A two-scale model for correlation between B cell VDJ usage in zebrafish

KEYAO PAN, MICHAEL DEEM, Rice University — The zebrafish (Danio rerio) is one of the model animals for study of immunology. The dynamics of the adaptive immune system in zebrafish is similar to that in higher animals. In this work, we built a two-scale model to simulate the dynamics of B cells in primary and secondary immune reactions in zebrafish and to explain the reported correlation between VDJ usage of B cell repertoires in distinct zebrafish. The first scale of the model consists of a generalized NK model to simulate the B cell maturation process in the 10-day primary immune response. The second scale uses a delay ordinary differential equation system to model the immune responses in the 6-month lifespan of zebrafish. The generalized NK model shows that mature B cells specific to one antigen mostly possess a single VDJ recombination. The probability that mature B cells in two zebrafish have the same VDJ recombination increases with the B cell population size or the B cell selection intensity and decreases with the B cell hypermutation rate. The ODE model shows a distribution of correlation in the VDJ usage of the B cell repertoires in two six-month-old zebrafish that is highly similar to that from experiment. This work presents a simple theory to explain the experimentally observed correlation in VDJ usage of distinct zebrafish B cell repertoires after an immune response.