

Transcriptional Leakage vs. Noise: Binary to Graded Response Conversion in Autoregulated Genes

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The response of a gene to a signal of increasing strength is binary when the protein distribution changes its shape from unimodal through bimodal to unimodal. Graded response occurs when the protein distribution remains unimodal while changing its mean. It became a common knowledge that positive feedback in gene regulation is an evolutionary way for obtaining bimodality, whereas negative feedback increases the precision of gene response and produces unimodal protein distributions in autoregulated genes.

But what if the cells need to evolutionarily adapt from the environment where binary response was beneficial to the environment where graded response is more preferred? The change of the regulation from positive to negative may not be the optimal way because it requires multiple mutations.

Using a stochastic model of autoregulated gene, we show that another, simpler mechanism is possible for the conversion between binary and graded response. It is based on fine-tuning of the transcriptional leakage and it has the opposite effect to the translational noise: An increase in the noise converts the response from graded to binary, whereas an increase in the leakage converts the response from binary to graded. Importantly, the change in the leakage level can be achieved by single mutations and therefore it seems to be a more probable evolutionary scenario than the change of the nature of feedback from positive to negative.

References

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