The basis of genetic inheritance biology essay

Science, Biology

The nucleus of a cell of any organism provides instructions to that that cell enabling it to grow, reproduce and survive (University of Utah, 2004). In the nucleus, chromosomes are present which contain heredity material made from many structural components. This genetic material is called deoxyribose nucleic acid, DNA. In the cell, DNA undergoes many different mechanisms including: mitosis, meiosis and replication in order to copy and divide cells and code for protein. These mechanisms show how DNA is able to form the ‘ basis of genetic inheritance’ carrying identical genes from one cell to another. Natural mechanisms within the cell are not the only evidence of genetic inheritance but experiments practiced by F. Griffiths, Avery, McCarty, Macleod, A. D. Hershey and M. Chase (Reece, Urry, Cain, Wasserman, Minorsky & Jackson, 9th Edition1) indicate man made evidence proving genetic inheritance in bacterial cells, researching the material used to transport these genes and to prove that the material is DNA (Dr Demetra Mavri-Damelin1). A gene is a part of inheritance (U. S. National Library of Medicine, 29 April 2013) which carries genetic information about the cell and is made from DNA molecules consisting of many complex structural components called nucleotides. DNA is made of pentose sugars (deoxyribose sugar), phosphate groups and a nitrogenous base which bond and form nucleotides. There are four different nitrogenous bases which form four different nucleotides: adenine, guanine, cytosine and thymine which bond to their complementary base pair to form a double stranded molecule of DNA called a double helix. Adenine is bonded by two hydrogen bonds to thymine to form a purine and cytosine is bonded by three hydrogen bonds to guanine to form a pyrimidine (Orono, December 18th, 2008). The pattern of repeated

pentose sugars and phosphate groups form a DNA backbone (Jim Clark, 2007) which is attracted to water enabling it to interact with its polar environment (Dr Demetra Mavri-Damelin2). Before DNA undergoes any process that proves it contains inherited evidence, the chromosomes within the cell must be ‘ replicated’ so that when the cells undergo divide, each cell contains the same number of chromosome, carrying the same genetic material. Firstly, the hydrogen bonds break apart and the double strand of DNA unwinds and untwists forming two single strands of DNA. Each base from both strands, bond with a complementary base pair forming two identical double stranded DNA strands. Each strand is said to consist of one old strand and the other strand being new, which results in the doubling of the cell’s genetic code. This process is called semi-conservative replication. (Reece, Urry, Cain, Wasserman, Minorsky & Jackson, 9th Edition2). DNA can be replicated by means of another two processes which also contribute to how genetic information from one cell is ‘ copied’ and carried into another cell to create cell inheritance. Conservative replication is the first process that involves the production of a completely new strand of DNA (M. J. Farabee, 1992, 1994, 1997, 1999, 2000, 2001, 2007) and dispersive replication is when all newly formed strands of DNA have been fragmentally formed as they contain a mixture of both old and new DNA. Once replication has occurred the cell is matured and is ready to undergo cell division contributing mainly to how genes are inherited from one cell to anther and how children inherit characteristics or genes from their parents. Mitosis occurs directly after DNA replication and involves the production of two identical daughter cells by means of the cell division (Department of

Biochemistry and Molecular Biophysics, April 1997). Mitosis consists of several intricate phases which are all vitally essential for the cell to divide. These processes indicate that the structure of DNA and the process of mitosis does contribute to genetic inheritance of DNA because a cell, that consists of double the number of identical chromosomes, divides into two identical single numbered chromosome cells which carry copies of their information . These identical cells will further divide and bind with other cells during sexual reproduction to form a variety of cells but will still carry that common chromosome. The processes involved in mitosis are: Interphase, Prophase, Prometaphase, Metaphase, Anaphase, Telophase and Cytokinesis (Department of Biochemistry and Molecular Biophysics, April 1997). Interphase is not a direct process of mitosis () but involves the maturing and replication of the cell preparing it for the beginning of cell division starting with prophase. During this phase the nucleolus degenerates, the centromeres of the double stranded chromatids move to opposite sides of the cell and spindle fibres assemble across the cell (Regina Bailey, 2013). During metaphase, the chromatids align along the metaphase plate and attach to the spindle fibres by their centromeres. (Regina Bailey, 2013). This process is essential for cell division because once these chromosomes are aligned, in the next phases they are separated to form single stranded chromatids which are present in the newly formed cell. If this process does not occur efficiently a mutation could occur which could form an abnormal cell with extra or a shortage of chromosomes. During metaphase, the spindle fibres dehydrate and pull apart, pulling the double stranded chromatids with them to the opposite sides of the cell resulting in the formation of the single

stranded chromatids (Regina Bailey, 2013). Telophase and cytokinesis are the end processes of cell division as a new membrane forms around each set of chromosomes and the cytoplasm constricts separating the single cell into two identically genetically coded cells (Department of Biochemistry and Molecular Biophysics, April 1997). Meiosis is the next phase related to genetic inheritance during sexual reproduction resulting in chromosomes being passed from one generation to the next where a parent passes their genetic characteristics, physical or behavioural, to their offspring. Meiosis is the binding of two cells, one male and another female, to create offspring with a deviation of genetic code carrying genes from both parents (Berkow, Robert, ed. 1999. The Merck Manual. 17th ed. Merck, Sharp & Dohme, Rahway, 1996). Mitosis and meiosis are very similar processes but do have differences as mitosis involves the division of cells forming cells that are identical in genetics and meiosis involves the division of cells forming cells that have a variation of genetic material. Meiosis occurs in two phases: meiosis I and meiosis II. During meiosis I, ‘ homologous’ pairs (Biology-Online, 27 April 2006) of chromosomes bind to form crossing, which is when chromosomes exchange genetic material resulting in genetic variation. These chromosomes line up along the equator of the cell attaching to the spindle fibres. Once these fibres detach, the chromosomes move to the ends of the cell. These single stranded chromatids are then surrounded by a membrane and cytokinesis occurs forming two half chromosome numbered cells (Biology-Online, 27 April 2006). Meiosis II is the process that initiates the production of the variation of genetic material within cells introduced by sexual reproduction. The starting phases of meiosis II are identical to the

phases of meiosis I but the difference is that not only two cells are formed but four cells are formed, each cell containing a half chromosome number carrying different genetic information (Biology-Online, 27 April 2006).). Each gamete cell (sex cell) will fuse with another gamete cell of the opposite sex. The cell will undergo fertilization forming a zygote. The offspring later produced by both male and female will carry variation genetic information, information from the mother and the father. This clearly indicates that genetic material has been passed down to the offspring by means of inheritance through DNA. Scientists have proven through experiments that DNA is the sole mechanism that is structurally suited in order to carry genes from one cell to another through generations of cells carrying characteristics with them. The first experiment was constructed by F. Griffith, 1928, (Reece, Urry, Cain, Wasserman, Minorsky & Jackson, 9th Edition3) to investigate if a component can be passed from one cell to another. Griffith used a genetic bacterial cell, smooth and rough strains of streptococcus pneumonia, and injected it into a specific species of rat. The smooth streptococcus pneumonia causes pneumonia as it contains an outer capsule which protects the bacteria (M. Edwardsa & J. M. Stark) and the rough streptococcus pneumonia is non-pathogenic as it lacks an outer shell. Griffith took a sample of a smooth strain and injected a rat and as expected the rat was infected and died. He then injected another rat with the rough strain, and again, as expected the rat was not infected and remained alive. Griffith then decided to destroy the smooth strain, changing its genetic orientation, by heating it. He infected the rat and because the bacterium was destroyed, the bacteria was unable to replicate and divide and the rat remained alive. Most

important experiment Griffiths constructed was when he combined the heated smooth strain with the rough strain infected the rat and the rat unexpectedly died. This is because the DNA of the rough strains take up the components of the heat treated smooth strains and replicate and divide. This converts the rough strains to retain the abilities of the smooth strain and infect the rat (Reece, Urry, Cain, Wasserman, Minorsky & Jackson, 9th Edition4). This experiment indicates that due to the heritable components in the bacterial cells, the genes were capable of being carried as well as manipulated to carry out a certain activity. This indicates that traits can be inherited regardless if that specific characteristic was present or not. The second experiment was constructed by scientists Avery, McCarty and Macleod. Their aim was determine which component transported these heritable traits from one cell to another (from the rough strain to the smooth strain). This process was referred to as the transformation process. Avery, McCarty and Macleod introduced three main candidates into the experiment: DNA, RNA (ribose nucleic acid) and protein. A smooth strain of bacterial cell was treated by each enzyme from the respective candidates. DNase removes the DNA, RNase removes the RNA and protease removes the protein. Each strain was then further treated with a rough strain of bacterial cell. Each treated substance was injected into a different rat. The only rat that survived was the rat that was treated with DNase, consisting of no DNA, as there is no DNA to be passed on. The cell has no ability to change from rough to smooth strain and therefore the genetics of the cell is not converted and the rat remains alive (DNA Learning Center, 2002). This experiment shows that DNA is the primary candidate for the transportation of genes. The

last experiment was practiced by A. D. Hershey and M. Chase in which they proved that DNA was not a protein but was genetic material carrying the specific genetic codes for a cell. They used a virus, bacteriophage (Dr. Gene Mayer, 2010), that infects bacteria and takes over the cell to spread the virus. The scientist also introduced two radioactive substances: sulphur and phosphorus. Each radioactive element was mixed in a blender with its corresponding virus either forming a sulphur coat or the main component of DNA from the phosphorus. Batch one, involving the sulphur, had an outcome of the liquid of the mixture being more radioactive then the virus. In Batch two, involving the phosphorus, the virus was more radioactive than the liquid. This outcome results in that DNA was transferred from one organism to another as the 32 phosphorus DNA was able to replicate and handle the radioactive phosphorus producing a new virus that is radioactive (Reece, Urry, Cain, Wasserman, Minorsky & Jackson, 9th Edition5). It is now clear that the DNA structure, containing chromosomes, which undergo replication, mitosis and meiosis, are able to carry genetic information from one cell to another. Genes being transported between cells indicates inheritance as that cell will undergo its own cell division and that gene will be inherited by another cell and the characteristic will be passed from one generation to a next which is most evident in human beings. Experiments constructed by scientists: F. Griffiths, Avery, McCarty, Macleod, A. D. Hershey and M. Chase are also a clear indication that DNA plays an important role in genetic transportation and alteration even though these mechanisms were man made and practiced on an animal species.