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# The Importance Of DNA In Science And Technology

DNA is of pivotal importance to science and technology as it holds the genetic information required to guide the life of every organism and the survival of every species. It contains the instructions needed to make proteins and coordinate internal processes throughout an organism's entire lifespan. Without DNA, individuals would not be able to progress through stages of development or reproduce to pass on this hereditary information to new generations and allow the continuation of the population. DNA facilitates this exchange of information by remaining relatively stable over time so that the genetic code remains principally constant when it is passed on. However, DNA also has the capacity for change and through mutation, the DNA sequence can diverge over time to allow evolution. This means species can survive over extended ranges of time as their phenotypes can be better suited to respond to environmental change when genotypes change. Through learning to manipulate an organism's original DNA, humans are able to increase chances of survival and extend lifespans, things that are fundamental to the existence of all species.

The structure of DNA is important as its arrangements dictate its stability. DNA needs to be stable so that it can pass on genetic information from cell to cell across generations without mutations. The formation of a double helix shape leads to an increase in entropy which allows for higher stability as the strands are unlikely to separate spontaneously. Various weak forces combine to stabilise the molecule. These include hydrogen bonds which form between bases and release energy, leading to higher entropy. The repulsion created by the negatively charged phosphate groups in the centre of DNA is minimised through the attraction of cations like  $\text{Na}^+$  and  $\text{Mg}^{2+}$  which creates charge-charge interactions to stabilise the helix. Base stacking also helps to increase stability. Additionally, the phosphodiester backbone is facing inwards in the helix which protects the more chemically reactive nitrogenous bases. This prevents DNA from mutating frequently so that the transfer of accurate information across generations is sustained.

However, DNA is not entirely stable and it does occasionally mutate during processes such as replication when the strands become separated and the bases are exposed, causing changes to the base sequences. This is beneficial and important in populations as these mutations occasionally produce alleles which provide a favourable phenotypic advantage. This can increase the likelihood of survival for the organism so populations can become better adapted to respond to environmental change and adversity. When this occurs, there will be a genetic drift in the gene pool of the population as natural selection occurs to increase the proportion of the favourable alleles so that the survival of the species of population is increased. An example concerns a mutation to an allele which gives resistance to antibiotics in bacteria as this will be passed on to offspring so the population are able to survive against the selection pressure.

This displays how the DNA molecule itself is able to provide some form of advantage for individuals and populations to show the importance of DNA. In addition, the interaction of this DNA molecule with the protein histones in cell nuclei through epigenetics shows the significance DNA can have on an organism. Epigenetics allows changes to the expression of genes as they are read from the DNA sequence, without change to the actual base sequence itself. Either through methylation or acetylation, the chromatin structure and degree of condensation changes to make genes more or less accessible for transcription. Environmental factors can

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cause these changes to occur, as they stimulate proteins to carry messages into the cell and begin these processes. These signals may lead to the unfavourable activation or silencing of genes, such as switching off tumour suppressor genes or switching on mutated oncogenes, which are linked with genomic disorders such as cancer. This shows that it is not just the content of the DNA sequence which is important, but the manner in which it is read as this can impact drastically on the survival of organisms.

With modern technology, these natural processes of gene expression can now be influenced by the action of humans. DNA can now be read, manipulated and used for the individual benefit of our species and the wider planet alike. Through sequencing genomes, humans can gain a better understanding of organisms' DNA in order to apply this knowledge to a variety of situations. For less complex individuals like bacteria and viruses, more can be learnt about the functioning of these organisms and this information can be transformed into real-world benefits. By sequencing the genome of a virus like malaria, its metabolic activities and the proteins coded for can be identified. This could potentially enable treatment of the condition in humans by synthesising the precise antigens present to be given in vaccines to reduce the levels of death caused by the virus. Additionally in bacteria, special genes could be identified that allow resistance to extreme or toxic environmental conditions, which could have uses in cleaning up pollutants or manufacturing biofuels. This is important as it can make the planet a more hospitable place for all organisms and make life possible for a wider abundance of individuals.

The sequencing of the human genome is also very important as it provides knowledge that can help in a therapeutic capacity to, for instance, cure diseases. It provides knowledge and identification of genes that are specifically responsible for causing problematic genetic disorders, such as locating the base sequences responsible for causing cystic fibrosis. This can be applied in the practice of genetic screening where individuals can have their DNA analysed for the presence of these faulty alleles to see if they are likely to be affected. This screening also has the capacity to provide personalised medicines which is beneficial and necessary since the actions of different people's genes on metabolism means that drugs are processed differently in many individuals in the body. This will enable medicines to be more effective as they are more likely to work better at treating conditions as well as saving money by reducing the cost from the application of ineffectual drugs. Analysing the human genome could also potentially allow the development of new medicines in response to identifying genetic abnormalities in DNA sequences. These capacities to improve life for individuals shows the importance of successfully understanding and using the DNA sequence.

The practice of DNA fingerprinting shows further how DNA can be important as it foregrounds some of the real-world applications of modern scientific technologies. This can resolve issues of paternity by providing scientific proof of relationships based on the presence of corresponding bands between the DNA of offspring and parents on gel test plates. It is also of great importance to the practice of forensics by analysing genetic evidence from crime scenes to establish a person's presence and thus potentially link them to involvement in the crime to provide sufficient legal grounding for conviction. Lastly, the technology can be used in the field of plant and animal breeding by determining paternity and pedigree of individuals or by allowing crosses that contain a combination of favourable alleles. This shows the analysis of DNA can provide many benefits across multiple facets in society.

Beyond reading or analysing DNA, genetic engineering technologies can enable the manipulation of the genetic code for clear benefit. The formation of recombinant DNA through

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technologies such as in vivo and in vitro cloning enable the genetic material of one organism to be edited or copied into another to provide some form of advantage. An example concerns the genetic engineering technology of CRISPR/Cas9. This has applications such as mitochondrial replacement therapy where the faulty female mitochondrial genome can be corrected during IVF to produce offspring unaffected by the condition. The technology can identify the target sequence of bases using specific bacterial restriction endonucleases and then edit parts of the genome by removing, adding or altering sections of the DNA sequence. This is just one example of genetic technology that allows genetic modification and though similar mechanisms of alteration have been possible before, CRISPR is regarded as one of the most important inventions in DNA science due to its heightened speed, accuracy and cost-effectiveness.

Using genetic engineering technologies, the impacts of transgenic modification have the potential to be very large in society. Many processes are already occurring currently, like the synthesis of human insulin genes in bacterial plasmids for purification and reinsertion back into humans to treat diabetes. Further examples include GMO crops, which have a range of functions from being resistant to pesticides to improve crop yields, to crops producing higher levels of beta carotene which can prevent vitamin A deficiencies when consumed. The technology has the capacity to have an even greater impact still in the future, such as tackling global environmental crises. An example concerns transferring certain genes from extreme species of coral that provide levels of resistance to heat to other species of coral. This would make coral beds less susceptible to bleaching from negative temperature fluctuation in oceans as a result of worsening global warming. This would ensure biodiversity within these pivotal habitats is maintained for the sustenance of many species in marine life.

Overall, DNA is vital to organisms as it is the language through which information is passed on, allowing it to ensure the survival of many generations of species and populations. But it is our growing understanding over DNA which is becoming of pivotal importance in the world of modern science as humans develop more technologies that allow control over the use and application of DNA. The field of genetic science and technology is rapidly growing and is of major global interest. This is because human intervention here has the capacity to revolutionise life for many, such as through curing disease or responding to environmental adversity.