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Transcriptomics: Open Access

ISSN: 2329-8936

Commentary

Computational Developments in Gene and Environment Interactions

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ABSTRACT

It was natural for much evolutionary research to focus on the forces that cause changes in gene and genotype frequencies within populations from these genetic beginnings. According to this genetics-centered viewpoint, the four evolutionary forces are cause micro-evolutionary change within and between populations. The same forces work together to convert genetic variation within populations into more or less permanent genetic variation between species. Micro-evolutionary forces are thought to be sufficient to account for macro-evolutionary patterns observed in higher taxonomic groups given enough time.

Keywords: Gene; Genotype frequencies; Environment interactions

DESCRIPTION

Ecological genetics is a broad field of study that investigates the relationship between genetic change and biotic and abiotic environmental features. The role of the environment in adaptive evolution is often hidden in population genetic theory's recursion equations for gene frequency dynamics, where the common assumption of a constant selection coefficient implies a constant relationship between genotype, phenotype, and fitness regardless of environment. In contrast, the central focus of ecological genetics is the causal relationship between genetic variation and environmental variation, where conspicuous (especially discrete) phenotypic variation is assumed to have a genetic component. Within the last fifteen years, the advent of molecular tools and the development of molecular ecology within ecological genetics have greatly broadened the conceptual scope of the field.

Micro-evolutionary forces are thought to be sufficient to account for macro-evolutionary patterns observed in higher taxonomic groups given enough time. In short, the central challenge of evolutionary genetics has been to describe how the four evolutionary forces shape patterns of gene, genome, and species diversity, with a special emphasis on natural selection's dominant role among the various evolutionary forces.

In the subfield of molecular ecology, ecological genetic research has recently been integrated with molecular genetic methods. Most ecological genetics studies begin with one of the two most prominent patterns in nature:

1. Adaptation, the "fit" between an organism and its environment.
2. Polymorphism, the natural selection-based maintenance of two or more phenotypic or genetic forms within a single population.

With the advancement of molecular ecology, it is now possible to investigate phenotypic differences between species in a phylogenetic context. This allows for a more in-depth examination of the environments that promote adaptive divergence of phenotypes between species. Furthermore, the same molecular methods used in phylogenetics can frequently be modified to identify the genes or chromosomal regions that are responsible for those inter-specific phenotypes.

Historically, the discovery of variation within a natural population, i.e., a phenotypic polymorphism, has been the starting point for ecological genetic research. The following objective is threefold:

- Determining whether the polymorphism has a genetic component;
- Determining the frequency of each polymorphic type and its spatial and temporal variability; and
- Determining how natural selection maintains the polymorphism, either alone or in conjunction with other evolutionary forces.

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Received: 01-Aug-2022, Manuscript No. TOA-22-18965; **Editor assigned:** 03-Aug-2022, Pre QC No. TOA-22-18965 (PQ); **Reviewed:** 17-Aug-2022, QC No. TOA-22-18965; **Revised:** 24-Aug-2022, Manuscript No. TOA-22-18965 (R); **Published:** 31-Aug-2022, DOI: 10.35248/2329-8936.22.8.123

Citation: Bhatia R (2022) Computational Developments in Gene and Environment Interactions. Transcriptomics. 8:123.

Thus, the primary goal of an ecological geneticist is to determine how natural selection is acting to maintain a balanced polymorphism based on the relative strength of opposing fitness effects acting on different sexes, at different stages in the life history, in different locations, or at different times in the organism's lifetime. The ecological geneticists did not completely dismiss random genetic drift as a significant evolutionary force. Field observations using ecological geneticists' mark-recapture methods revealed generation-to-generation fluctuations in population size of an order of magnitude or greater in most natural populations studied over time. Thus, ecological geneticists did not regard small local population sizes as unusual. Few diseases are caused by a single or multiple gene mutation. Most diseases, on the other hand, are complex and result from an interaction between your genes and your environment. Environmental factors can include chemicals in air or water pollution, mould, pesticides, dietary choices, or grooming products. Subtle genetic differences can cause one person to react differently to the same environmental exposure as another. As a result, while some people may develop a disease as a result of being exposed to something in the environment, others may not. As scientists learn more about the relationship between genes and the environment, they pursue novel approaches to disease prevention and treatment that take into account individual genetic codes. NIEHS investigates a wide range of genetic and environmental diseases and disorders. Furthermore, new technologies and computational approaches are being developed to elucidate the gene-environment interactions that underpin disease.

Autism: Children with a genetic variant called MET, which is involved in brain development, are more likely to develop autism when exposed to high levels of air pollution. This genetic variant did not increase the risk of autism in the 75% of the population exposed to lower levels of air pollution, implying that autism is caused by a combination of genetic and environmental factors.

DNA Repair Molecules that have been damaged by environmental exposures such as ultraviolet light or certain chemicals are incorporated into DNA, causing cell death and potentially leading to cancer, diabetes, hypertension, cardiovascular and lung disease, and Alzheimer's disease.

Metabolism NIEHS Metabolism, Genes, and Environment Group researchers discovered that a protein called SIRT1, which plays a critical role in early development and metabolism, could provide the basis for genetic therapeutic targets for metabolic diseases and ageing.

Parkinson's disease People who had a genetic variation that affected the production of nitric oxide, a molecule that can damage neurons, had a higher risk of developing Parkinson's disease after pesticide exposure. Diet, exercise, and nicotine use have all been linked to an increased risk of developing Parkinson's disease.

Respiratory Syncytial Virus (RSV) **N**An international study involving NIEHS researchers discovered that children with variations in a gene called TLR4 who were exposed to certain environmental factors developed severe cases of RSV bronchiolitis, a potentially fatal respiratory disease.