

190 bps → 2 turns
 95 bps → 1 turn

(1) Extra 10 bases ^{per bead} could give $\frac{10}{95}$ turn
 Substitution of ~ 95 beads would accommodate ^{extra complete turn} $\frac{10}{95}$ turn
 of same kind $\approx 9.5 \rightarrow$ regular factors reduce this to 8 or so

(2) Extra 30 bases $\frac{30}{95}$ turn
 Substitution of $\frac{95}{30} = 3.2$ beads would accommodate this

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1000
 1000
 1000
 1000

January 17, 1977

Dr. Aaron Klug, F.R.S.
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Dear Aaron,

I enclose a copy of a short paper by Bak, Zeuthen and myself which I have just sent off to PNAS. I have not been entirely successful in my efforts to get Bak to do what I consider necessary to make his results solid (though he was kind enough to send me about 1000 of his photographs!) so that I have some reservations about the reliability of it all, but it was clear that we would either have to leave it all till August or send it off now more or less as it is. If he comes to London you may be able to get a firmer impression of him. My worries concern the reliability of measuring something of diameter 0.4 μ m with the light microscope, the variability of this figure both along a fiber and between fibers, the evidence for "doubleness" and its interpretation, the effects of different salts, methods of fixation, staining, etc. (I enclose xerox copies of some of my recent letters to him which deal with these and other points.) I have managed to remove most of the nonsense from the section on 'The Final Level of Folding' but have quite failed to convince them that their double helix is almost certainly wrong. Anyway, let me know what you think of it. I have reluctantly come to the conclusion that if the general idea of a 7 x 6 x 40 x 5 hierarchy is correct, the telling evidence will come from other people rather than from Bak and Zeuthen.

Worcel was here. He gave quite a good seminar. Again, you will hear it all in London. The new idea is that the nucleosomes/unit turn of the solenoid is a function of the exact "200" b.p. repeat. They assume that for 190 b.p. the nucleofilament is straight. For 200 b.p. there are about 8 nucleosomes/turn, for 220 b.p. about 3 -- the relationship is a continuous one. For figures less than 190 the super-solenoid is right-handed rather

N bps	n ns/turn solen
190	∞ (∞)
200	8
220	3

3.2 beads should be there

conclusion

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- 2 -

January 17, 1977

than left-handed. You will see how this is derived though he expressed it in a cumbersome way. I imagine the approximate formula is

$$\sqrt{n} = \frac{N - 190}{95}$$

It assumes (roughly speaking) that the curvature of the DNA is constant and that 'extra' DNA, above or below 190 (which represents exactly 2 turns of DNA) is used to form the extra 'turns' (between dyads) needed for the supersolenoid. He explained it all in terms of H1 interactions but they were not quantized.

As far as I know there is no evidence for any such relationship (for instance, the exact diameter of a supersolenoid should vary with the "200" b.p. repeat and be a little smaller for erythrocytes than for liver, for example) but I suspect there is some relationship of this sort. It's possible it might even lead, if combined with kinking, to a supersolenoid. It's clearly going to be another case of pseudo-symmetry. Perhaps it's time we started to think about it again.

Yours ever,

Francis