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About Our Cover

This cover features the wasp *Encyrtus fuscus*, which is a little under a millimeter and a half long. Though small, this wasp is mighty, in that it helps keep cities green. *E. fuscus* is a parasitoid, which means it lays its eggs inside other insects, and when its larvae hatch, they eat the insect from the inside out. By killing insects that eat plants, parasitoids protect plants that people care about all over the world, from cities to greenhouses and farmlands.

Very little is known about *Encyrtus fuscus*. Like most insects, its small size makes understanding where it goes and what it eats difficult. However, scientists do know that *E. fuscus* and its relatives play a strong role in controlling pest "scale insects." Scale insects are a group of pests that damage trees that line our streets and clean the air in urban areas, where most people in the world live. The wasp in this photo was reared from a scale insect and then quickly photographed as it emerged as an adult. No matter where you live in the world, parasitoids are emerging from other insects and spiders all around you, though they are often too small to notice.

This photo was taken in the NCSU Department of Entomology by Emily Meineke, Ph.D., who is a postdoctoral fellow at the Harvard University Herbaria, and Andrew Ernst, who is a lab technician at BASF. The camera was an Olympus DP72. We used an Olympus CX41 trinocular scope and lenses with a long working distance so we could use brightfield light as opposed to transmitted light.

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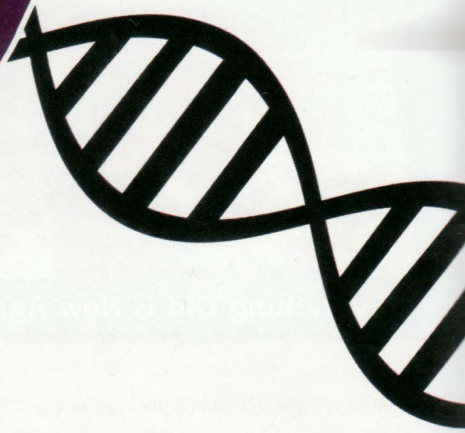
Genes and Protein Synthesis—Updating Our Understanding



TIMOTHY P. BRADY

ABSTRACT

That genes are indispensable is indisputable but that they are the source of information for protein synthesis—to the extent reflected by statements such as "genes are blueprints for proteins" or "genomes constitute developmental programs"—is challenged by discoveries such as post-translational modification of protein and alternative splicing.

Key Words: *alternative splicing; post-translational modification of protein; mRNA editing; primary mRNA transcript; functional (mature) mRNA transcript; alternative transcript; protein isoforms.*

○ Introduction

I take it for granted that genetics teaching, at both the high school and undergraduate levels, pretty much reinforces the longstanding belief that genes are, ultimately, blueprints for proteins and, given the workhorse nature of proteins, that organisms' genomes constitute the blueprints for making organisms. The Next-Generation Science Standards' Disciplinary Core Ideas include L.S.1.A., "Genes are regions in the DNA that contain the instructions that code for the formation of proteins. . ." and L.S.3.A., "The instructions for forming species' characteristics are carried in DNA" (NGSS, n.d.). The premise of this paper, however, is that consideration of the influence post-translational modification of protein (PTM) and alternative splicing (AS) have on protein synthesis and consideration of the factors involved in regulating these processes cast doubt on the continued appropriateness of the gene-as-blueprint and genome-as-developmental-program metaphors. AP biology textbooks do discuss PTM and AS, over-looking, though, the possibility that these phenomena, properly considered, suggest the need to qualify the paradigm that insists genes largely dictate to cells and organisms via genetic influence on protein synthesis.

Genes appear very much to be blueprints for primary mRNA molecules but not blueprints for the functional mRNA molecules resulting from AS.

○ Post-Translational Modification of Protein

PTM provides for the covalent attachment of chemical groups such as phosphate or the acetyl group or sugar moieties, or even larger groups such as ubiquitin, to amino acid residues of proteins. Most eukaryotic proteins are post-translationally modified after their synthesis on ribosomes and these modifications are critical for the protein's functioning and for getting the protein to the site in the cell where it needs to be to in order to carry out its function (Reece et al., 2014, pp. 351–352). In the next section, examples of PTM are provided to show the extent to which modification status can influence protein function and to show the extent to which factors other than the nucleotide sequence of the associated gene can influence modification status. Any influence by a factor that is not itself a direct product of a gene is termed "non-genetic."

Evidence for Context-Dependence of PTM, Including Non-Genetic Context Dependence

PTM appears to be a very dynamic process. For instance, all of the examples of PTM mentioned above are reversible (Prabakaran et al., 2012, HHS Public Access Version, p. 28). These authors also stress the combinatorial possibilities associated with PTM as suggesting its dynamic nature and provide the following example to make clear their understanding of "combinatorial." If a particular lysine residue can bind an ubiquitin, and a second ubiquitin can bind to the first,

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FEATURE ARTICLE

Time Travel and the Naturalist's Notebook: Vladimir Nabokov Meets the TimeTree of Life

CARYN BABAIAN

Abstract

Combining the TimeTree of Life database with the skill set of a naturalist, transitional changes, speciation, and evolutionary concepts emerge as a process in which students create and are fully engaged in a narrative & theme-based lesson plan/lab that merges with a scientific drawing experience that shadows the life of the naturalist and author Vladimir Nabokov. The interdisciplinary story and science of Nabokov offer a glimpse into applied arts as an exploratory scientific practice that encourages creativity and evolutionary thinking.

Key Words: *drawing-for-evolution; TimeTree of Life; naturalists; macroevolution; characters; butterflies.*

> Imagine a modern taxonomist straddling a Wellsian time machine. Going back millions of years (to the Cenozoic), he would end up at a time when only Asian forms of the butterflies existed. Then, moving forward again, the taxonomist would see five waves of butterflies arriving in the new world.
>
> —Vladimir Nabokov

○ Introduction

The TimeTree of Life (TTOL) database is a public database created by Blair Hedges and Sudhir Kumar, which provides divergence times of species from published studies in the database and allows for a search and comparison of two species' divergence times. It also permits easy access for educational experiences with evolutionary concepts such as speciation and geological time scales. The TTOL can be easily accessed at http://www.timetree.org/ (Hedges & Kumar, 2009). The software delivers a "big picture" experience of timing for junior high school, high school, and college courses that teach evolutionary concepts and encounter topics in bioinformatics, phylogenies, and "tree-like" thinking. The TTOL gives students the opportunity to instantaneously explore two species, like "cat" and "dog," and their relationship in the abstract concept of geological time (Metzger, 2011).

The naturalist experience allows students to generate their own original observations, drawings, and concepts about variation in nature, and ponder evolutionary time and processes.

The database experience is a unique, exploratory one of genomic data and nodes of departure for new species in the often difficult to grasp 4.5 billion year timeframe, stimulating interest in evolution, biodiversity, and phylogenetics. It can be further expanded and deepened by merging it with the hands-on processes and "slowed down" methods of naturalists and the arts. The naturalist experience allows students to generate their own original observations, drawings, and concepts about variation in nature, and ponder evolutionary time and processes, leading up to the exercise of building phylogenetic trees and engaging with the TTOL database. But what are the best practices that benefit students in discovering the natural world and developing passion for it in a time when "nature deficit disorder" abounds (Driessnack, 2009)? Naturalists employed the descriptive practice of drawing with astute and often direct observation of nature. With the re-emergence of the art/science paradigm and so-called STEAM (Science, Technology, Engineering, Art, and Math) education movement, what practices lead students in the direction of self-discovery and the development of their own descriptive drawing and writing skills?

The complexity of thought that goes into the observant analysis of nature through drawing processes makes the TTOL database experience even more thought-provoking. Students, today, however, spend

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