CONCEPT: LAMBDA BACTERIOPHAGE LIFE CYCLE REGULATION

● **Bacteriophages** are viruses that infect bacteria

□ Bacteriophages have _____ life cycles

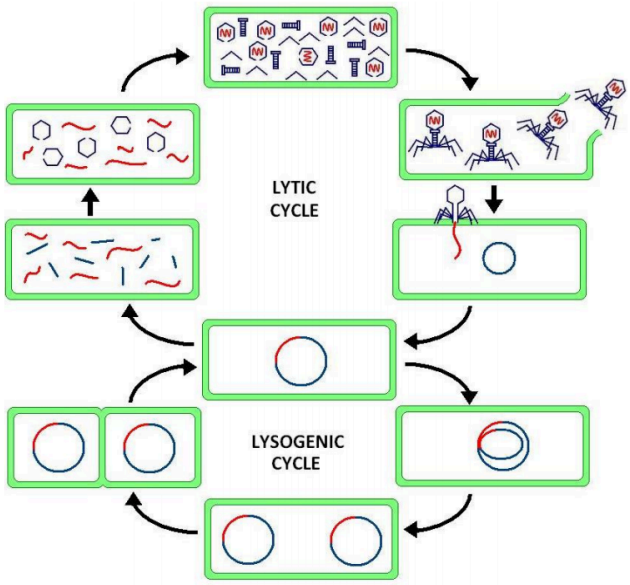
- **Lytic cycle** is a period of active virus replication, which bursts the host cell

- **Lysogenic cycle** is a period where the virus integrates into the genome, and is silent

□ The bacteriophage chromosome contains two sets of genes: One for each the lytic and lysogenic cycle

- Regulating the expression of these genes determines which cycle the bacteriophage enters

EXAMPLE:



□ If there are good growth conditions, there will be more **cro protein** which leads to lytic cycle

□ If there are poor growth conditions, there will be more **lambda protein (cI)** which leads to the lysogenic cycle

Mechanism of Regulation

- The regulatory genes are physically _____ on the bacterial chromosome
  - □ The *lytic cycle* involves the O, P, and Q genes
  - □ The *lysogenic cycle* includes the *int* and *xis* genes
  - □ In between the lytic and lysogenic cycle genes there four genes: cIII, N, cI, cro, and cII

EXAMPLE:

Lysogenic Cycle Genes		Regulatory Genes					Lytic Cycle Genes		
int	*xis*	cIII	N	cI	cro	cII	O	P	Q

□ The first two mRNAs transcribed are controlled via different _____

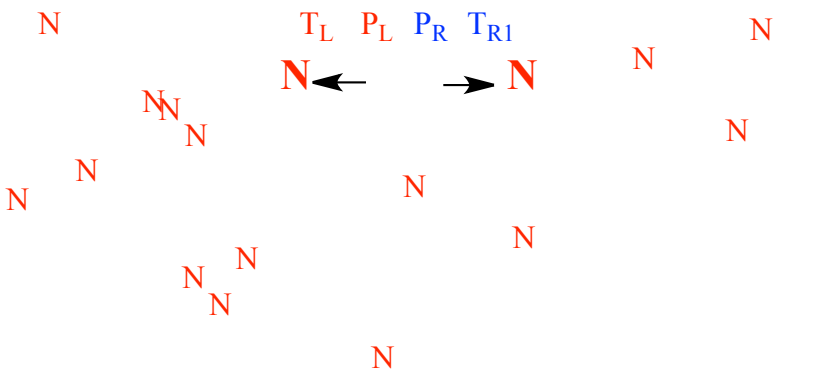
- The **N** gene is transcribed by the P_L promoter. It is terminated by T_L
- The **cro** gene is transcribed by the P_R promoter. It is terminated by T_{R1}
- These genes are transcribed in reverse of the other

□ If there is a lot of N protein around, this will cause both the N and cro genes to transcribe past the terminator

- The N protein is an **anti-terminator**, which allows transcription to take place

EXAMPLE:

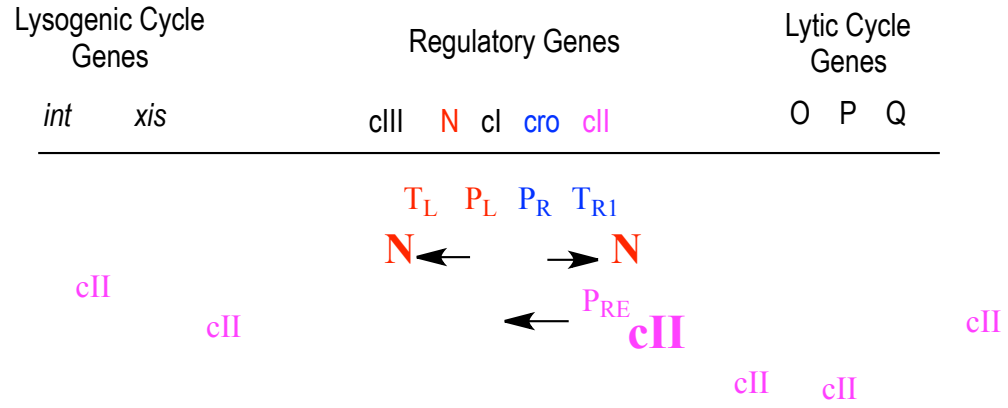
Lysogenic Cycle Genes		Regulatory Genes					Lytic Cycle Genes		
int	*xis*	cIII	N	cI	cro	cII	O	P	Q



Decision to enter the lysogenic vs. lytic cycles

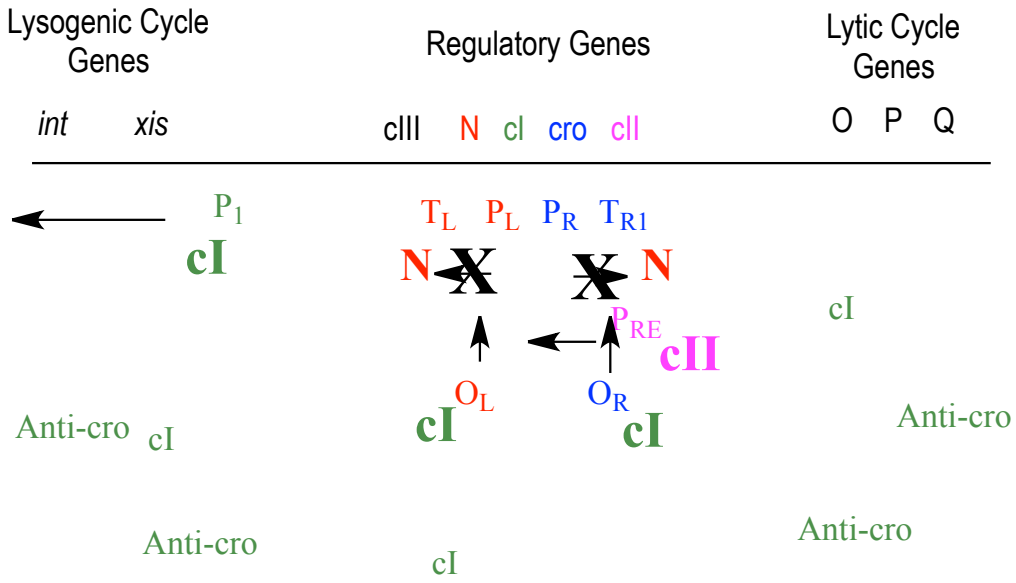
- The **cI protein (lamda protein)** controls entrance into the lysogenic cycle
  - □ After the N gene blocks termination, the **cII** protein is _____
    - The **cII protein** activates the P_{RE} promoter that sits at the T_{R1}, and transcribes **anti-cro** and **cI**
      - **Anti-cro** is the reverse of the cro gene
      - **cI (lambda protein)** controls entering the lysogenic cycle

EXAMPLE:



- □ **cI** binds to two operator regions: O_R and O_L and inhibits them by preventing transcription of N and cro and longer
  - **cI** activates the P_{RM} **promoter** which promotes transcription of more cI protein
  - **cI** activates the P_1 **promoter** which activates the transcription of *int* and *xis*

EXAMPLE:



● The **cro protein** controls _____ into the lytic cycle

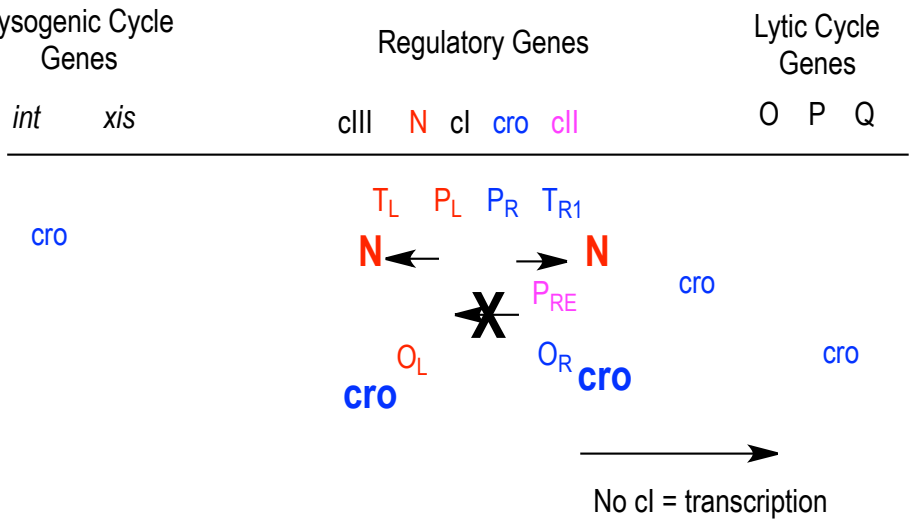
□ When there is more cro around it binds to $\mathbf{O_L}$ and $\mathbf{O_R}$ and repress them

- When $\mathbf{O_L}$ and $\mathbf{O_R}$ are inhibited, this inhibits P_L and P_{RM}

- This lowers the amount of cI in the cell – which means it wont inhibit anything

- A lot of lytic cycle genes are created

EXAMPLE:



● In bacterial cells, **proteases** which destroy the cII protein, control _____ into the lytic or lysogenic cycle

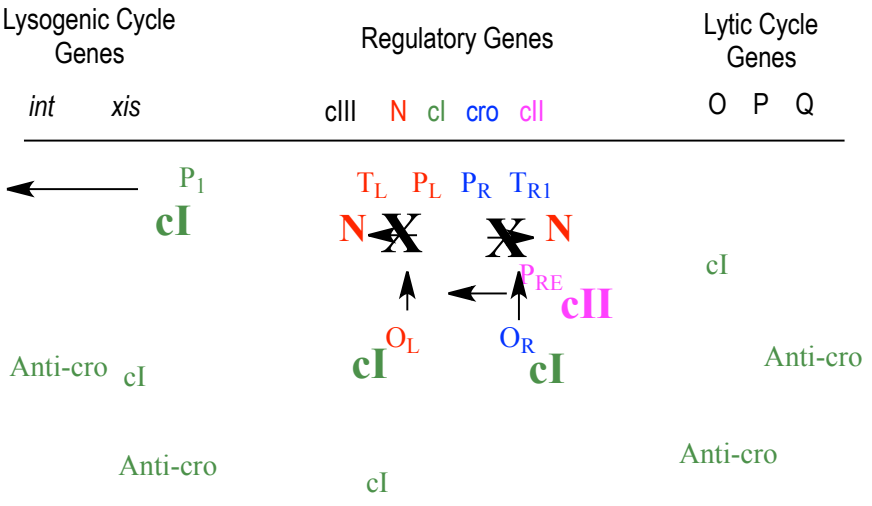
□ In good growth conditions there are plenty of **cII proteases** that degrade cII

- Less cII means that the P_1 promoter wont be activated by cI, and therefore promote the lytic cycle

□ In poor growth conditions there are not many cII proteases, meaning that there are high levels of cII

- High levels of cII will activate cI and P_1 and activate the lysogenic cycle

EXAMPLE:



PRACTICE:

1. In which of the following life cycles does a bacteriophage integrate itself into the host genome?
    a. Lysogenic cycle
    b. Integrative cycle
    c. Lytic cycle
    d. Subdued cycle

2. In good growth conditions the bacteriophage is more likely to enter into which life cycle?
    a. Lysogenic cycle
    b. Integrative cycle
    c. Lytic cycle
    d. Subdued cycle

3. Activation of which of the following genes leads to entrance into the lysogenic cycle?
    a. N, cro, and O genes
    b. O, P, and Q genes
    c. *Int* and *xis* genes
    d. cIII genes

4. The N protein is an anti-terminator. What does this mean?
    a. The N protein terminates transcription
    b. The N protein allows for transcription to occur
    c. The N protein terminates translation
    d. The N protein allows for translation to occur

5. Which of the following proteins is mainly responsible for entering the bacteriophage into the lysogenic cycle?
    a. N protein
    b. Cro protein
    c. cI (Lambda) protein
    d. cII proteases