Fifteen resonant wavelengths in DNA primary structure (UV range)

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Abstract: It is propounded that in response to conformational constraints in chain linkages, DNA primary structure resonates precisely to fifteen discrete wavelengths from the UV spectrum. Correlations for DNA pitch and DNA breadth involving the ubiquitous golden ratio are proposed.

1.   Introduction

After the discovery of Watson & Crick in the 1950's it was suggested that DNA double helix could behave as an helical antenna [1]. The helical pitch of DNA primary structure was later determined in the nanometer range, corresponding to ultraviolet (UV) light. More recently (2017), it was reported that DNA was a UV light–harvesting antenna [2]. Nowadays, it is widely recognized that DNA may act as a true fractal antenna, emitting and receiving a wide range of electromagnetic frequencies (EMFs) [3], and very likely scalar and sound waves.

The ability of DNA antenna to operate in a wide range of frequencies is largely due to its plasticity via concomitant base pair melting and helical unwinding [4]. Such plasticity may be required in vivo to absorb local changes in linking number. On the other hand, DNA has the ability to wind itself into secondary, tertiary, and even greater dimensional structures. Each additional structure creates longer wavelength patterns, all the way to a terminal structure known as "fractal globule", which is adopted by DNA to fit itself into the cell space. Eventually it can be considered that the total length of the double helix (~2m) is DNA's longest helical pitch, which coincidentally falls into sound wave domain. Fig.1 illustrates this fractal nature.

Figure 1: Examples of DNA primary (i) & secondary (helix (ii) and spiral (iii)) structures
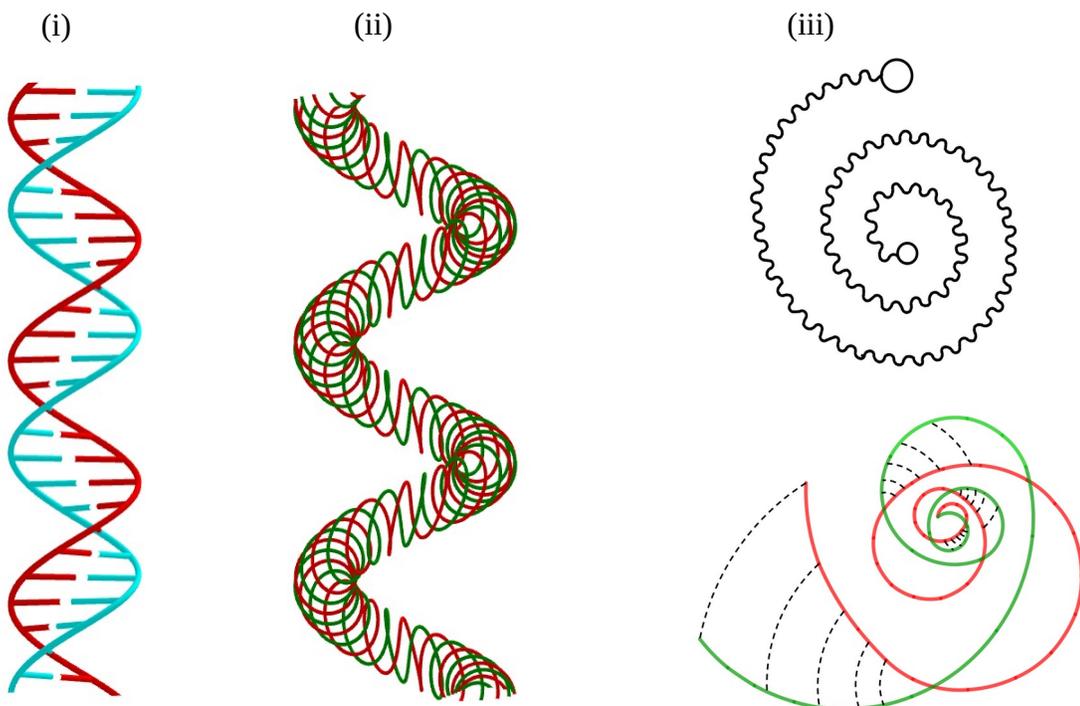
2. Fifteen discrete UV frequencies in DNA primary structure ?

In order to accommodate multiple resonant frequencies along its chain, DNA as a fractal antenna must expand or lessen its helical pitch, regardless of concomitant base pair melting processes. Theoretical predictions and experiments indicate that DNA has a remarkable structural plasticity, and local changes in linking number can be absorbed by the rest of the DNA duplex [4]. Smith *et al.* [5] and Cluzel *et al.* [6] reported in the 1990s that stretching the common double stranded B-form of λ-DNA (~48,500 base pairs (bps)) along its helix axis leads to a highly cooperative and well-defined elongation by 70% without strand separation, at forces of 60–70 picoNewton, followed by a steep force increase of the new ds-DNA structure that is ~3-fold less extensible than B-DNA. This overstretched form of ds-DNA was termed S-DNA.

As a result, it appears that DNA has the flexibility and plasticity to modulate its pitch to variable values. It is propounded in this article that DNA primary structure resonates to 15 discrete wavelengths in the UV spectrum (Fig.2-3). Discrete values are likely dictated by preferred molecular conformations in chain linkages and/or conformational constraints.
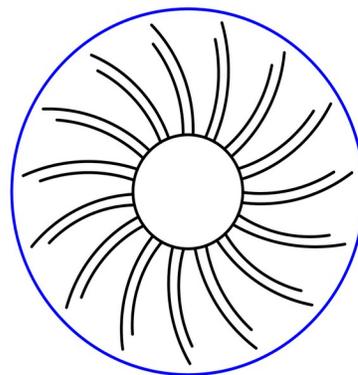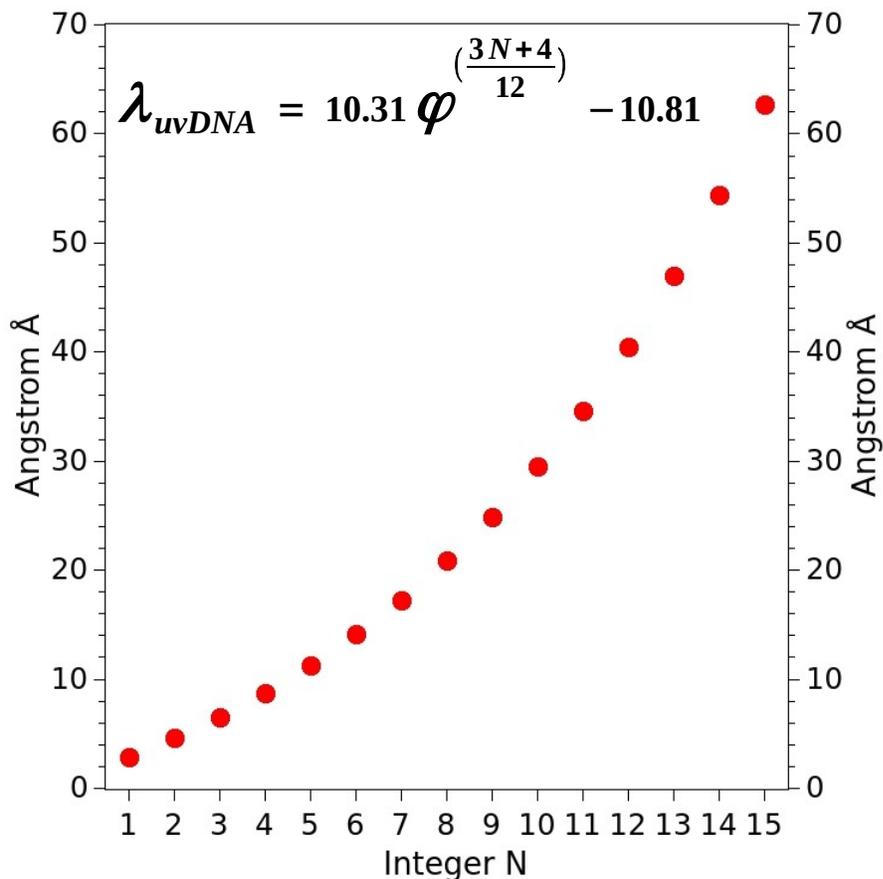

Figure 2: DNA primary structure can resonate to 15 discrete wavelengths (UV range)

Figure 3: Correlation between DNA primary structure resonant wavelengths (in Å unit) and integer, involving the inescapable golden ratio φ

$$\lambda_{uvDNA} = 10.31\,\varphi^{\left(\frac{3N+4}{12}\right)} - 10.81$$

Of interest is the peculiarity of the correlation on the left hand side, in particular the two numbers 10.31 and 10.81 that seem to revolve around the golden ratio. As the matter of fact, the ratio $0.81/0.31 \equiv \varphi^2$ when $0.81 = \varphi/2$ and $0.31 = 1/2\varphi$

Integer N

3. DNA cross section, decagon/pentagon, and the golden ratio

The cross section of DNA reveals a ten-sided geometry (decagon), which was demonstrated decades ago. In fact, Franklin and Gosling [7] provided the first measurement of the diameter of the DNA molecule: "*Thus... we find that the phosphate groups or phosphorus atoms lie on a helix of diameter about 20 Å ...*". In particular, the DNA cross section show how bps align themselves around a decagon (Fig.4), which is in essence two pentagons, with one rotated by 36 degrees from the other, so each spiral of the double helix traces out the shape of a pentagon (Fig.5) [8].

Figure 4: Schematic of DNA cross sectio showing basepairs alignment within a decagon. The 2 different colors represent the two DNA strands
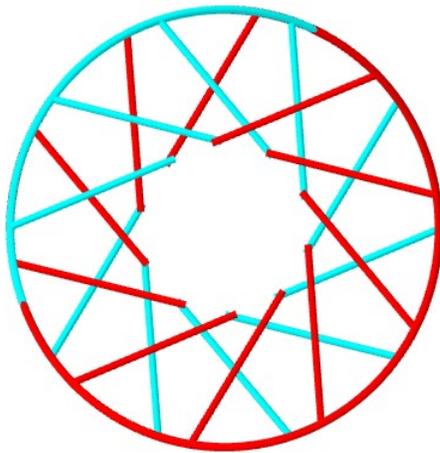
Figure 5: A more complex and realistic depiction of the two pentagons and nucleotides
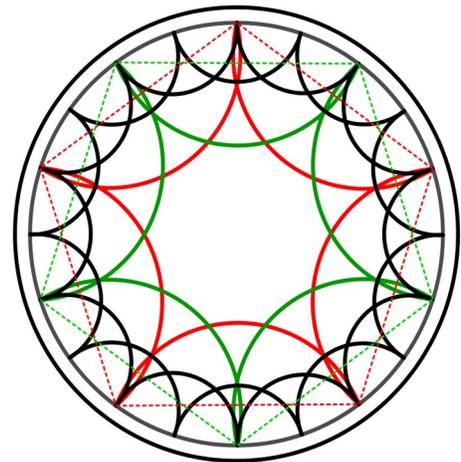

Fig.6 shows the particularity of a regular pentagon, which is constructed around φ the golden ratio. As the matter of fact, the ratio of the diagonal AC to its side AB equals φ, and so does the ratio OE/OB. Therefore, regardless of the way we look at it, even in its smallest element, DNA is constructed using the golden mean. The two pentagrams in Fig.7 depict the superposition of the two five-sided geometries.

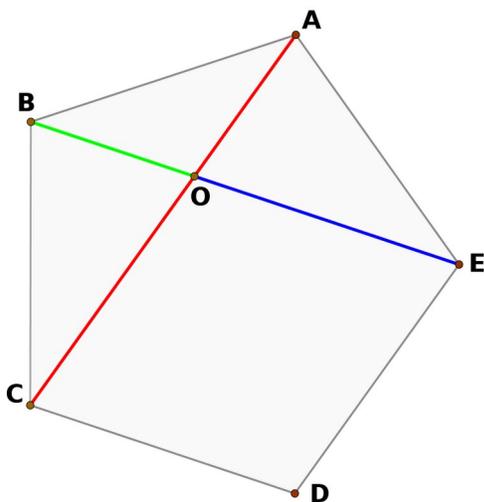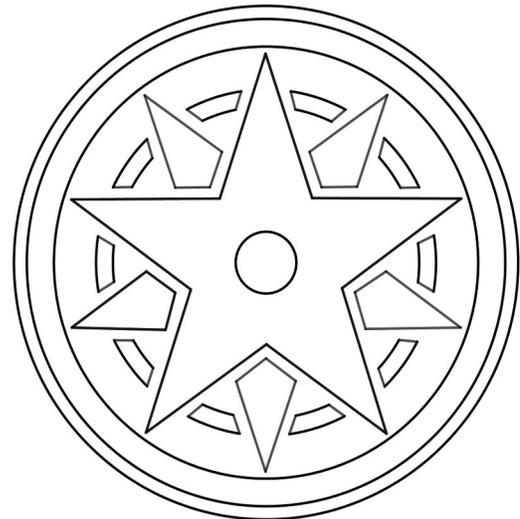**Figure 6:** The golden ratio is embedded in the regular pentagon

Figure 7: Superposition of 2 pentagrams

4. Breadth vs. Pitch

As a UV-light harvesting helical antenna, DNA primary structure requires local adjustment of its pitch in order to resonate with the fifteen UV wavelengths between 2–64Å presented earlier. Further, the modification of its cross section diameter (breadth) must be required in order to cooperate with the pitch elongation / reduction process. In doing so, the base pairs may locally disconnect along the helix, with water molecule superstructures holding temporarily the double helix in proper configuration. Fig.8 depicts the various DNA cross sections at various breadth values, like a fractal design.

Figure 8: Various DNA cross sections at various breadth values, depicting corresponding basepairs and decagons
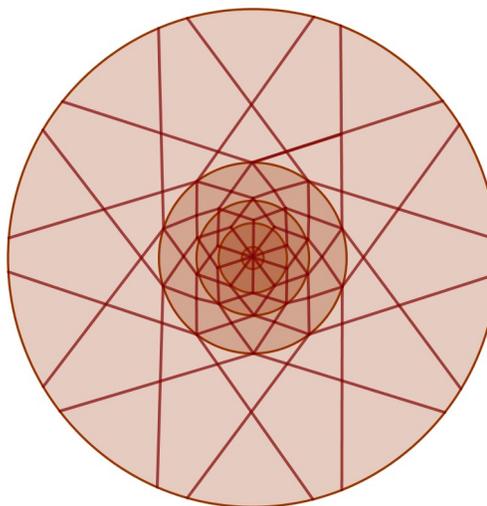
It has been investigated whether DNA pitch variation necessarily induce a change of its cross section diameter. It is concluded that conformational constraints likely produce variation of DNA breadth on both ends of the elongation curve (Fig.9), and that the values are governed by Fibonacci numbers and the golden mean. In this process, base pairs unpairing may locally and briefly occur to allow variation of DNA cross section. The DNA cross section variation is conveniently depicted by a 3rd order polynomial function (Fig.9).

Figure 9: Correlation between DNA primary structure resonant wavelength (in Å) and corresponding cross section diameter (fitted with a 3rd order polynomial function of the type : $41-8.9n+1.2n^2-0.05n^3$)
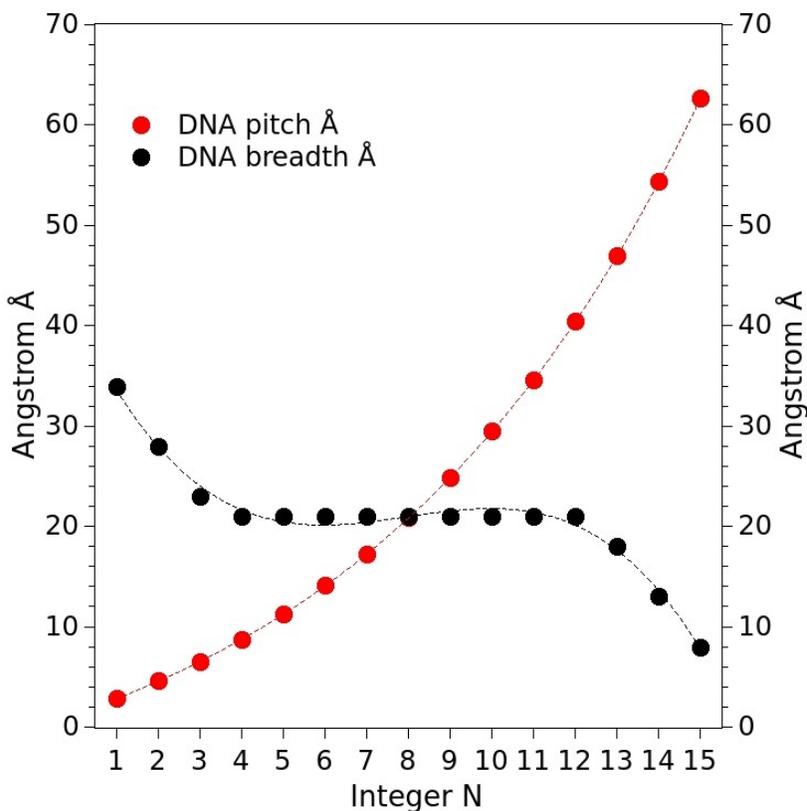
5.   References

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