Geometry and mechanics of condensed DNA: Toroids and beyond

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DNA, like other semiflexible polymer chains, is known to condense, under certain conditions, into compact structures. The shape of these structures results as a compromise between the costs of the elastic bending energy and the energy of the DNA-DNA and DNA-solution interactions. To achieve maximum density, DNA has to align itself to form a parallel hexagonal bundle which imposes constraints on the global geometry and topology of the condensate. A theoretical consideration of this perfect arrangement is given with particular attention to non-contractible shapes. An expression for the elastic energy of a perfectly packed bundle is derived. Ability of various conformations to minimise the total energy is summed up as a diagram of state for rod-like, toroidal and racquet conformations. A unified description is developed to describe the metamorphosis of toroidal globules into hollow biconcave and convex spheroids.