Fupli, NETADIS!

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Consiglio Nazionale delle Ricerche

SAPIENZA UNIVERSITÀ DI ROMA

Armenia


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SAUDI ARABIA

My Way

- BS in Applied Physics and Mathematics
- MS-1 Theoretical Physics
- Stage – Virus Evolution Models
- MS-2 Theoretical Physics and Applications/ Complex Systems
- Stage – Modeling of Cell Metabolism
- PhD, Applications of Stat. Physics and Inf. Theory in Biology

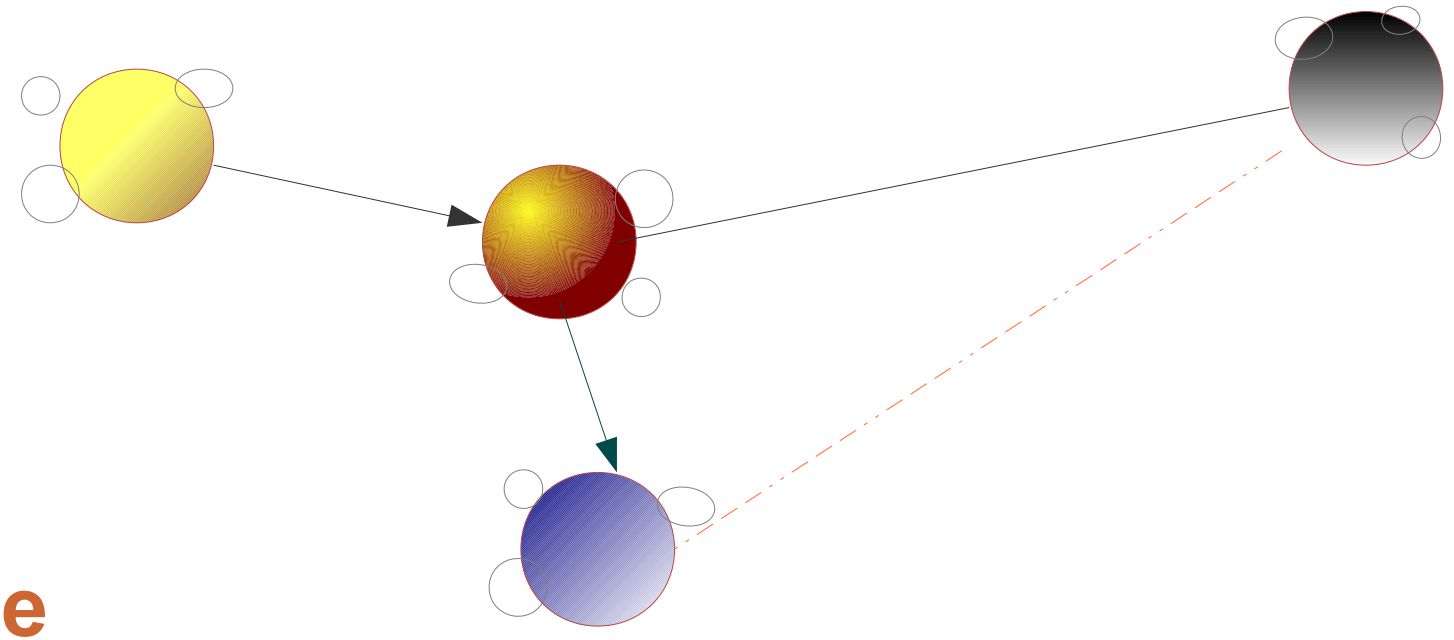
Plan

- Project
- Model
- State of The Art
- Next Steps

Project

Regulatory Control in Metabolic Networks

Advisers: Enzo Marinari, Andrea De Martino



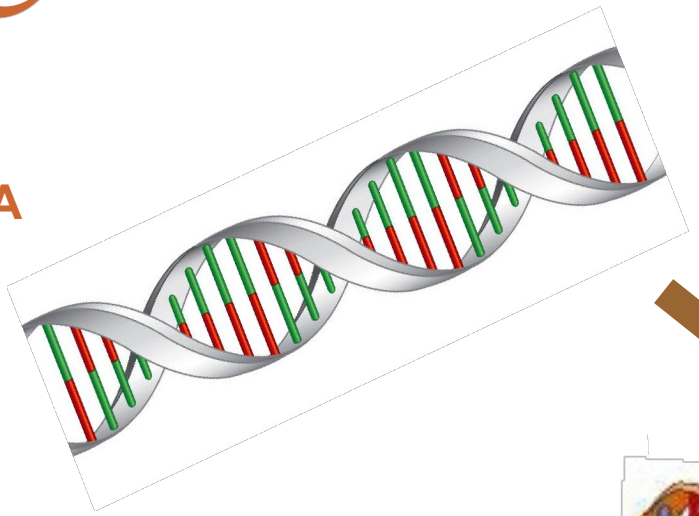
+ noise

Questions?

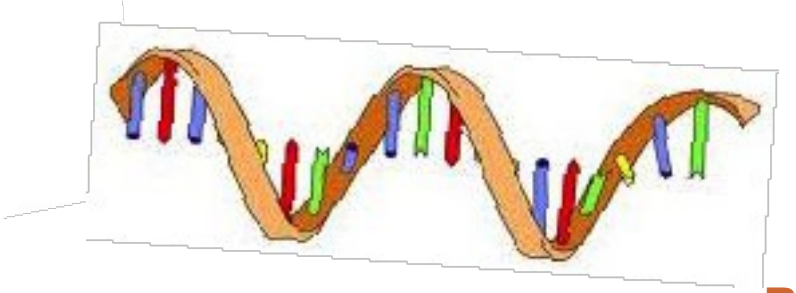
- Why certain biological channels work *optimally*?
- What is the *optimal concentration* of objects that the given channel of interaction transfer maximum amount of information?
- What is the *optimal channel* of interaction that for given concentrations of objects transfers maximum amount of information?

ChanneL

DNA

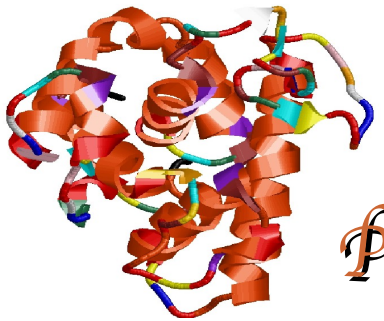


Transcription



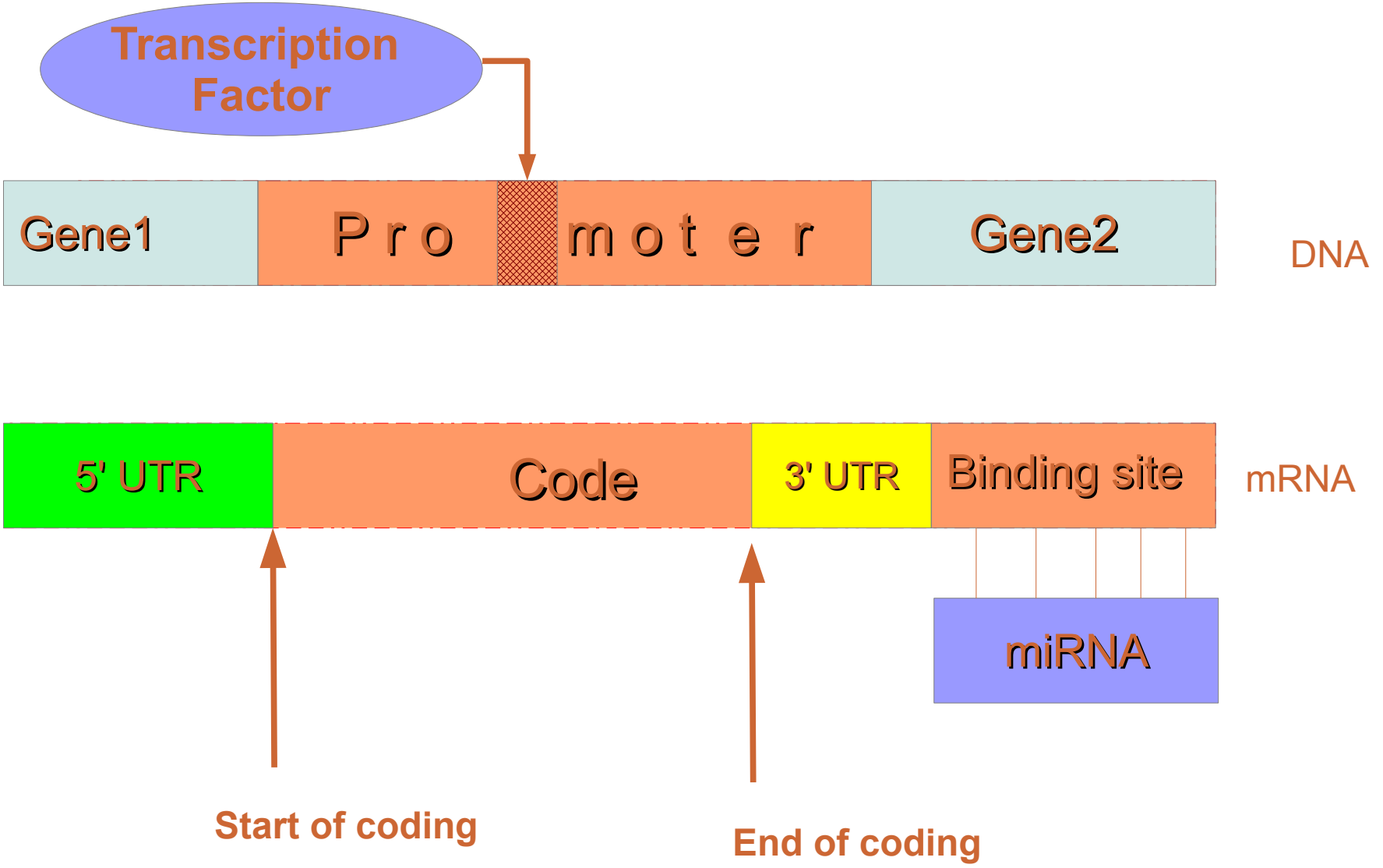
mRNA

Translation

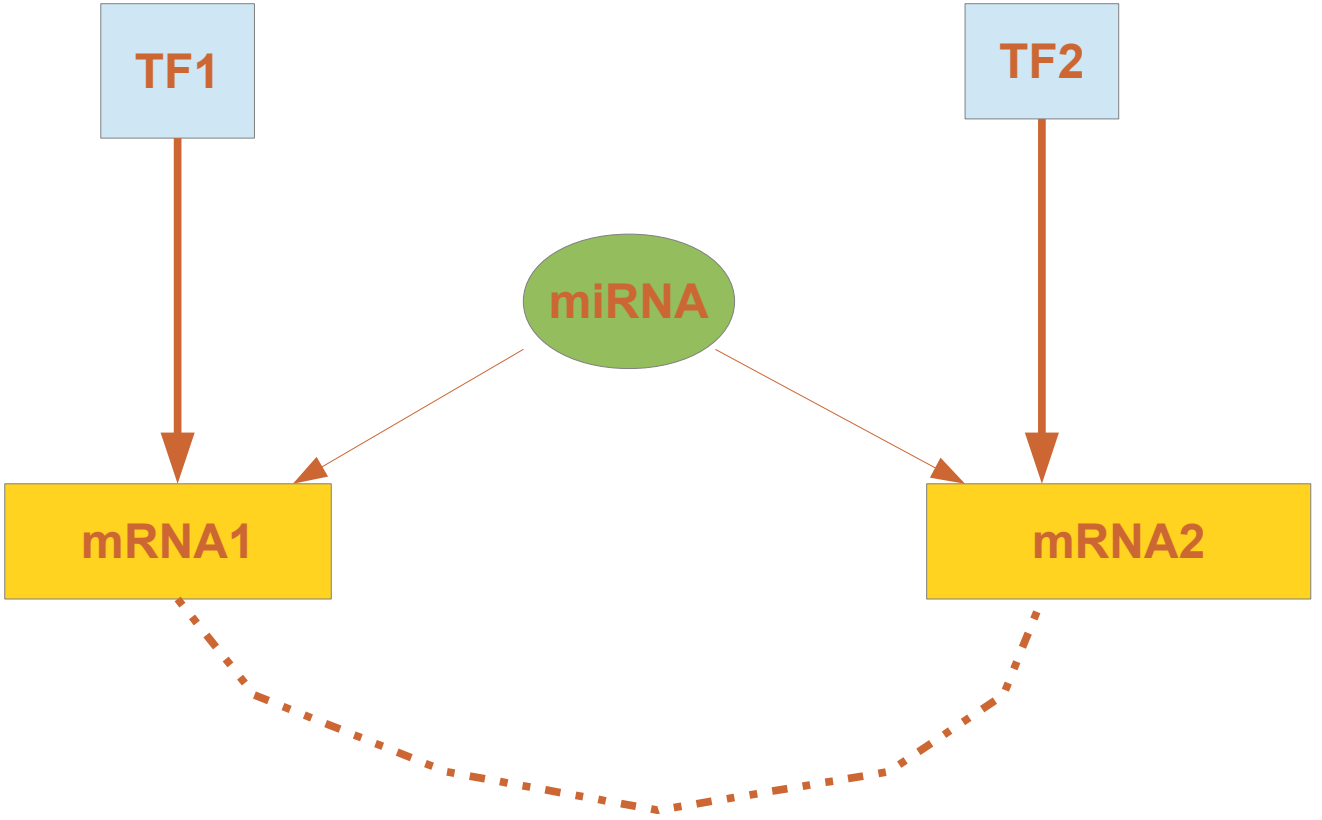


Protein

Regulation


Transcription Factor
Gene1
Pro
moter
Gene2
DNA
5' UTR
Code
3' UTR
Binding site
mRNA
miRNA
Start of coding
End of coding

Model



Ref: Matteo Figliuzzi, Enzo Marinari, Andrea De Martino, MicroRNAs as a selective, post-transcriptional channel of communication between ceRNAs: a steady state theory To appear in Biophy J

State of The Art

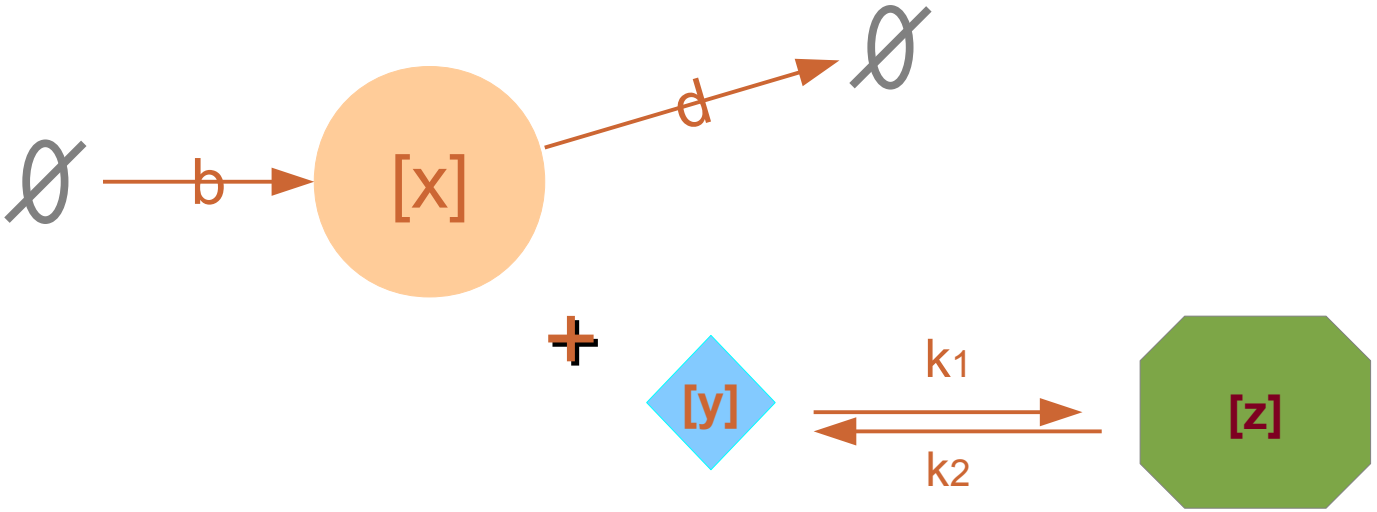
1. ODE Approach and Steady State Analyses

2. Noise Integration

3. Information Theory

4. Optimization

ODE Approach and Steady State Analyses



creation

$$\frac{d[x]}{dt} = b - d[x] - k_1[x][y] + k_2[z]$$

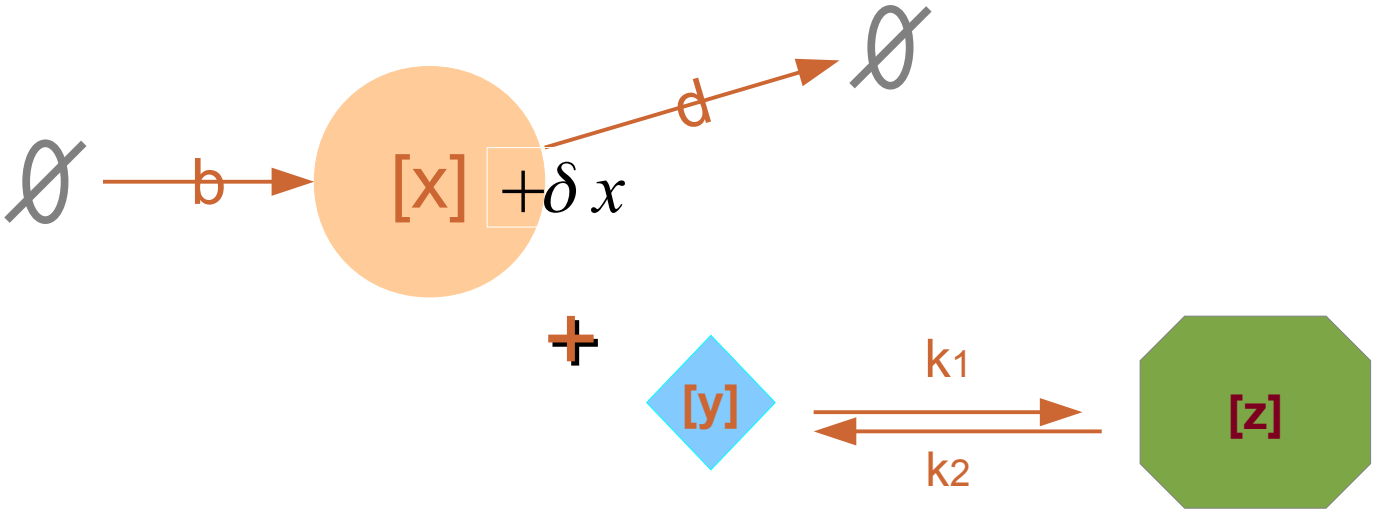
degradation

complex coupling

complex decoupling

Ref: Matteo Figliuzzi, Enzo Marinari, Andrea De Martino, MicroRNAs as a selective, post-transcriptional channel of communication between ceRNAs: a steady state theory, To appear in Biophy J

Noise Integration

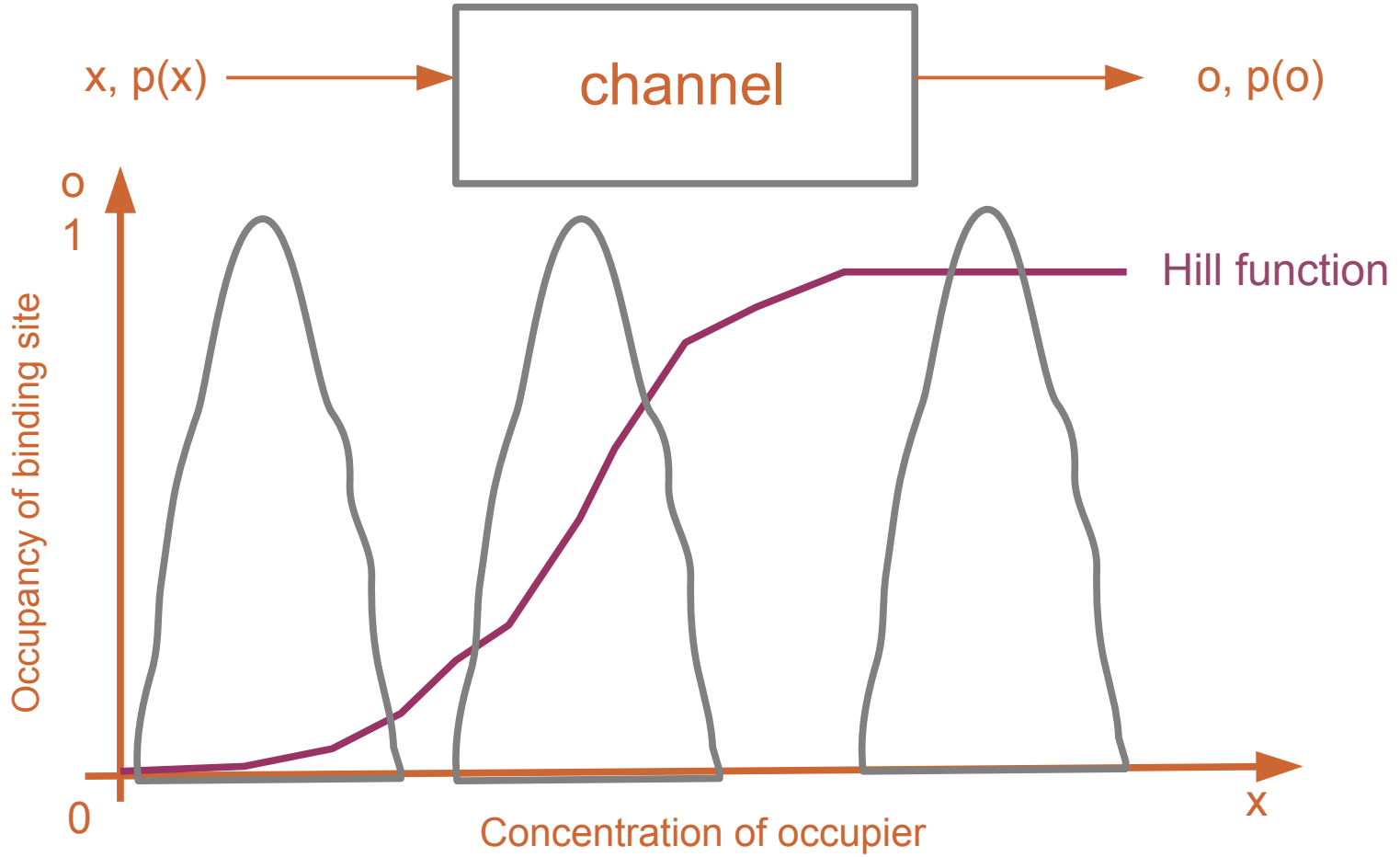


$$\frac{d[x]}{dt} = b - d[x] - k_1[x][y] + k_2[z] + \zeta_x$$

noise

Ref: Gasper Tkacik and Aleksandra M. Walczak, Information transmission in genetic Regulatory network, J Phys Condes Matt 23 (2011)

Noise Integration



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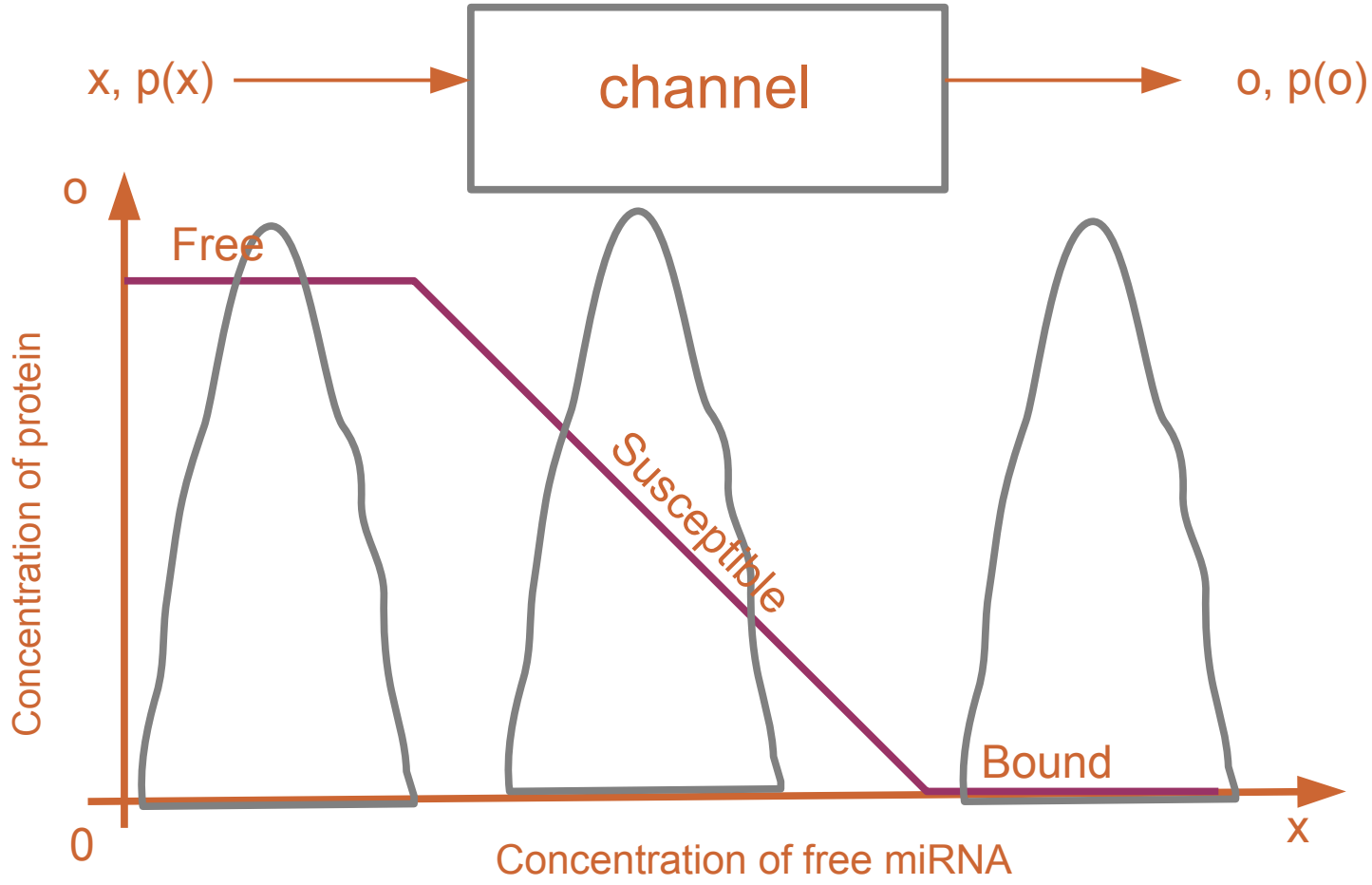
Noise Integration



Ref: Matteo Figliuzzi, Enzo Marinari, Andrea De Martino, MicroRNAs as a selective, post-transcriptional channel of communication between ceRNAs: a steady state theory Biophy J, 2013

Information Theory

Information

= knowledge

= loss of uncertainty

Entropy

$$S = -\int dx\, p(x) \log_2 p(x)$$

Entropy

Probability distribution

Ref: Shannon, Information Theory, Mathematical Theory Of communications, bell Sys Tech J 27: 379 & 623, 1948

Mutual Information

Question: How much our ***uncertainty*** about output o ***reduces*** by knowing input x?

$$I(x;o)=\int dp(x)\left(S[p(o)]-S[p(o/x)]\right)$$

mutual information

input variable prob. dist.

output variable prob. dist.

conditional prob. describing x-> o regulatory element

Ref: Gasper Tkacik and Aleksandra M. Walczak, Information transmission in genetic Regulatory network, , J Phys Condens Matt 23 (2011)

Optimization

Channel

Input

Ref: Gasper Tkacik and Aleksandra M. Walczak, Information transmission in genetic Regulatory network, , J Phys Condes Matt 23 (2011)

Optimization

Entropy for the **Gaussian** distribution is:

$$S_{Gaussian} = \log_2 \sqrt{2\pi e \sigma^2}$$

variance

Using Langrange multiplier methods one can show that **when the noise is Gaussian and additive**, then ***information*** transmission is **maximized** at fixed input variance when input is drawn from a ***Gaussian distribution***.

Ref: Gasper Tkacik and Aleksandra M. Walczak, Information transmission in genetic Regulatory network, , J Phys Condes Matt 23 (2011)

Next Steps...


Develop the cRNA Model
add noise
optimize
calculate I
switch?
Attend to schools/ conferences/ meetings
NETADIS
NETADIS
Attend to the courses of La Sapienza
Spin Glass Theory
Inf Theory
Struct glasses
Bayes inf and learning
Random Graphs

Secondary

Norges Teknisk-Naturvitenskapelige

Université Paris-Sud

Politecnico di Torino

Kungliga Tekniska Högskolan

Kings College

École Normale Supérieure

ICTP

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Thank you!