

The role of microRNAs in neurons

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To Alex, Leo, Marija,
Matias and Steve

This thesis is the result of my own work and includes nothing which is the outcome of work done in collaboration except where specifically indicated in the text.

This thesis does not exceed the specified length limit of 60,000 words as defined by the Biology Degree Committee.

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Siarhei Manakou

“The role of microRNAs in neurons”

Abstract

Many individual functional microRNA (miRNA) targets have been identified in neurons, and their importance for neuronal differentiation is well established. However, with over 50% of genes in a mammalian genome being computationally predicted as miRNA targets, the global significance of the role of miRNAs in neurons is not yet fully understood. Using chemical transfection, I artificially overexpressed ten miRNAs in primary neuronal cultures. For six of them I identified hundreds of putative direct targets through analysis of the differential gene expression associated with the transfection experiments. Among these six miRNAs, there were two that are naturally enriched in the adult mouse brain (miR-124 and miR-434-3p), three miRNAs that were depleted from neurites (miR-143, miR-145 and miR-25) and one non-mouse miRNA (cel-miR-67). Analysis of the miRNA mediated effects on gene expression revealed that upon overexpression both miR-124 and miR-434-3p destabilised mRNA transcripts that are seen to be induced in stress conditions. The effect of overexpression of the other four miRNAs was found to be similar to that of miR-124 and miR-434-3p, although it was less significant. The ability of miRNAs to downregulate the inducibly expressed genes, and a widespread upregulation of these genes in stress conditions, implies that miRNAs normally act to prevent changes to equilibrium in the transcriptome. The results of this thesis also demonstrate that a repertoire of miRNA targets, including that of the neuron specific miR-124, is context-dependent. Given that the context can be influenced by a stress associated with experimental treatments, this work bears direct implications for future experiments aiming to ascribe particular functions to miRNAs.

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Abbreviations and comments

Abbreviations:

Cat. no.	catalogue number
DIV	days of <i>in vitro</i> development
miRNA	microRNA
<i>n</i>-mer	an oligomer of a length <i>n</i>
nt	nucleotides
ref.	reference
RT-PCR	real-time PCR
qRT-PCR	quantitative real-time PCR
<i>P</i>	P-value
UTR	Untranslated region

Comments:

- Very small numbers are presented using “E notation” as an alternative to the standard decimal notation. In this notation a letter *e* is used to represent *times ten risen to the power of*. For example, 0.000000012 in “E notation” is presented as $1.2e - 8$ or $1.2e - 08$.
- DNA is a polymer consisting predominantly of four types of units (nucleotides) containing the following four bases: adenine (the corresponding nucleotide is commonly denoted as *A*), cytosine (*C*), guanine (*G*) and thymine (*T*). RNA is also a polymer, which predominantly consists of nucleotides containing adenine, cytosine, guanine and uracil (the corresponding nucleotide is denoted as *U*) bases. In conventional Watson-Crick double stranded forms of RNA, DNA or DNA-RNA heteroduplexes, *G*s form connections with *C*s, while *A*s pair with both *T*s and *U*s. Therefore, *U* is RNA’s equivalent of DNA’s *T*. For purposes of consistency, sequences of DNA and RNA are frequently stored in databases as a sequence of the four letters *A*, *G*, *C* and *T*, where *T* is understood to be *U* in case of RNA sequences. In this thesis, I

preserved this notation, and both DNA and RNA nucleotide words are represented as sequences of *A*, *T*, *G* and *C*.

- The research of miRNA function that is presented in this system was conducted in an *in vitro* cell culture system derived from mice (*Mus musculus*). Conventionally, names of genes that encode miRNAs and names of miRNAs themselves are preceded by a three letter prefix, which uniquely corresponds to the species of the origin. Mouse miRNAs are preceded by three letters “mmu” (as in mmu-miR-124 or mmu-let-7c), while, human miRNAs (*Homo sapiens*) are preceded by “hsa” (as in hsa-miR-124 or hsa-let-7c). For convenience the three letter prefix of mouse miRNAs is frequently omitted, therefore names miR-124 and let-7c mean mmu-miR-124 and mmu-let-7c. Prefixes for other species are not omitted.

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