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Inevitability of nTP: Information-energy carriers

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Abstract: The reason why bio-energy carrier is mainly ATP is clarified by examining the frequencies of Guanine (G) and Cytosine (C) in nucleic acids. Living being uses only the five types of nTPs (ATP, GTP, TTP, CTP, and UTP) for constructing nucleic acids, although only ATP is employed as main carrier of energy. Nucleic acids such as tRNA and rRNA in living being use Guanine with relatively higher densities in comparison with Adenine (A). Thus, mass conservation law teaches us that Adenine is relatively redundant in comparison with Guanine. This leads to the natural consequence that the redundant Adenine becomes energy source as ATP. Next, we will focus on the fact that UTP, GTP, and CTP are also used for generating polysaccharide, protein, and lipid, respectively. We will try to clarify the inevitability of five types of nTPs.

Keywords: Energy carrier, nTP, Inevitability, Physics.

I. INTRODUCTION

Living beings employ the five bases of adenine (A), guanine (G), cytosine (C), thymine (T), and uracil (U). These can be classified into two groups, purine and pyrimidine. Purines, i.e., A and G, have relatively larger size, while pyrimidines, i.e., C, T, and U, are smaller. (See Fig. 1.) [1, 2]
The size asymmetry of the main rings in purines and pyrimidines around 3:2 naturally leads us to the asymmetric number of types, i.e., "two" types of purines (adenine and guanine) and "three" types of pyrimidines (cytosine, thymine, and uracil). (See Fig. 1.) This can be understood from the mass conservation law with respect to molecular weight, that is, from the fact that the main rings of purines have "nine" molecules of carbon and nitrogen, while "six" molecules of carbon and nitrogen form the main rings of pyrimidines. (The number of base types will be proportional to the density.) [3 - 8]

Frequencies of the five nitrogenous bases in living beings are given by mass conservation law. The previous researches [3-8] clarify the inevitability on the frequencies and sizes of the five nitrogenous bases as information carriers.

However, five bases are also energy carriers with the forms of nTP (ATP, GTP, CTP, UTP, and TTP).[1] Then, ATP is mainly used as energy carrier.Duve [9] wrote that the inevitability of ATP as energy source is still in fog.

II. FIVE BASES USED FOR FIVE STAGES

While the five nitrogenous bases of A, T, G, C, and U make nucleic acids, simultaneously, these are also energy carriers in life. Especially, ATP is the main energy carrier. (See Table 1. [1]) UTP, GTP, CTP, and TTP are also employed for generating polysaccharide, protein, lipid, and DNA, respectively.

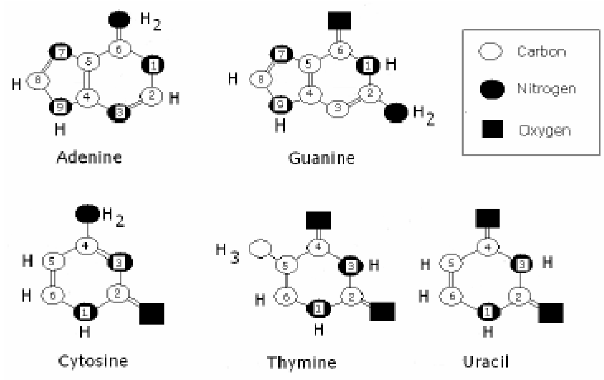


Fig. 1. Two types of purines and three types of pyrimidines, which mainly construct DNA and RNA. (Two types of purines: adenine (A) and guanine (G); three types of pyrimidines: cytosine (C), thymine (T) and urasil (U)).

Table 1: nTP used for five processes

tRNA and rRNA	ATP, UTP, CTP, GTP
Energy for Polysaccharide	**ATP**, UTP
Energy for generating Protein	**ATP**, GTP, (UTP, CTP)
Energy for generating Lipid	**ATP**, CTP
DNA	ATP, TTP, CTP, GTP

III. ATP

Let us think about the reason why ATP is the main energy carrier, while the other nTP such as GTP and UTP are relatively less as energy carriers. This is consistent with the fact that GTP is rich in tRNA and rRNA in most of species preferring high temperatures. (See Table 2.) As free molecules of G and A exist with same frequencies in the first pool before connections, the richer GTP in RNA leads to relatively redundant free ATP. Mass conservation law can explain theinevitability of ATP as energy carrier.

Table 2: Values of (G+C) /(A+U) for tRNA
[calculated by using [10-14]]

Species	Temp.	GC/AU rate in tRNA
Pyrococcus furiosus	95	2.62
Pyrococcus horikoshii	95	2.63
Pyrobaculum aerophilum	95	2.56
Sulfolobus solfataricus	80	2.47
Aeropyrum pernix	90	2.85
Escherichia coli K12	37	1.5
Pseudomonau aeruginosa		1.59

Base-pair A-T has two hydrogen bond connections, while the G-C pair is with three hydrogen-bond connections. Thus, more energy is necessary to cut the G-C pair in comparison with A-T pair. Thus, relatively, A-T pair does not need lots of ATP. In other word, the cut of G-C needs more energy of ATP. This will correspond to that G-C rich leads to the strong dependence on ATP. Problem of energy lies in both the number of hydrogen-bond connections and energy source.

IV. GC-RATE AND TEMPERATURE

It should be stressed in Table 1 that polysaccharide, mRNA of protein, and lipid need UTP, GTP, and CTP as energy sources, respectively. Why will UTP, GTP, and CTP be used? The reason why different UTP is used for each stage is examined in this section.
We can see the linear correlation between temperature and the value of (G+C) /(A+U), the GC rate in tRNA. (See Fig. 2.) Figure 2 shows the very important characteristic, because the richness of G + C in tRNA and rRNA is necessary for stabilizing hydrogen-bond connections in base-pairs at high temperatures.
It is well-known that a lot of archaea and bacteria having relatively short DNA sequences prefer environments at high temperatures. This fact leads to richer rates of Guanine and Cytosine in tRNA and rRNA, while Adenine and Uracil relatively are redundant as free molecules.
Thus, redundant Uracil can be used for generating polysaccharide, which may produce cell-wall. (See Fig. 3.) Moreover, redundant Uracil may produce also ribose for generating chains of bases.
In the pre-biotic processes such as RNA-world with high temperatures, cell-surface will also be produced with the foregoing mechanism.

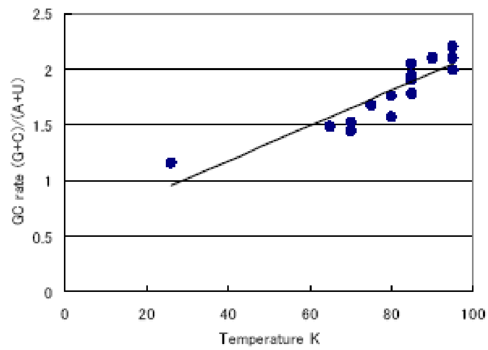
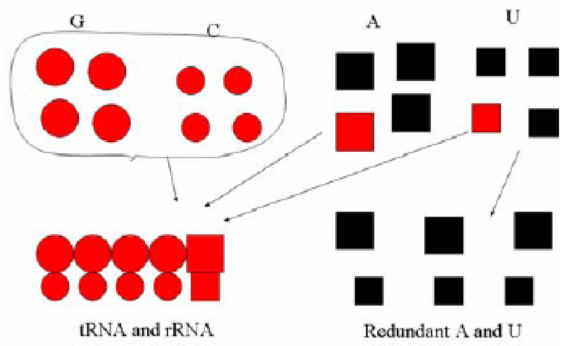
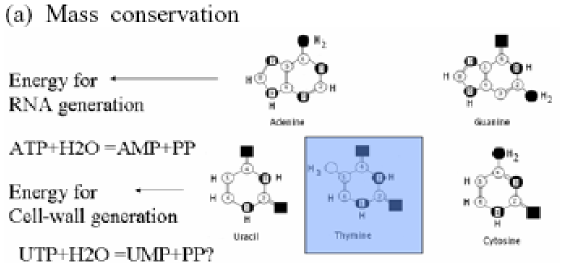


Fig. 2 GC rate plotted against temperature.



(a) Mass conservation



(b) Reaction path

Fig. 3. G and C rich in RNAs brings redundant A and U. (Redundant A becomes the supply of energy for generating tRNA and rRNA. Redundant U works for making polysaccharide.)

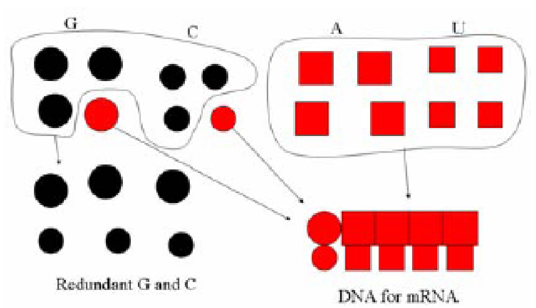
VI. LOWER TEMPERATURE

Let us think that the molecular pool in Fig. 3 moved from the pool of the higher temperatures to lower that of temperature. This lower temperatures bring new reaction paths related to protein and lipid, because A and U richer in tRNA and rRNA lead to redundant monomers of G and C. Table 1 shows that, at the next stage, redundant G and C could use for generating also proteins and lipids. This will lead to first cell including RNAs, proteins, enzyme, cell-wall, and cell-membrane.

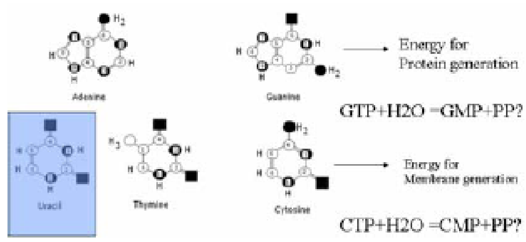
Codons (mRNAs) of many species have the GC rates less than those in tRNA and rRNA. (See Table 3.) Thus, the generation of mRNA is relatively easy.

Table 3: GC rates in codon (mRNA)
[calculated by using [10-14]]

Species	Temp.	GC/AU
Acidianus ambivalens	80	0.5857
Sulfolobus solfataricus	80	0.5635
Sulfolobus acidocaldarius	70	0.5564
Pyrococcus furiosus	95	0.6916
Pyrococcus horikoshii	95	0.7341
Pyrococcus woesei	95	0.7535
Aeropyrum pernix	90	1.3655
Thermoproteus tenax	85	1.4745
Methanopyrus kandleri	95	1.5959



(a) Mass conservation



(b) Reaction path

Fig. 4 Low temperatures leading to free G and C.

Table 3 shows us that the GC rates in mRNAs (codons) are not related to temperature very much, although the GC rates in tRNA and rRNA are proportional to temperature. This is because mRNA does not make base-pair. As mRNA of straight shape has no base-pairs, the high GC rate is not necessary.

VIII. DNA world

Four types of nitrogenous bases among five, A, U, G, and C, are used in the RNA world and primitive cell wall. Finally, redundant T is used for going to the system using DNA.

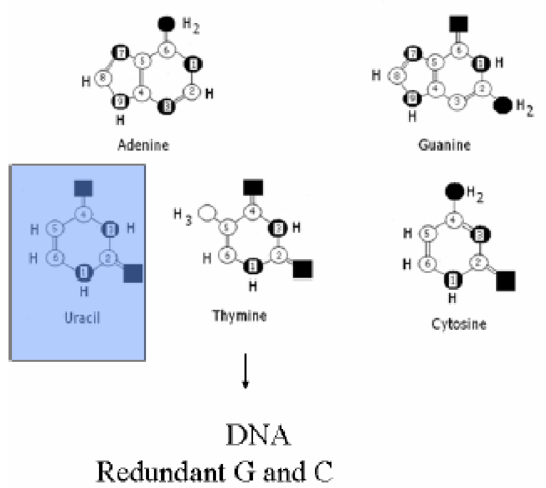


Fig.5. DNA world

CONCLUSION

The present thought experiment based on mass and energy conservation laws clarifies the outline of five steps toward first cell.

These five steps may proceed simultaneously with the repeats of high and low temperatures.

People living at relatively cold regions may have relatively AT-rich DNA. This will leads to redundant GTP and CTP, which promote the more generation of lipid and protein.

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