Origin of Life on Earth: A Review by Leslie Orgel

Orgel, L. C. The Origin of Life - A Review of Facts and Speculations. Trends in Biochem. Sci. 23, 491-495 (1998).

1. Define the following terms: prebiotic, *de novo*, self-replicating, RNA world, carbonaceous, chondrite, carbonaceous chondrite, self-contained, clay mineral, nucleoside, nucleotide, furanosly/pyranosyl, oligo, Watson-Crick base pairs

prebiotic:	an adjective meaning before life
de novo:	anew (in this context: life arose from from basic or newly synthesized chemical substances
self-replicating:	an adjective meaning self-generating or having the ability to make copies of self
RNA world:	this is a term that refers to the hypothesis that the first self-replicating molecules were ribonucleic acids.
carbonaceous:	adjective meaning "containing carbon"
chondrite:	a piece of matter that has granular texture (*chondros* = Gr grain)
carbonaceous chondrite:	these are carbon-containing meteorites that have small globules, or grains of of melted materials.
self-contained:	an adjective meaning the ability of a molecule or system to limit its own boundaries; synonym: self-organized
clay mineral:	a finely divided SiO_2 mineral with MgO, Al_2O_3, Fe_2O_3, etc.
nucleoside:	a compound containing a sugar and a N-containing base (without the phosphate)
nucleotide:	a nucleoside derivatized on an -OH with a phosphate.
pyranosyl:	an adjective for a 6-membered ring with one O atom
furanosyl:	an adjective for a 5-membered ring with one O atom
oligo:	a prefix meaning few or several but not many (poly)
Watson-Crick base pairs:	these are pairs of bases in nucleic acids that always occur together according to their ability to form complimentary H-bonding structures.

2. According to Orgel, what are the two main "simple" questions concerning the orgin of life on Earth?

Two "simple" questions:	What were the sources of prebiotic molecules? How did biological organization arise from these molecules?

Origin of Life on Earth: A Review by Leslie Orgel

3. List the three hypotheses about the orgin of prebiotic molecules. Give at least one argument for and one argument against each hypothesis.

a. Prebiotic molecules arose in a reducing atmosphere of CO_2, H_2O, NH_3 through which electrical discharges from lightening caused the formation of small organic molecules.

Pros: The 1953 Miller-Urey experiment demonstrated a number of amino acids and other small molecules were formed in experiments in discharge tubes. Also, geological evidence suggests the atmosphere and Earth's mantle were reduced before the evolution of O_2 into the atmosphere by photosynthetic organisms.

Con: Geological evidence suggests very little NH_3 was available, only N_2.

3. List the three hypotheses about the orgin of prebiotic molecules. Give at least one argument for and one argument against each hypothesis, continued.

b. Prebiotic molecules formed on the solid materials which accreted to form the Earth. Additional meteorite or asteroid impacts brought more of these molecules.

Pros: meteorites contain organic molecules (amino acids, derivatives of bases in nucleic acids) and tons of these meteorites continue to "rain" upon the Earth today. The assumption is made that a similar "rain" brought these materials to the prebiotic Earth.

Cons: The organic materials would have been unlikely to survive the intense heat generated when the meteorites entered the Earth's atmosphere.

c. Prebiotic molecules formed at deep ocean spreading centers (vents) where abundant metal sulfide catalysts (and abundance of reducing H_2S) acted in C-C bond formation using CO and/or CO_2.

Pros: experiments with NiS/FeS catalysts have shown C-C bond formation; deep ocean vents have incredibly abundant life.

Cons: none to date; since 1998: this theory is beginning to dominate the work of many prebiotic scientists.

4. What are two main questions about the origin of "organization" necessary for life to begin?

a. Was RNA first or was there a self-replicating molecule that preceeded RNA?
b. How much self-organization was possible without the direction of a genome?

5. What questions are asked about RNA if it is accepted to be the first self-replicating molecule?

a. How did this self-replicating RNA molecule arise?!
b. Once self-replication arose, how did these RNA molecules avoid becoming dispersed in the environment and therefore not available for "self-containment" or "self-organization"?

Origin of Life on Earth: A Review by Leslie Orgel

6. Why do you think scientists proposed that clay minerals were catalysts for oligonucleotide synthesis?

A clay minerals called montmorillonite has been used in a chemical system to catalyze the formation of RNA oligomers.

7. What is an imidazolide? How is the group important in the nonenzymatic synthesis of nucleotides?

The imidazolide is a good leaving group attached to a phosphorus where attack by an -OH group would lead to condensation of two oligonucleotides.

8. List the properties of pyranosyl-RNA (p-RNA) molecules that supports arguments that these types of RNA molecules may have been the first self-replicating RNA.

a. They form Watson-Crick base paired double helices.
b. The double helices are more stable than the ribose-based helices.
c. They form fewer competing base-pairing structures.
d. The helical twist is more gradual than in the ribose-based helices making the strands easier to separate for replication.