PHENOTYPIC WALKS THROUGH PLANT FITNESS LANDSCAPES: DOES INCREASING FUNCTIONAL COMPLEXITY EXPEDITE MORPHOLOGICAL DIVERSIFICATION?

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Sewall Wright's genotypic fitness landscape is used as a model to explore phenotypic walks through computer generated morphospaces for unicellular and multicellular plants. Within each morphospace, plant phenotypes are described with the aid of a few simple geometries, while internal structure is defined by tessellation rules governing these geometries within larger, albeit equally simple geometries. Each morphospace is then rendered as a "fitness landscape" by assigning a relative fitness to each phenotype based on the influence of size, shape and geometry on performing biological tasks essential to plant growth and survival (light interception, passive diffusion, water conservation, mechanical stability, or long-distance dispersal of spores). Evolutionary walks through each fitness landscape are initiated with the phenotype best reflecting the last common ancestor to all other phenotypes within the morphospace. Each walk proceeds by searching the fitness landscape for sequentially more fit phenotypes. Each walk ends once it locates the most fit phenotype(s) within a particular fitness landscape.

Phenotypic walks through a fitness landscape for unicellular aquatic plants identify cells with a slender cylindrical or flattened oblate shape as the optimal phenotype; walks through a fitness landscape for multicellular aquatic plants also identify these shapes as the optimal phenotype; and walks walks through a fitness landscape for early vascular land plants identify seven phenotypic optima each bearing a striking similarity to Devonian plant remains. Analyses show that landscapes where fitness is defined on the basis of performing a single biological task (e. g., light interception) generally contain one or only a few fitness peaks well above the average fitness, whereas landscapes where fitness is defined on the basis of performing two or more tasks simultaneously contain many fitness peaks differing modestly from the average fitness. Based on these computer simulated phenotypic walks, it is suggested that phenotypic diversification within a morphospace becomes easier as the number of biological tasks that must be simultaneously performed increases because the number of phenotypic optima increases and the fitness-differential among phenotypes decreases in proportion with the number of tasks that must be performed.