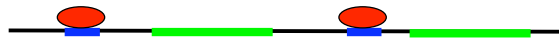


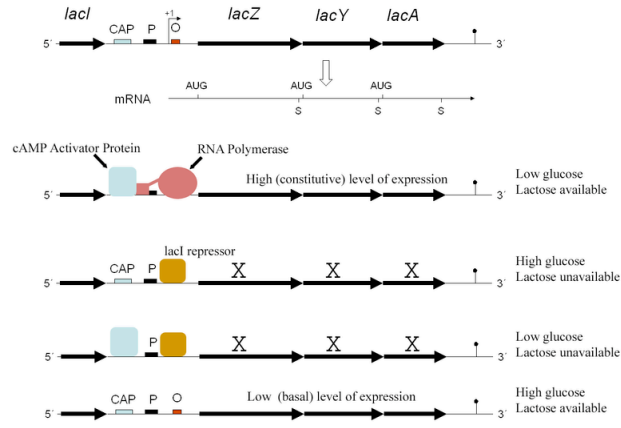
Protein-DNA interactions

Introduction: DNA, genes and regulation



- DNA contains **genes**
- genes need to be turned on and off
- genes are regulated by proteins that bind to specific **regulatory sequences** on DNA.
- proteins that regulate genes are called **transcription factors** (TFs)

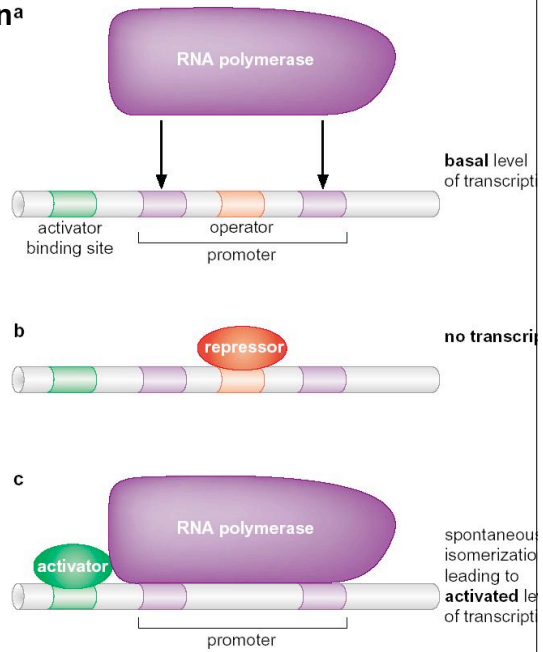
The *lac* Operon and its Control Elements



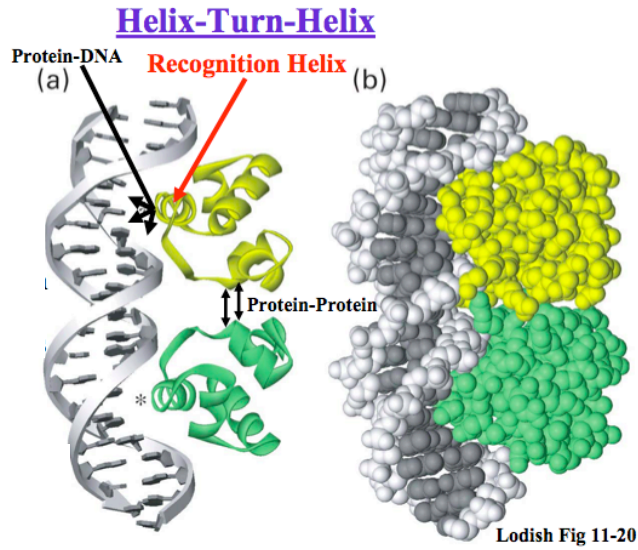
http://en.wikipedia.org/wiki/Lac_operon

**Introduction:
DNA, genes and regulation^a**

- TF can either repress or activate gene expression



Introduction:
DNA, genes and regulation



Introduction:
DNA, genes and regulation

- TFs recognize specific DNA motifs
- protein-DNA complexes are very stable (life time $\sim 10^3$ sec)
- stabilized by interactions between DNA base-pairs and protein amino acids.

```

- - - - - + + + + + + + + +
9 8 7 6 5 4 3 2 1 0 1 2 3 4 5 6 7 8 9
. . . . .
1  G T A T C A C C G C C A G T G G T A T
2  A T A C C A C T G C C G G T G A T A C
3  T C A A C A C C G C C A G A G A T A A
4  T T A T C T C T G C C G G T G T T G A
5  T T A T C A C C G C C A G A T G G T T A
6  T A A C C A T C T G C C G G T G A T A A
7  C T A T C A C C G C A A G G G A T A A
8  T T A T C C C T T G C C G G T G A T A G
9  C T A A C A C C G T G C G T G T T G A
10 T C A A C A C G C A C G G T G T T A G
11 T T A C C T C T G C C G G T G A T A A
12 T T A T C A C C G C C A G A G G T A A

```

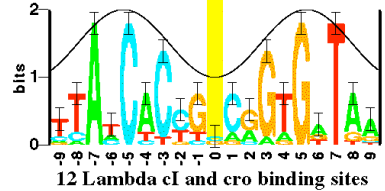
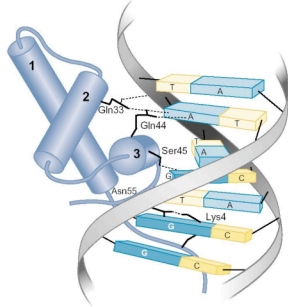


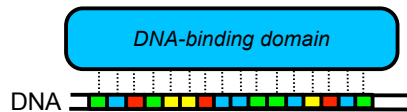
Fig. 1. Some aligned sequences and their sequence logo. At the top of the figure are listed the 12 DNA sequences from the D_{cro} and D_{cI} -controlled regions in bacteriophage lambda. These are bound by

Protein-DNA interaction energy



- Specific (sequence-dependent) and non-specific interactions
- Specificity is achieved by formation of local interactions with DNA

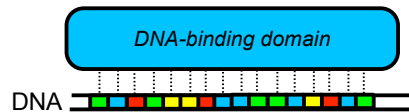
Model



Assumption:
Independent contributions of individual base-pairs.

Protein-DNA interaction energy

Model



$$E = \sum_{i=1}^l e(i, b_i)$$

Example: *Mnt* protein weight matrix
(Stormo & Fields, TIBS 23, p. 109, 1998)

	11	12	13	14	15	16	17	18	19
A	0.26	0.37	0.91	0.31	0.058	-0.29	0.55	0.14	0.39
C	-0.16	0.87	0.58	1.90	0.74	-0.11	-0.72	-0.33	-0.33
G	-0.16	-0.68	0.36	-0.68	-0.56	0.45	1.30	0.30	0.45
T	0.26	1.20	-0.63	0.68	0.85	0.13	0.74	0.11	-0.16

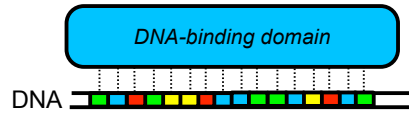
(a)

	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19
a	g	g	t	c	c	a	c		g	g	t	g	g	a	c	c	t

(b)

Protein-DNA interaction energy

Model



$$E = \sum_{i=1}^l e(i, b_i)$$

CGATGGACTT
 CCATGGCCCT
 GGATGGGCTT
 GGATGGTCCT
 GGATGCACCT

$$e(i, x) = -\beta \log(f(i, x) / g(x))$$

	11	12	13	14	15	16	17	18	19
A	0.26	0.37	0.91	0.31	0.058	-0.29	0.55	0.14	0.39
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	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19
a	g	g	t	c	c	a	c		g	g	t	g	g	a	c	c	t

GIVEN THIS ENERGETICS, CAN A PROTEIN FIND ITS SITE?