Nature's super software

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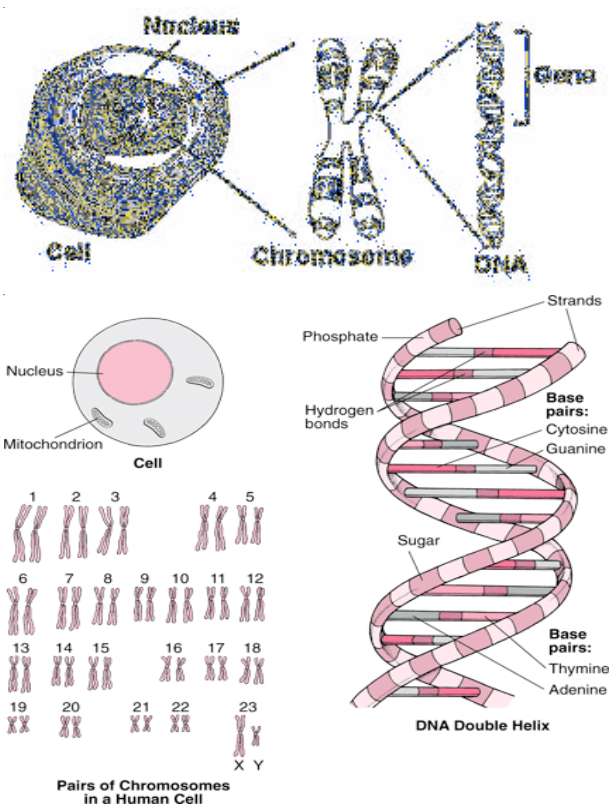
Judging by its miniature size and the range of outputs it generates, ***the set of genes*** in a zygote is the ultimate super software and the man-made software is no match to it.

All living beings begin their life from a single cell including higher forms. Human too are no exceptional to this phenomenon. Human development can be taken for better understanding of this nature's spectacle. In man, it all starts with the fusion of sperm (one of the smallest cell of human) from father and ovum (largest cell of human) from mother. Each parent donates half the total number of chromosomes in this union and the event is termed as fertilization and the product is called zygote. It contains 46 or 23 pairs of chromosomes. Each chromosome pair has a male and female parent representation. Zygote (size about 100 micro meters) is the first cell of human capable of forming an entire individual. This potent cell is said to possess totipotency, which is the capacity to give rise to any type of human cell.

The chromosomes present in the zygote contain a wonder molecule called DNA (Deoxyribonucleic acid), a complex molecule present in twisted form. DNA contains simple units called nucleotides. Variable numbers of nucleotide may function as a single unit which is popularly known as gene. A single DNA may contain hundreds of this unit and naturally the number of genes far exceeds the number of chromosomes. The entire DNA in the zygote with its genes is considered as the 'blue print of human life'.

Human genome contains about 23000 protein coding genes. Each gene is unique in its expression, basically has coded

information for a particular protein. The coded message reveals the amino acid sequence of the protein molecule for which it is coded. The message is encrypted in form of nucleotide sequence. A nucleotide is a combination of sugar, phosphate and any one of four types of molecules called bases. The four types of bases are adenine (A), guanine (G), cytosine(C) and thymine (T). Nucleotides are present in pairs in a DNA molecule. A human genome occupies about 3 billion DNA base pairs which occur in just 4 types: AT, TA, CG and GC. They may be alternative or repetitive in the DNA to account for the enormous number. As already stated a set of nucleotides may function as a single unit (Gene). The genes are unique for a species and naturally its product the proteins are unique too. The proteins thus formed contribute to the character (complexion, hair pattern, body constitution, biometric measurements etc.,) of an individual. We should not forget that for a particular protein synthesis, a pair of genes is available from two different parent. Depending upon the genes nature, either one of the parental gene expression or cumulative expression of two



parental genes is brought about. Moreover a character (combination of polypeptide chains or proteins) itself is the result of a single or two or more gene expression.

Coming back to the zygote, it has all the information for formation of various cell types, tissues, organs and organ systems in the form of genetic code. Only four bases are utilized in recording these codes and they code for the different amino acids. The genetic code sequence determines the sequence of amino acid in a

protein molecule. There occur codes to initiate and to end protein synthesis. This silent information in the zygote waits for a trigger sets a cascade of numerous, precise and systematic events to go. The first and foremost event is the division of zygote into a mass of cells. During this division, the chromosomes including the genes are duplicated and the original number is maintained in the resulting cells by the action of genes meant for cell division. The mass of cells continue to divide and transforms into a three layered ball by the organised cellular movements. In this process, the resulting cells start to lose their totipotency and similar groups of cells organise and appear as mosaic of cells in the multi-layered structure. These groups of cells are responsible for 210 cell types, 4 tissues types and various subtypes, 12 organ systems and in all about hundred trillion cells. The cells and tissues are so varied in the type of protein they harbour. All the tissues and systems work in perfect harmony unless disturbed. The entire set of events described is the handiwork of genes.

Let us understand some of the amazing nature of gene,

- All the genes present in the chromosomes are not functional. Only 1.5% of the genome code for proteins.
- There are also many dormant genes in our body cells. Some of them are dormant during childhood and some become active only during middle age. For instance, the production of sperms and menstrual cycle is the breaking of dormancy at the teens and certain genetic diseases are triggered only at a ripe age. Each cell of our body has the information for all types of human proteins but all of them are not functional in all the cells. For example, liver proteins producing genes are switched off in the skin cells and vice versa.
- The rate of cell division in different cell types varies. Some human somatic cells are frequently replaced by new ones and other cells are rarely duplicated. Hair, skin, and fingernails are replaced constantly and at a rapid rate throughout our lives. In contrast, brain and nerve cells in the central nervous system are rarely produced after we are a few months old. Liver cells usually do not reproduce after an individual has finished growing and are not replaced except when there is an injury.
- Stem cells have the remarkable potential to develop into many different cell types in the body during early life and growth - e.g. embryonic stem cells and stem cells of bone marrow.
- The power of regeneration differs in tissues. The replacement of worn-out tissues is a form of regeneration and goes on throughout life. The most obvious is the replacement of skin from below as the outer layers rub off.

Super software: It is hard to believe that the entire structure of our body is the descendent of a single cell – zygote. The complete program for a human life is encoded in it. It is an amalgamation of numerous small and sub programs, each having a specific role to play in the output of *Homo sapiens.* Not all programs are made operational at all times. Depending upon the need and situation they operate. Switching on and off mechanism of encrypted message in the genes has no parallel. The duplication and distribution of encoded program during cell division is picture perfect. Masking of certain genes at times is a part of the human project. Memory of experience encountered in another unique aspect in the program which results in speeding up of execution. (e.g. Memory cells of immune system). To store this massive bio-informatics, the nature needs only four nitrogenous bases (adenine (A), guanine (G), cytosine(C) and thymine (T)). To run and to bring the output it requires one more base, uracil(C) instead of thymine (T) apart from the other three bases. They all code for the amino acid sequence of proteins of human. The language is termed as genetic code, basically 64 in number. English literature is the outcome of 26 letters of English alphabet. Then imagine the versatility of genetic code which explains the variations within the species and accounts for the biodiversity.

A very high level program in the software industry is the one that accommodates and adapts to several external parameters. (e.g. Robotics program, space mission program etc.). The chemically written code on the first cell of human is much more superior as it is influenced by vagaries of environment and has the ability to think and furthermore possess the capacity to learn. The three billion base pairs of the haploid human genome, which is the information content, correspond to a maximum of about 691.4 megabytes of data, since every base pair can be coded by 2 bits. However, due to the high degree of redundancy of the human genome, it can be compressed without of loss of information to a mere 4 megabytes. Moreover, the entire man-made software is one of the work of art of genes.