil and re-shape the head of the baby immediately after birth to give it a characteristic round shape.

Aristotle (350BC) however questioned the views of Hippocrates, pointing out the flaws. Aristotle eventually suggested that children may resemble their grand parent more closely than their parents.

Reverend Father Gregor Mendel

A very prominent scholar who made a very strong impact in Genetics and is forever held in highest esteem as the 'father of Genetics" was Rev. Father Gregor Mendel (1822-1884). Gregor Mendel was an Austrian Augustinian Monk in Bruun in Czechoslovakia and deployed as a pupil teacher in the monastery. Being a naturalist, he set up a small research garden in the compound of the monastery where he carried out researches on garden pea *Pisum sativum.* The plant has a short generation time (about 3 months) and is self pollinating, but cross pollination can be carried out by man. Gregor Mendel worked on a series of characters including plant height, stem, yield and shape of fruit i.e. whether rounded or wrinkled. The result he obtained from his elegant investigation led to propounding of two important laws of heredity on which other laws were based. Gregor Mendel was not the first person to carry out a hybridization experiment but he considered his results in terms of single traits. His predecessors had considered whole organisms which incorporated a nebulous complex of traits; thus, they could only observe similarities and differences among parents and off springs. They however missed the significance of individual differences.

Although Gregor Mendel devised a mathematical model for the transmission of hereditary units, he had no concept of the biological mechanisms involved. Nevertheless, on the basis of his preliminary experiments and hypothesis, he predicted and subsequently verified his predictions with results of latter crosses and enunciated two important laws of heredity – viz the law of germinal

units and law of independent assortment of genes, Gregor Mendel however did not live long enough to see the fruitful result of his work.

His work was however re-discovered by three Botanists; Hugo-de-vries in Holland, who is also known for his mutation theory and studies on evening primerose and maize; Carl Corns in Germany who investigated on maize, peas and beans and Eric Von Tschemark – Seysenegy in Austria who worked on several plants including pea.

Genetics blossomed after the First World War. The mathematical aspects of Genetics called Biometrics or Biometrical Genetics or Biometry grew stronger with the works of William Bateson, R. N. Fisher, Mather and Jinks. The theory of inheritance and the revealing analysis of cell division by Darlington C. D. (1929) extended the frontier of knowledge of science of genetics. The knowledge of Genetics had ever since gained considerable ground and can be applied to all organisms whether animals or plants to solve a variety of problems. This inaugural lecture, deals with the application of genetic knowledge in the quest to better human, animal and plant stocks.

The study of Genetics is very closely linked with evolution or a series of gradual processes of development of organisms into different forms. For example lower organisms develop into more complex organism – a process called progressive evolution or a complex organism can degenerate into simpler forms – a process called retrogressive evolution or where a number of closely related organisms come together to interbreed to give rise to a variety of biotypes called divergent evolution

or finally where a series of closely related individuals can interbreed to produce off types and this type of evolution is called convergent evolution.

About the Origin of Man

The book on the origin of man by Charles Darwin makes for an interesting reading, but there are many loopholes to doubt the authenticity of the facts presented and these tend to conflict with the stories of the Bible about the creation of man. I strongly believe the biblical stories about the creation of man by the most superior being our God (Jehovah Emmanuel). The evolutionary stories were punctuated by unbelievable facts about origin of human beings from great apes. There are still doubts about missing links and no scientist had stepped forward to claim the authenticity of Darwinian story. However, the age of giants, the great flood and discovery of fossil remains of early man from the rift valley of east Africa reconciled some facts in Darwinian Theory with the Biblical stories.

The first man as recorded in Archeological records existed on earth about 2,750,000 years ago and this man was called **Zinjanthropus boisei.** This man, as shown by archeological records from fossil remains had an erect posture but the skeleton bore close resemblance to that of a gorilla. An estimation of the age of the earth as shown by fossil records was above 5,000,000 years. It shows in essence, that Adam and Eve - the first human beings - were created roughly above 2,300,000 years before Zinjanthropus boisei. The resemblance of Zinjanthropus to an ape might be as a result of primitive nature of early

man with his wandering attitude, after man had sinned and was chased out of the Garden of Eden. Facts to be investigated by scientists, are if man actually originated from apes? If the story is true when a baby is born, the baby will first be an ape and I doubt how long it will take the baby to change to normal human being. Some apes in the British museum have stayed over 150 years.

A descendant of Zinjanthropus boisei, called *Pithcauthropus erectus* or Java man, came into existence about 2,000,000 years ago and is taller than *Zinjanthropus boisei,* with more human features than a gorilla. The third species of man called Cro-Magnon man came into being about 1,500,000 years ago and was a giant. His existence coincided with the age of giants in the Bible. There is no doubt however that man and lower animals have different lines of evolution, and God created man to be distinct from lower animals. The changes in heights and behaviour patterns of human beings from the time Adam and Eve were sent out of the Garden of Eden may be due to changes in environmental factors. Even nowadays some poor peasant village farmers look like apes in the way they appear after staying in the farm for days.

Difficulties in Studying Human Genetics

The long generation time between birth and reproduction which at least takes about 18 years makes study of human genetics difficult and tedious. The use of questionnaires is completely ruled out because behaviour and motives in human is unpredictable. Most

information are attained from hospital records where births and deaths are recorded and study of lineage of closely related members of a family. Since the development of science of genetics, there had been suggestions on how to study human genetics and encourage breeding for better characteristics like skin complexion, aquiline nose, well-set teeth, good pair of eyes and elimination of human genetic diseases. One such study is called Eugenics.

The concept of Eugenics was misconstrued by some laypeople who practiced it to ridiculous dimension. For example, in some parts of Europe, Eugenics entailed destruction of all human beings with one type of abnormality or another. An abnormality like albinism is seriously frowned at by the general public. Albinism could be avoided if one is careful in studying family history and listening to advise from counselors.

Albinism can be classified in two ways -viz the real albino with the genetic constitution (aa) and red skinned albino with the genetic constitution Aa but mutation has taken place in the gene for pigmentation. Apart from absence of gene for skin pigmentation, in pure albinos they are as normal as any normal person in terms of intelligence and other factors. On the other hand, red-skinned albinos have better physical appearance, because of slight mutation in the gene for skin pigmentation leading to olive coloured complexion. Other harmful genes which can be carefully avoided include insanitary gene, genes for juvenile eye cataract, haemophilia and phenyliketoneuria which are classed as genetic diseases.

Insanitary genes can appear once in a while in human population and these have a variety of causes. Some are brought about by physical accidents involving head injuries and spinal injuries, some by environmental factors while the rest are brought about by genetic accidents and are therefore transmitted from generation to generation. However madness caused by other factors other than genetic can be rectified with time. If the principles of eugenics are applied to all cases of madness as was done in the early nineteenth century, this can lead to unwanted destruction of human lives. In a town in Njikoka local government there was the case of a man who was mad for over 20 years. The name of the man was Reuben Achuama Nwankwo and he is fully recovered and gives testimonies of what the Lord did for him. He was not mad from birth but became mad in his late teens probably due to some traumatic environmental events. Perhaps, a better way of avoiding these harmful genes instead of messy killings is to offer sound advice based on genetic principles to spouses about to get married. In Nigeria, eugenics is practiced in a subtle manner. This is in the form of information needed from the extended families of the spouses before consent is given to such a contract.

Abnormalities like sickle cell anaemia, melancholy, blindness at an early age and a host of genetic diseases are cleared by both families before the final consent is given. In many parts of Nigeria especially in big hospitals, genetic counseling centres are set up to give information and counseling about inborn defects and how to avoid families with such defects. Blood tests are also conducted so that a sound advice is given on determination of sexes of babies

pre-selection and family planning. On this note it is important to deal with sex determination, pre-selection and family planning, as ways of alleviating human problems, connected with sex and family planning.

Sex Determination, Pre-selection and Family Planning

The sexual dimorphism which persisted from generation to generation is determined at conception and depends on which gametes fertilizes the egg. The male sex has got the genetic constitution XY and in said to be Heterogametic sex because of the different chromosomes X and Y. The female sex however has got the genetic constitution XX and in said to be Homogametic sex. In terms of morphological difference the x-chromosomes are rod shaped while the Y-chromosomes are hooked. So out of 23 chromosomes found in the male gametes 22 of them are rod shaped and are called autosomes while one is hooked and called Y-chromosomes. In females there is only one x-sex chromosome and 22 autosomes. So a man at maturity can produce two types of sperms viz one with X-chromosome and the other with Y-chromosome but the two types of sperms differ in longevity. The sperm bearing Y-chromosome moves very fast but lasts only for one day, while the sperm bearing X- chromosomes moves very slowly but can last longer when released in the body of a female.

Ovulation:

This is the period when females release matured eggs into the fallopian tube. Ovulation period is not easy to tag in most women but there is a popular belief that every 14 day starting from the first day of menses a matured woman releases one matured egg. A cyclical change lasting for 28 days during which new eggs are released in women is called oestrous cycle. In some women the oestrous cycle can last longer or shorter than 28 days. In women who alternate long with short cycles, the real ovulation period can be calculated by adding the long and short cycle and dividing by two. More details about getting the actual ovulation period could be obtained in Ezeonu Emeka and Ben Okeke 1999 and Leonie P. McSweeney as cited by Billings makes use of clinical thermometer to monitor changes in temperature for about 6 months. Any slight rise in temperature during the cycle is indicated as the ovulation time. Some women can even tell when they are ovulating. Some report that a day to their ovulation that they feel some stabbing pains around the groin which lasts for a few hours. If no treatment is given, the pain disappears and with its disappearance is release of egg in the fallopian tube.

Conception and Sex of Baby

If intercourse takes place when an ovum is released, it is possible that a sperm will surely fertilize it. As pointed out earlier, two types of sperm viz Y-chromosome carrying sperm and X-chromosome carrying sperm are released at the same time. The sperm with Y-chromosome usually moves faster than the one with X-chromosome but can die

after 1 day. The sperm carrying X-chromosome moves sluggishly but can last for 3-4 days in the body of a woman when released. If eventually the Y-chromosome carrying sperm fertilizes the egg then the baby will be a boy with the genetic constitution XY. A factor that had helped most couple is that ovulation following longer days of menses usually yields a male offspring.

Myths About Pre-selection

There was a popular belief among the illiterates that a woman can determine the sex of her babies. According to this group of people, women should be appeased when they take in so that they will give birth to male issues as requested by their husbands. But such a belief is without foundation and there is no scientific proof. Whatsoever you give to a woman during reproduction following ovulation, the same she gives you after nine month gestation period.

Secondly, some couples who have been giving birth to female children were advised by some elders in the village to change the position of their bed during the next intercourse. This also had no scientific proof because it has failed to yield the desired result in most couples.

Thirdly some herbalists like Ezeudu, (unpublished), Iyida and a host of others (unpublished) advertised the potency of some herbs (only known to them) to change the sexes of a female embryo a few weeks after conception to male. This is not also easy to prove because the chances are that the embryo maybe a male before the administration of the so called herbal concoction. But one thing is abundantly clear; whether you get a male or

female child depends on the decision of the Almighty God. So it is very important that people to be married should remain chaste, during which they have to commit themselves to serious meditation about the contract they will enter into

In a lighter mood, whenever people hear such names as *"Nwanyi Ezugo"* (or enough of females) and *'Nwoke abia"* (a man has arrived), it entails that such a family was in dare need of a male issue before the arrival of one. Other names like *"Atuanya"* (for boys) and *"Eyiuche"* (for girls) are given to children who were born when their parents have lost hope to child bearing.

Recent Advances in Human Genetics

Recently, a number of biotechnological breakthroughs have been made in areas of cell and tissue cultures. Cases of *in vitro* fertilization and cryogenic ovular storage are recent developments in Genetics. At the close of the last millennium reports were made about some scientists who cloned sheep and called the process "dolling". These scientists went a step further to clone human beings. The church and the government are highly against this development because "God" who created man in his own image made it that production of human beings should only be by sexual reproduction. As such rearing of children is a collective responsibility. So any method of reproduction involving cloning may incur the anger of the "ALMIGHTY".

DNA Technology

The most recently developed offshoot of genetics called "Genetic Engineering" had gone into molecular aspects of genetics leading to modification of DNA technology. The DNA was interpreted by Watson and Greek in 1953 as the gene itself.

However, modern discoveries have shown that the DNA has the same chemical composition as the gene and contain the gene. Genetic engineering has so modified DNA technology in such a way that a small segment of DNA can be used in copying a whole DNA. This branch of genetic engineering is called forensics application of DNA technology. By this method, application of principles of polymerase chain reaction (PRC) in which millions of copies of a nucleotide sequence can be synthesized *in vitro* in a few hours. It was first developed by Setus Corporation of the USA in 1986 and since then been bought and used by "Roche" company. It allows the selective amplification of any fragment of DNA provided that the DNA flanking the fragments are known. Shorter stretches of synthetic DNA consisting of 15 to 60 nucleotides are used as primer and are complimentary to 5 prime and 5 prime flanking regions. Other applications of DNA technology include the use of microorganisms for producing human growth hormones, crop improvement, and improvement of farm animals for higher performance through injection with Human Growth Hormone engineered into yeast.

There had also been a lot of improvement in the health of people suffering from genetic diseases. For example sickle cell anaemia which had claimed a lot of lives in the past can now be treated both with drugs and gene

transplant developed in genetic engineering. Also Leukemia or blood cancer can be successfully treated with genetically transformed Rosy periwinkle a herb found in African forest.

The Hereditary Characters

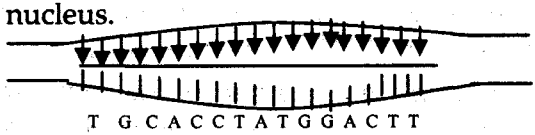
Perhaps we can ask about two or more pertinent questions to help us understand fully the mechanism of inheritance. These questions are "what are hereditary factors?" And how are characters transmitted from parents to offsprings.

A close look at various organisms show that each organism gives rise to offspring of its own species – that offsprings resemble their parents to some extent; that is "like begets like" what is actually responsible for offspring to resemble their parents and how is this factor transmitted?

To begin with the gene is lodged permanently on the chromosome (called gene Carrier) and the chromosome cannot move out of the nucleus because the nuclear pores which perforate the nuclear membrane are so tiny to allow the chromosome to pass. Three macromolecules are designed to carry information from the gene to cytoplasm of the cell. These are messenger-RNA, transfer-RNA and Ribosomal RNA. The messenger RNA is a single stranded molecule which bears very close resemblance to the gene but differs in one of the organic bases- uracil, which replaces thymine. The transfer-RNA resembles the messenger –RNA but differ in the arrangement in that the strand of transfer RNA is double backed on itself and twisted into a helix. One of the molecules has three unpaired base projecting from it and these vary from the

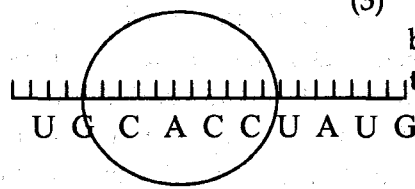
molecule to another. The messenger-RNA, transfer RNA and ribosomal-RNA were assumed by some theories to have originated from the molecules of a young daughter cell and later migrate to their definitive positions.

(1) Messenger RNA (-) synthesis along DNA Strand in the nucleus.



(2) Messenger RNA passes out of the nucleus into cytoplasm

(3) Messenger RNA becomes attached to the ribosome



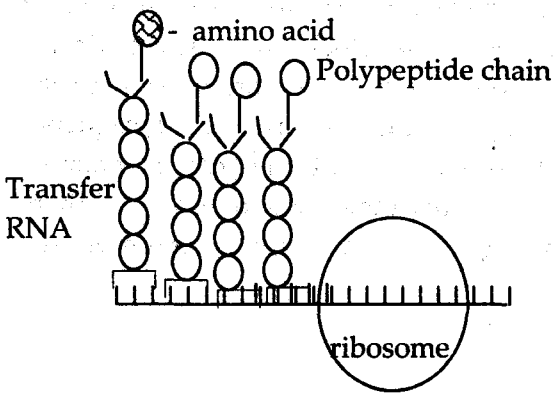


Figure 1: *Stages in RNA Synthesis*

What is transmitted from the gene of parent organism is the ability to produce a particular type of protein. The information is stored in form of a code, called genetic code, or triplet code or codon. This code is written in form of three organic bases which go together AAT- Adenine, Adenine, thymine; others are GCC-Guaine cytosine, cytosine and so forth.

To transmit the information carried by the gene, free RNA radical crawls in between the arms of the DNA which unzips to allow it. As it enters, the zip closes and information is stored in the messenger RNA by transduction so that clearly the sequence of bases in the completed RNA molecule will be identical with one of the two strands of the DNA, the one which did not act as a template. After collecting the information, the messenger –RNA moves out through the nuclear pore to the cytoplasm and attaches itself to one end of ribosome. Then the ribosome moves to the other end As the ribosome passes a triplet of bases the appropriate transfer RNA molecule takes up position bringing its amino acid with it. The ribosome then moves on to the next section of messenger RNA strand and another amino acid is drawn into position and so on. There are 20 amino acids in the body of a human being and they are arranged in sequence so that one comes before the other. If the order is retained, the young organism will resemble the parents but if there is deviation, the young organism may not resemble the parent.

Application of Knowledge of Genetics in Plant Improvement

Plants are very important in the life of animals including human beings, because they play very important role. First, plants are starting point of food chains since they serve as producers. They harness the sun's energy carbon dioxide and nutrients from the soil and through the process of photosynthesis are able to manufacture carbohydrates releasing oxygen as waste product. As a result the percent of oxygen in air is constant.

Secondly, the potentialities of plants are exploited to the fullest by plant geneticides for purpose of fibre and medicare. In the plants kingdom, the four divisions to which plants are grouped each play vital role for the sustenance of life on earth. Out of about 250 known species of plants one third has so far provided the world population with very high gross primary productivity while a larger percentage remain relatively unexplored; the rest are becoming extinct due to senseless restocking and carelessness of some breeders.

The increase in yield and enhancement of many agronomical characteristics registered by phytogeneticists in the last millennium is not unconnected with early clarion call made by Reverend Father Robert Malthus in the 19th century. Reverend Father Robert Malthus foresaw catastrophe in the mid-nineteenth century as the world population was growing at an astronomical rate but there was not enough food to sustain the teeming population. Little did Reverend Father Robert Malthus know that

scientists especially geneticists all over the world were about to usher in a phase of scientific agriculture which started with local biotechnology.

Primitive agriculture as we all know took off when man started to live a settled life and agricultural tools used then included wooden hoes and matchets. This was followed by brief period when plants were selected and grown on the basis of visual characters. Plants breeders and geneticists were able to raise plants with desirable characters for food therapy and aesthetics purpose. With full establishment of biotechnology genetic engineering was developed to take care of plants and animals through selective mutation breeding. Mutation breeding *per se* aims at creating genetic variability which forms the gene pool from which selections were made in an attempt to improve on local breeds.

Allard (1960) suggested three methods of improving or raising substantial genetic variability which included Mendelian variation interspecific and intergeneric hybridization and polyploidy. Mendalian variation arises spontaneously from chromosomal aberration and gene mutations but most gene mutations were reported to be disharmonious, and produced discouraging yield unless strict pedigree selection followed by trial breeding is carried out. These variations resulting from chromosomal aberrations include inversion, deletion and duplication, translocation, asynapsis, shifts and polyploidy.

Inversion

This is a chromosomal abnormality in which an arm of chromosome is twisted through an angle of 180^0. If the twisted arm contains a centromere, the inversion is said to

be pericentric, but if it does not contain a centromere, it is said to be paracentric. The diagram below shows a cases of paracetric inversion.

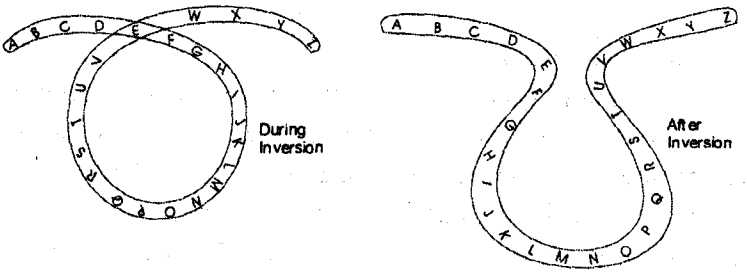


Figure 2: *Paracetric Inversion*

Cytogenetic implication of this is that when inversion takes place, it indicates that accurate pairing of chromosomes has not taken place. This may be due to loss of homology among some chromosomes about to pair at the zygotene stage which finally may lead to the formation of dicentric chromatid bidges during first and second anaphase stages of meiosis.

Inversion is not very beneficial during cell division since inversion can lead to the chromosome not pairing fully. This can lead to some chromosomes not pairing and subsequently to unequal division and distribution of chromosomes along the second metaphase plate. As a result, pollen grains of different sizes will be formed viz; giant and small ones with the giant ones being more viable. Bridges which accompany inversion lead to unequal distribution and separation of chromosome. Normal polyploidy can be formed by chromosomes doubling but when giant pollen grains fertilize normal

ova, there is aneuploidy (Anaso and Okereke, 1986; Anaso and Uzo, 1987). Anaso (1988, 1989 and 1990) reported cases of inversion which eventually led to bridge formation, abnormal pollen development and aneuploidy.

Deletion and Duplication

Deletion and duplication are chromosomal abnormalities that occur together. Deletion is a chromosomal abnormality in which one segment of a chromosome breaks off and is added to another arm of the same chromosome making it longer. Figure 3 shows a case of deletion in which the deleted arm is shorter while the duplicated arm is longer. Cytogenetic implication of this abnormality rests on gene duplication.

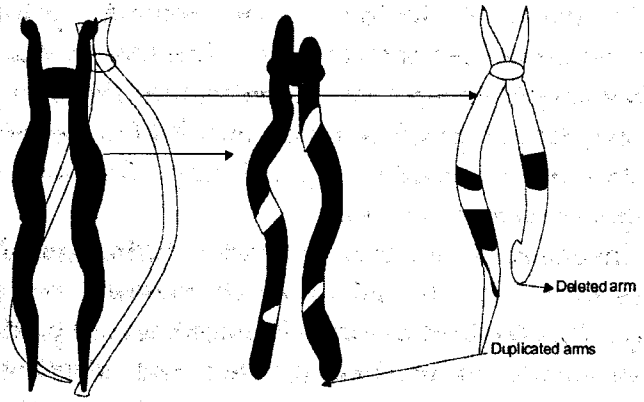


Figure 3: *A case of deletion*

It is somehow beneficial in that if the longer segment or arm contains the same gene as the other gene added to it, then such genes may serve as enhancers that help to promote the effect of already existing genes.

Translocation:

In a genetic sense, translocation is a chromosomal aberration in which a segment of a homologous chromosome separates from one arm and joins another arm of the same or different chromosome. If there is an exchange to the extent that the segments lost to one arm of a chromosome is regained by another arm of the same chromosome, we say that the translocation is reciprocal. The individuals formed as a result of this development are known as translocation heterozygote. The individuals are hybrids with profound expression of hybrid vigour. Some heterozygote shows hybrid sterility but the ones that survive under conducive environmental have many adaptive themes due to extra-chromosomes. The figure below shows translocation.

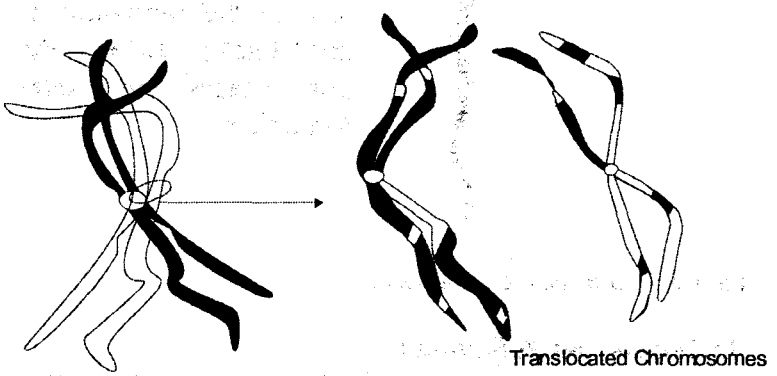


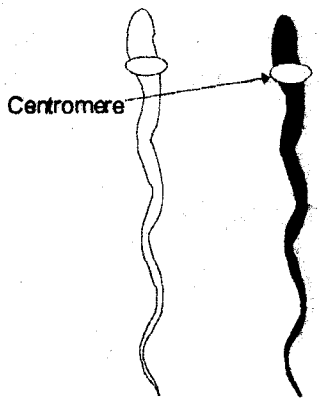
Figure 4: *Translocation*

Univalent

This is another chromosomal abnormality which is very important to plant breeders. Univalent are formed as a result of inability of chromosomes to pair up in pairable

chromosomes mates. Univalent can be formed as a result of loss of homology among pairing homologous chromosomes due to the presence of recessive genes (Gottoschalk and Baquar 1971). The univalent chromosomes behave in a variety of ways. They may lag, divide or are eliminated and this can lead to unequal distribution of chromosomes along the second metaphase plate.

Figure below show univalent chromosomes



Once these chromosomes are eliminated they can lead to the formation of micronuclei during the last stages of tetra formation

Figure 5: *Univalent chromosomes*

Asynapsis and Polyploidy

Asynapsis is a situation in which spindle formation is hindered and the chromosomes will divide as in mitosis but no separation of chromatides take place. This can be brought about by the action of drugs such as colchicines and nitric acid. The after effect is doubling of chromosomes and a polyploid is formed. Polyploidization is the most recent method of evolution and increasing a

plants genetic variability because the doubled chromosomes help to multiply certain adaptive themes. In an induced autotetraploid like the non-tuberiferious *Solanum incanum,* Anaso (1989) reported that the multiplier effect created a gene pool having many genes whose adaptive themes can help the new crop to enhance yield. Two types of polyploids recognizable include autopolyploid and allopolyploid or hybrid polyploidy. All these chromosomal mutations are regarded as structural changes in chromosomes.

Application of Genetics in Animals Breeding

Application of Genetics in animal breeding I s easier than in humans because of shorter generation time from birth to maturity. A West African dwarf goat takes about 1½ years to mature from birth and this maturity dates also vary with species of animals. Sexual reproduction is the only way of producing offsprings but artificial insemination can also be used to supplement natural method of reproduction in these lower animals. This is really the case in animals not very closely related genetically. By artificial insemination, semen from a male animal can be drawn and used to fertilize the female organism during heat period. This not only helps in keeping off sexually transmitted disease but can afford an opportunity for wide range crosses, even up to generic level. Artificial insemination had proved to be very effective not only in transferring wild germplasm but also in crossbreeding of domesticated animals. Ogundipe

(1986) reported the use of artificial insemination in raising large breeds of healthy turkey birds. Lasley (1978) pointed out the fact that wild horse *Equus przewalskii* which is a wild relative of domestic horse had a reservoir of germplasm connected with vigour and longevity and can be introduced into domestic horse during breeding by artificial insemination. For artificial insemination to succeed very well, cytological status of the animals to be crossed will be checked ahead of time to show that the chromosomes are homologous.

Pure breeds of any animal are not easy unless the genotypes of the parents were discovered earlier and the offsprings were raised by pedigree method. The first pure breed of diary cattle and sheep were introduced into the United States of America after the American war of independence. This was actually due to their pressing needs for milk and fresh meat. In-breeds of lower animals like sheep and goat can be obtained by brother-sister mating (SIBS) between closely related species using pedigree methods of breeding.

One can make use of karyotype studies in breeding and this involves studies on pachytene chromosome morphology. It is not so reliable but it can help in tracing the evolutionary relationship between the local strain and wild ancestor before cross breeding is attempted. An example is cited by Lasley (1978) in which the Karyotype of European *Bos Taurus*- Zebu, *Bos indices* and these of wild species *Bos bison* were very similar in number and appearance of chromosomes except that in males, the Y-chromosomes are sub- metcentric in *Bos Taurus* and acrocentric in *Bos indicus* and *Bos bison.*

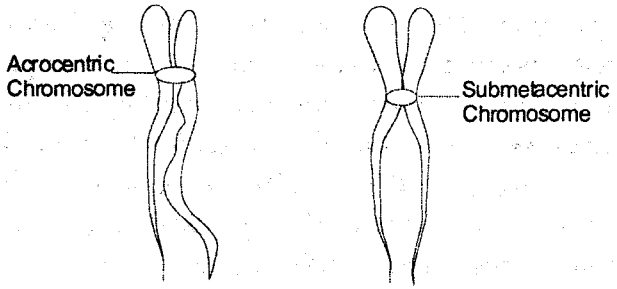


Figure 6: *Acrocentric and Submetacentric Chromosomes (Results obtained from breeding of two brown rats)*

Breeding of smaller mammals like the albino rats and rabbits is a more serious exercise. The breeding procedure run along the same dimension as those of larger mammals but greater care will be exercised during selection as regards the colour of fur coat. This is because in mice yellow colour which is recessive gene represents lethal combination of genes. The figure above shows results obtained from breeding of two brown rats which yielded yellow offsprings most of which died in embryonic stage.

Application of knowledge of genetics in breeding of fishes is yielding a very big dividend. High protein yield in fishes had been achieved through direct application of techniques like hypophysation and hormone induction, hybridization and manual stripping and artificial fertilization (Aguigwo 1994). It is also possible to change the sexes of fingerlings at certain periods in their development due to the ingenuity of geneticists.

In fish farming, there had been much improvement in fingerling producing through the application of exogenous homogenate and/or manual stripping and fertilization of fish species of *Clarias, angullaris* through the injection of

fish pituitary extract. Sex reversals are a common practice in fish farming. This is done by mere application of appropriate hormones. Gametogenesis was completely inhibited in rainbow trout (Salmogairdneri) by addition of methyltesterone, and estradiol in pellet feeds of the fishes (Billard and Richard 1982). 100% maleness in *Clarias albopuntatus* were obtained by injecting methyl-testosterous to fingerlings of fish (Aguigwo 1994).

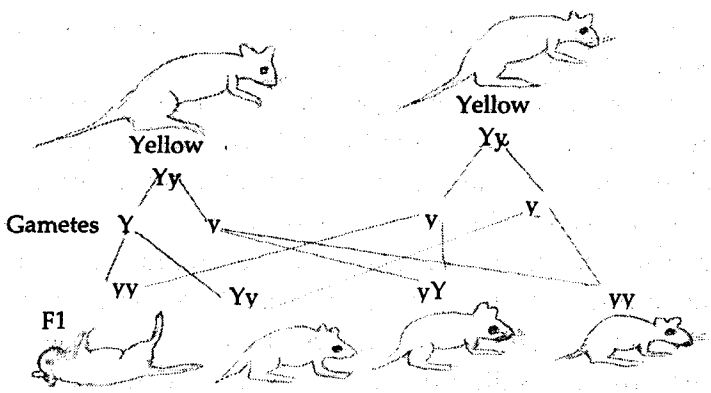


Figure 7: *Inheritance of fur colour in mice. The gene for yellow coat (Y) is dominant grey(y). The YY combination of genes is lethal so the normal 3:1 ratio is upset.* Courtesy of M. B.V. Roberts.

In poultry industry application of knowledge of biotechnology by geneticists had also made very serious impact in meat yield, control of poultry diseases through artificial insemination and feed formula leading to production of table eggs. The use of artificial insemination and cryogenic ovular transplant for transferring sperm from male to female birds have also helped to reduce the

incidence of turkey X-diseases of turkey and other sexually transmitted diseases.

Geneticists were also able to improve on strains of species of pathogenic organisms by cloning and using them for food processing (Anaso and Chukwurah, 2000).

Application of Knowledge of Genetics in Plant Improvement through tissue culture

The use of tissue culture in generating genetic variabilities in cultivated plants is another very important biotechnological breakthrough. One of the experiments in tissue culture was ventilated before the turn of the century, historically by Haberlan (1902). He did the first recorded experiments on maintaining plant tissues on artificial media. When he attempted the first plant cell culture, Haberland (1902) hoped to develop a more versatile tool to explore morphogenesis and to demonstrate totepotency of plant cells. Little did he suspect that the cell culture technique would become a valuable aid in economically oriented activities.

In 1971 Changwyal produced haploid plants from anthers of *Solanum nigrum*. These anthers were cultured in Murashinge and Skoogie's medium supplemented with NAA, IAA and kinetin of various concentrations. The medium is said to be callus stimulating medium because calluses emerge from anther slits and when transferred to differentiating media plantlets began to develop. In a series of follow up experiments by Ng (1997) and Waithaka (1992) showed that the experiment could be

extended to terminal, lateral buds cells and tissues of plants and animals with good results. Monti (1992) had earlier outlined progress made by new biotechnologies in agriculture such as micropopagation for commercial uses and overcoming interspecific barriers while *in vitro* production of haploids is now performed routinely in many laboratories. There is also somaclonal and gametoclonal variation: while direct selection in vitro have also been used to produce new cultures; somatic embryogenesis has also been used in several crops, opening the way to the development of the so called artificial seeds.

Selection techniques have made considerable progress using restriction fragment length polymorphism (RFCLPS) and this technique is useful in mapping beneficial genes and in selection of qualitative and quantitative traits. To be more explicit, tissues or cell of pollen grains after being treated with appropriate media can germinate and are regarded as ex-plants. The next interesting exercise is on raising the progeny so as to make it acclimatized to the environment and that is by trail breeding using many concentrations of farmyard manure.

Genetics in Poverty Alleviation

Genetics has also played very significant role in poverty alleviation. There had been reported cases of crop failure either through overflooding of farm lands or through pests and diseases. Overflooding can be caused by multifarious events which include rains, erosion and

landslides. These natural events can be controlled by afforestation and reforestation with fast growing plants, avoidance of cultivation in erosion prone areas and avoiding the use of drastic explosives and mines while carrying out construction works. A second way of alleviating poverty is for even the peasant farmers to make use of well certified seeds and seeds treated with chemicals while planting.

A third way is to limit mixed cropping type of farming because each crop will make different demand on the soil. More than in any other time in human history, the issues of poverty, hunger, environment, equity and low economic growth became critical globally. It is also reported that population growth is very high where poverty, hunger, environmental degradation and economic stagnation are very severe. The issue is being tackled in the tropics by various means. In Nigeria, the establishment of research institutes and colleges of agriculture is helping to stem the tide. These institutes are stepping up cultivation of common staple food materials like groundnut, maize, sorghum, cassava and yam, etc which is accessible to every one. Also even peasant farmers benefited from extension services.

Finally, there had been wide range biologically control of pests in preference to chemical control which thereby limits wiping out of biodiversity.

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GLOSSARY OF SOME BASIC TERMS USED

Biometrics Statistical analysis of biological data

Biotypes A group of individuals with the same genotypes may be homozygous or heterozygous

Chromosomal Aberration Chromosomal mutation.

Convergent Evolution An evolutionary process in which a series of closely related can come together in form off-types

Cro-magnum Man The first set of giants on earth

Divergent Evolution An evolutionary process in which a number of closely related organisms interbreed to form biotypes

Eugenics Science of improving human race by breeding

Forensic Connected with scientific tests carried out by the police in order to find out a criminal

Gene-mutation Change in the biochemical nature of the gene

Lineage Line of ancestor or descendants

Macrocephali An ancient race of human

Monk A male catholic priest who lives in a monastery

Progressive Evolution An evolutionary process in which simplex organism develop into more complex ones

Retrogressive Evolution Evolutionary trends in which a complex organism degenerate into simple form.

Species A group into which plants and animals that can interbreed is places

Zinjanthropus Boisei First early man believed to come from East Africa according to archeological records.