Understanding Biological Phenomena From the Mechanics Aspects

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Mechanics can play important roles in various biological processes. In this talk, mechanics studies of several biological phenomena will be presented. For part I, we model DNA as an elastic rod inlaid with fibrils to explain its flexibility. It is then found that the persistence length of short DNA can be much smaller than that of long DNA. Consequently, the cyclization rate for short DNA is found to be much higher than the previous prediction of the wormlike chain model. For part II, within the framework of two-state models, we construct two types of catch bonds that have a similar force-lifetime profile upon a constant force-clamp load. However, when a single catch bond of either type is subjected to varied forces, we find that they can behave very differently. Our results suggest that it is necessary to further differentiate those bonds that are all phenomenological referred to as “Catch bonds”. For part III, in understanding how multiple motors can perform coordinated and synchronous actions, we study the motor force regulation in skeletal muscle contraction. With a two-level mechanics model for sarcomere unit, we show that the unique force-stretch relation of a myosin motor is critical to cause the average number of working motors to increase in linear proportion to the filament load so that the motor force is rather precisely regulated. At the level of a single motor, we further show that the unique force-stretch relation of a myosin motor can be due to that a “working” motor is arrested in a transitional state when the motor force is ~6 pN. All these studies are consistent with many experimental results and may provide important insights into understanding respective biological phenomena from the mechanics aspects.