

Your DNA holds the key

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Hugo has recently finished school and will be going to university in September to study Biological Sciences. He has a particular interest in DNA and has researched and written this article.

DNA is our biological instruction manual, and is present in just about every single living organism, including human beings. The arrangement of the four nucleotide bases inside the DNA of an organism dictate control of everything about the organism, from its species to its gender. Examining the DNA found in our bodies has led to a much better understanding of how the human body works, and by further examination, may reveal more answers to current mysteries about how we function.

How do you read DNA?

In order to examine DNA, it must first be sequenced, revealing the order the nucleotide bases are in. This is usually done by computers, as they sequence lengths of DNA in just a few hours, whereas a human would need weeks, or even months. This is done by first fragmenting an entire genome using enzymes called restriction enzymes to cut it, like a pair of scissors. The length of DNA that is to be sequenced is then extracted, and is heat shocked to separate the double helix into two separate strands.

The strand to be sequenced is then put into a solution with lots of spare nucleotide bases, and an enzyme called DNA polymerase which joins the bases together to make lengths of DNA. Special altered bases with fluorescent markers attached are then added to the solution, and the DNA polymerase is allowed to work. As it gathers up loose bases to make strands, every time it uses one of the special bases, it is forced to stop the strand there, and begin making a new one. This means lots of varying lengths of the same strand of DNA are produced, each ending with a special base. They are all then gathered up, and are put through a process called electrophoresis which orders all the DNA strands based on size. As each length of DNA is part of the same sequence, reading each of the fluorescent markers at the end of all the lengths will show the base sequence of that strand of DNA, thus allowing it to be read.

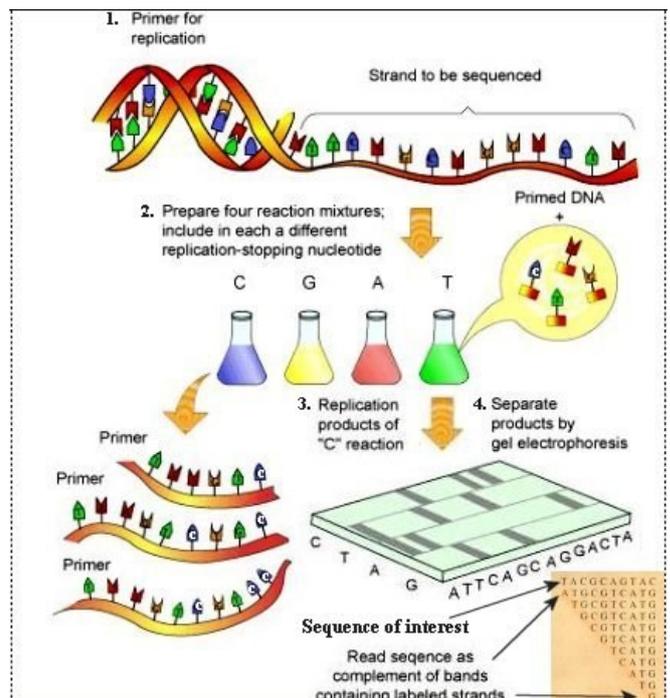


Fig 1. While most ways of DNA sequencing follow roughly the same process, there are quite a few different methods of doing it. Fig 1 above showcases the Sanger method, one of the easiest and most widely used methods to date.

DNA reveals your ancestors

First and foremost, DNA sequencing can be used to determine how closely related two different organisms are. The more similar the DNA from one organism resembles the DNA from another, the more closely they are related. This is called genetic testing. One application of this is to check someone's parentage, normally to check if a child is related to the father. Genetic testing can go back further generations than just your parents, people also commonly use it to find their ancestors and where they came from, by comparing their DNA with historical records. This process can also allow scientists to classify animals, as comparing animals of different species will show how closely related they are to each other, while comparing their DNA to fossils or older species of animals will help shed light on how they have evolved, and draw evolutionary family trees.

DNA sequencing can diagnose diseases

Sometimes DNA can be faulty. A mutation may have caused the addition, subtraction or substitution of a base in the DNA sequence, which causes a different protein to be produced or nothing at all when that strand of DNA is read. Sometimes this change doesn't matter, but if the protein is an important one, it can cause some serious genetic disorders, such as Coeliac disease, sickle cell anaemia and cystic fibrosis. They are caused by mutations in your DNA, so these disorders may be inherited or passed on. By testing your DNA for these disorders, scientists can identify if you have a genetic condition, or if you are at risk of developing one, if you will pass one on to your children or even rule out that you have one. To figure out if you have a disorder, your DNA is compared with a normal version of the same, and is checked for any differences along both lengths. This allows mutated genes in your DNA to be spotted relatively easily, so an appropriate course of treatment can be taken.

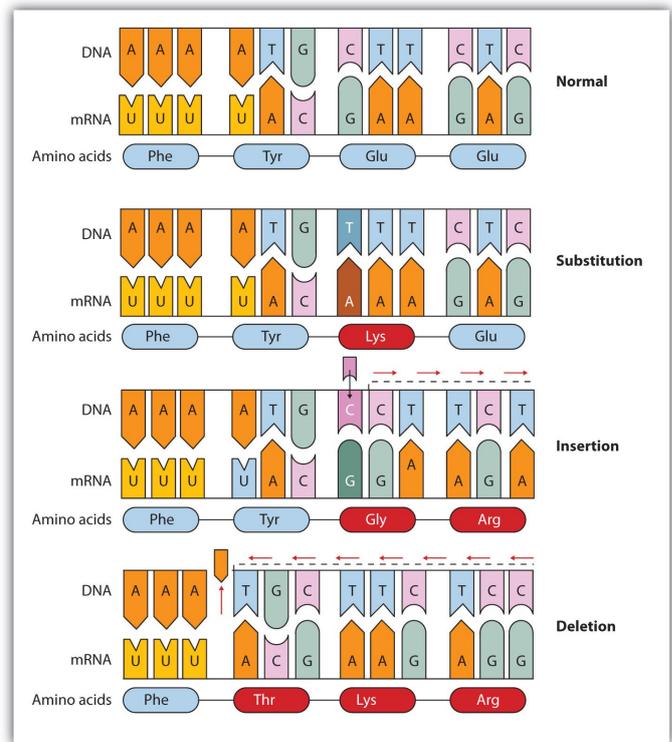
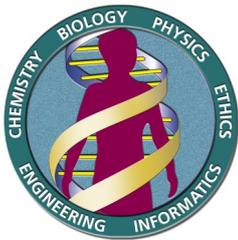


Fig 2 . Showcases point mutations, which occur when errors are made during DNA replication. Most of the time, these mutations are not harmful.

DNA holds mysteries of its own

While studying the human genome can answer many questions, occasionally some puzzling oddities are found, one such being the fact that our DNA contains roughly 2.9 billion base pairs, but only 20,000 (or 4%) actually code for the proteins that are needed to function. This is further compounded by the fact that only 20% of the DNA found in comparatively simple organisms like prokaryotes doesn't seem to directly do anything. Scientists now know that some of the non coding DNA codes for markers that say when to start and stop during DNA replication. It also codes for genetic switches that turn other genes on and off, such as controlling when lactase enzymes are produced, as well as keeping genes dormant that code for characteristics that were once useful to our ancestors, such as having tails. Scientists think that non coding DNA also helps with keeping mutations in the base sequence from affecting the rest of the genome. However, they are not completely sure of why we need so much and this area of the human genome is still being investigated.

The Human Genome Project



Starting in 1990, and ending in 2003, the human genome project was a massive collaborative effort by more than 20 countries to completely identify and map out every single DNA base pair in the entire human genome, all 2.9 billion of them. It is the world's largest international biological project, and cost \$3 billion. Having mapped out our entire genome is incredibly beneficial over a wide range of areas, such as disease diagnosis, increasing the effectiveness of medicine, understanding human evolution, and forensic sciences.

DNA also holds some unexpected surprises

Not all of our DNA is human. Scientists have found some very small parts of the human genome that contain foreign DNA, with one source being from viruses. This DNA mainly comes from a certain type of virus called endogenous retroviruses, which reproduce by attaching to the DNA in the host cell and causing it to make copies of the virus. If the virus happens to infect a reproductive cell, such as an egg cell, and that cell is then fertilised and develops into another organism, the viral DNA will become part of the genome for that organism. However, this will not have happened to you; all the viral DNA in our genome is millions of years old, and can not hurt you, as due to mutations acquired when undergoing DNA replication, is fragmented and inactive.

Conclusion

As technology progresses, the greater our understanding of DNA will become. The field of genetics is an ever expanding one, and will only continue to grow. The impact of being able to read DNA in our daily lives is enormous already, from helping to solve crimes with forensic testing, to diagnosing and curing genetic disorders, and new applications for genetic testing are being found all the time. DNA is our code, and it holds the key to understanding how we work.

About the author— Hugo Macfadyen

During my time at secondary school, I had an incredibly enthusiastic biology teacher, Dr Love. He has passed on his love of biology to me, and helped me realise I want to pursue a career in biology. Come September I will be studying for a degree in Biological Sciences at University. This is the first article I've ever written, but I do hope to write more.

Sources used/further reading:

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Image credits:

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