

VIBS613 - Homework 1

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1. Write a short paragraph to describe the two models (DDC and IAD) for gene duplication and summarize the differences between them:

Gene duplication is the origin of most new genes and likely underlies the origin of most new functions, duplication generates redundant gene copies, and if gene dosage is not crucial, one copy can evolve free from functional constraints, while the ancestral function is maintained in the other copy through purifying selection. The copy that is free to evolve could occasionally accept mutations that generate a new function. In the duplication-degeneration-complementation (DDC) model, both genes resulting from duplication experience degenerating mutations that cause loss of function. In the quantitative sub-functionalization version of the model, there is one single function, and the duplicates are maintained because their lower function levels impose that the two copies are required to reach the level of the ancestral gene. In the qualitative sub-functionalization version of the DDC model, on the other hand, the ancestral gene has two different functions that are independently mutable. Degeneration after duplication causes complementary loss of function in the duplicate genes. Each copy thus becomes specialized in one function through degeneration of the other function, while the pre-duplication ancestral gene had the two functions. By contrast with the DDC models, the innovation-amplification-divergence (IAD) model proposes that the duplication step is not neutral. This model still assumes more than one function in the parent gene with, perhaps, one major original function and one (or several) minor side activities. At a certain point, one of the side functions may become valuable (due to a change in an ecological niche, for instance). Since duplication and amplification events are far more common than improvement by point mutations, the requirement for increased levels of the side activity will be more likely met in the first place by amplification of the original gene. Subsequently, however, the possibility of improvement by point mutation is increased because of the presence of several extra copies of the gene that acts as mutational targets. Improvement in one copy brings about relaxation on the other copies, and these could then be removed from the population in such a way that the required level of the new function is eventually provided by one copy of the gene. Since optimization of the new function is likely detrimental to the original one, selection will maintain one copy with the original major function.s

Adapted from: Alcalde, M. (Ed.). (2017). Directed Enzyme Evolution: Advances and Applications. Springer.