Rna world theory: summary and analysis

This essay will explore the principles of the RNA world theory and supports and criticisms for it. It will look at the properties of RNA which make this theory viable and it will also look briefly at alternate competing theories. RNA, which stands for ribonucleic acid, is a polymeric molecule made up of one or more nucleotides. Each nucleotide is made up of a base: adenine, cytosine, guanine, and uracil, a ribose sugar, and a phosphate which can then form chains. Like DNA, RNA has four main structures: primary, which is the basic polypeptide chain. The Secondary structure is a twisted form of the chain into usually an alpha helix and beta sheet. The tertiary structure is a further folded shape and is often unique. This structure determines the function of the protein. Finally the quaternary is the joining together of multiple tertiary subunits to form one large subunit.

The discovery of ribozymes supported the RNA World Hypothesis. This is the theory that earlier life forms may have relied solely on RNA to catalyse chemical reactions and store genetic information. This hypothesis was proposed by Carl Woese, Francis Crick and Leslie Orgel in the 1960s, this was decades before the discovery of ribozymes but soon after the double-helical structure of DNA was determined. According to the RNA World Hypothesis, life later evolved to use DNA and proteins due to RNA’s instability relative to DNA and its’ poorer catalytic properties. Gradually, ribozymes became increasingly phased out. A ribozyme, ribonucleic acid enzyme, is an RNA molecule that is capable of performing specific biochemical reactions, similar to the action of protein enzymes.

The structure of RNA nucleotides is very similar to that of DNA nucleotides, with the main difference being that the ribose sugar backbone in RNA has a hydroxyl group that DNA does not. Another minor difference is that DNA uses the base thymine in place of uracil. Despite great structural similarities, DNA and RNA play very different roles from one another in modern cells.

RNA plays a central role in the pathway from DNA to proteins, known as the " Central Dogma" of molecular biology. An organism's genetic information is encoded as a linear sequence of bases in the cell's DNA. During transcription, an RNA copy of a segment of DNA, messenger RNA (mRNA), is made. This strand of RNA can then be read by a ribosome to form a protein.

Another major difference between DNA and RNA is that DNA is usually found in a double-stranded form in cells, while RNA is typically found in a single-stranded form. The lack of a paired strand allows RNA to fold into complex, three-dimensional structures. RNA folding is typically mediated by the same type of base-base interactions that are found in DNA, with the difference being that bonds are formed within a single strand in the case of RNA, rather than between two strands, in the case of DNA.

The strongest evidence for the RNA World Hypothesis is the fact that the ribosome, a large molecular complex that assembles proteins, is a ribozyme. Although the ribosome is made up of both RNA and protein components, structural and biochemical analyses revealed that the mechanisms for translation is catalysed by RNA, not proteins. This suggests that the use of RNA by early life forms to carry out chemical reactions may have preceded the use of proteins.

John Sutherland and his colleagues from the University of Manchester performed and experiment that greatly supports the RNA world hypothesis.

He and his team created a ribonucleotide, which is a major part of RNA, from simple chemicals. These chemicals are those though to be present on the early earth, or primordial soup. Donna Blackmond, a chemist at Imperial College London, stated that " this is extremely strong evidence for the RNA world. We don't know if these chemical steps reflect what actually happened, but before this work there were large doubts that it could happen at all."

Critics of these ideas suggest that other organic molecules, rather than nucleic acids, were the first self-replicating chemicals capable of storing genetic information. According to this idea, these simple hereditary systems were later replaced by nucleic acids during the course of evolution.

Electric Spark – Generation of amino acids and sugars from the atmosphere. The Miller-Urey supports this theory. The experiment in 1952 was one that simulated the conditions thought at the time to be present on the early Earth, and tested for the occurrence of the chemical origins of life. Miller took molecules which were believed to represent the major components of the early Earth's atmosphere and put them into a closed system. The gases they used were methane (CH4), ammonia (NH3), hydrogen (H2), and water (H2O). Next, he ran a continuous electric current through the system, to simulate lightning storms believed to be common on the early earth. Miller observed that as much as 10-15% of the carbon was now in the form of organic compounds. Two percent of the carbon had formed some of the amino acids which are used to make proteins. Miller's experiment showed that organic compounds such as amino acids, which are essential to cellular life, could be made easily under the conditions that scientists believed to be present on the early earth.

Community Clay –The first molecules of life might have met on clay, according to an idea elaborated by organic chemist Alexander Graham Cairns-Smith at the University of Glasgow in Scotland. These surfaces might not only have concentrated these organic compounds together, but also helped organize them into patterns much like our genes do now.

Chilly Start –As the sun was about a third less luminous than it is now. This layer of ice, possibly hundreds of feet thick, might have protected fragile organic compounds in the water below from ultraviolet light and destruction from cosmic impacts. The cold might have also helped these molecules to survive longer, allowing key reactions to happen.

Simple Beginnings –Instead of developing from complex molecules such as RNA, life might have begun with smaller molecules interacting with each other in cycles of reactions. These might have been contained in simple capsules akin to cell membranes, and over time more complex molecules that performed these reactions better than the smaller ones could have evolved.

Panspermia –Rocks regularly get blasted off Mars by cosmic impacts, and a number of Martian meteorites have been found on Earth that some researchers have controversially suggested brought microbes over here, potentially making us all Martians originally. Other scientists have even suggested that life might have hitchhiked on comets from other star systems.

There is no scientific evidence to suggest that RNA is spontaneously being created and capable of forming pre-cellular life today. While some artificial ribozymes have been created in the laboratory (reviewed in Chen, et al., 2007), there are still significant holes in reproducing an RNA world to support the hypothesis. The ribozymes created artificially lack the abilities to sufficiently process themselves, and there is no evidence of them producing large quantities of advantageous nucleotide sequences. Moreover, no system has ever created cellular life. There is even significant debate among scientists over the conditions and constituents of a “ prebiotic Earth” model.