RNA WorldAugust 19, 2015

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Home (edit)
Ideas (edit)
Self (edit)

Contents

1 Origination of the RNA world idea

For a while people thought that RNA doesn't have enzymatic activity. And proteins cannot store genetic information. Assumption was that in order to store information a carrier must be one dimensional for ease of copying. Proteins are however have complex 3D structure and don't follow demands of copying mechanisms. Because of that people thought life had to originate with both polymers simultaneously. One responsible for information and another for function. However at some point people discovered that RNA can have enzymatic activity:

1. RNA molecule in E. coli: ribonuclease-P cuts phosphodiester bonds during the maturation of the transfer RNA molecule[1, 2]

2. In Tetrahymena ribosomal RNA contains a self-splicing exon [3, 4]

So people thought that if there are two enzymatic activities associated with RNA there might be more. Later more self-splicinge introns were found [5].

People contemplated an *RNA world*: a world which has only RNA molecules which synthesize and catalyze themselves. An assumption was made that a self-splicing intron, which can cut itself out of RNA can have a reverse reaction and put itself back into RNA in the proper place. Self-inserting introns can this way have a major evolutionary advantage – recombination: the ability to produce new combination of genes. RNA world also solves dichotomy between DNA and proteins.

Stages of evolution would be the following according to the original idea:

1. ??

2. RNA molecules perform catalytic activities to assemble itself from prebiotic soup.
3. RNA molecules evolve in self-replicating patterns, using recombination and mutation.
4. By using RNA cofactors the develop the whole range of enzymatic activity.
5. RNA molecules begin to synthesize proteins: first by developing RNA adapter molecules that can bind activated amino acids and then by arranging them according to RNA template using RNA molecules such as ribosome core.
6. The first proteins would be better enzymes (*right away*) and they perform *the same reactions* as RNA not of different nature. Therefore they will eventually dominate. This proteins are encoded in RNA exons.
7. Then DNA appears and here we go.

2 Rise of the idea. Experiments

3 Difficulties with RNA world

3.1 RNA doesn't like water.

In his article [6] Pace suggested that RNA world isn't viable on highly aquas hot early earth: "Problems with RNA world: "If it ever existed, however, the RNA world was not exposed to free solution. The ribose 21-OH group that renders RNA, in contrast to DNA, catalytic also renders the RNA chain particularly susceptible to hydrolysis. The RNA phosphodiester in aqueous solution is highly labile to hydrolysis promoted by the ribose 2'-OH group, which forms the 2',3'-cyclic phosphate and breaks the RNA chain. This reaction is accelerated by high pH, high temperature, and the presence of divalent (or other multivalent) cations, which bind to and polarize phosphates, enhancing reactivity. The early hydrosphere would have contained substantial concentrations of many multivalent cations. RNA molecules of much complexity could not have survived if exposed to solution in that environment, particularly if at high temperatures.

The RNA-based world would have required a special environment, in the least as protection from hydrolysis. This environment need not have been low in water concentration, only low in water chemical activity. It therefore seems unlikely that the prebiotic milieu was an organics-containing aqueous soup, as commonly supposed. Rather, life more likely arose in an organic scum that could provide an environment of low water activity. "[6]

3.2 The initial appearance of an RNA world itself is still mostly an open question

Read [7–10]

References

[1] Cecilia Guerrier-Takada, Katheleen Gardiner, Terry Marsh, Norman Pace, Sidney Altman, and Others. The RNA moiety of ribonuclease P is the catalytic subunit of the enzyme. *Cell*, 35(3):849–857, December 1983.

[2] C Guerrier-Takada and S Altman. Catalytic activity of an RNA molecule prepared by transcription in vitro. *Science*, 223(4633):285–286, January 1984.

[3] Thomas R. Cech, Arthur J. Zaug, and Paula J. Grabowski. In vitro splicing of the ribosomal RNA precursor of tetrahymena: Involvement of a guanosine nucleotide in the excision of the intervening sequence. *Cell*, 27(3):487–496, December 1981.

[4] Kelly Kruger, Paula J. Grabowski, Arthur J. Zaug, Julie Sands, Daniel E. Gottschling, and Thomas R. Cech. Self-splicing RNA: Autoexcision and autocyclization of the ribosomal RNA intervening sequence of tetrahymena. *Cell*, 31(1):147–157, November 1982.

[5] T R Cech. The generality of self-splicing RNA: relationship to nuclear mRNA splicing. *Cell*, 44(2):207–210, 1986.

[6] N. R. Pace. Origin of life - Facing up to the physical setting. *Cell*, 65(4):531–533, 1991.

[7] Gerald F. Joyce. The antiquity of RNA-based evolution. *Nature*, 418(6894):214–221, July 2002.

[8] G F Joyce. RNA evolution and the origins of life. *Nature*, 338(6212):217–224, 1989.

[9] David Penny. An Interpretive Review of the Origin of Life Research. *Biology & Philosophy*, 20(4):633–671, September 2005.

[10] Carole Anastasi, Fabien F. Buchet, Michael A. Crowe, Alastair L. Parkes, Matthew W. Powner, James M. Smith, and John D. Sutherland. RNA: Prebiotic Product, or Biotic Invention? *Chemistry & Biodiversity*, 4(4):721–739, April 2007.