Table 8.1

TABLE 8.1 Some λ gene products and their function

Gene product	Function
N	Antitermination protein acting at t_L^1, t_R^1, and t_R^2
O, P	Initiation of λ DNA replication
Q	Antitermination protein acting at t_R'
CI	Repressor; protein inhibitor of transcription from p_L and p_R
CII	Activator of transcription of *c*I and *int*
CIII	Stabilizer of CII
Cro	Protein inhibitor of CI synthesis
Gam	Protein required for rolling-circle replication
Red	Proteins involved in λ recombination
Int	Integrase; protein required for site-specific recombination with chromosome
Xis	Excisase; protein forms complex with Int and functions in excision of prophage

Table 8.2

TABLE 8.2 Some sites involved in phage λ transcription and replication[a]

Sites	Function
p_L	Left promoter
p_R, p_R'	Right promoters
o_L	Operator for leftward transcription; binding sites for CI and Cro repressors
o_R	Operator for rightward transcription; binding sites for CI and Cro repressors
t_L^1, t_L^2	Termination sites of leftward transcription
t_R^1, t_R^2, t_R'	Termination sites of rightward transcription
nutL	N utilization site for leftward transcribing RNA Pol (i.e., the site at which N binds to RNA Pol)
nutR	N utilization site for rightward transcribing RNA Pol
qut	Q utilization site for antitermination at p_R'
p_{RE}	Promoter for repressor establishment; activated by CII
p_{RM}	Promoter for repressor maintenance; activated by CI
p_I	Promoter for *int* transcription; activated by CII
POP′	Attachment site (*att*λ)
cos	Cohesive ends of λ genome (12-bp single-stranded ends in linear genome anneal to form circular genome after infection)

[a]In λ, essential genes have single-letter names while nonessential genes have more conventional three-letter names.

Figure 8.1

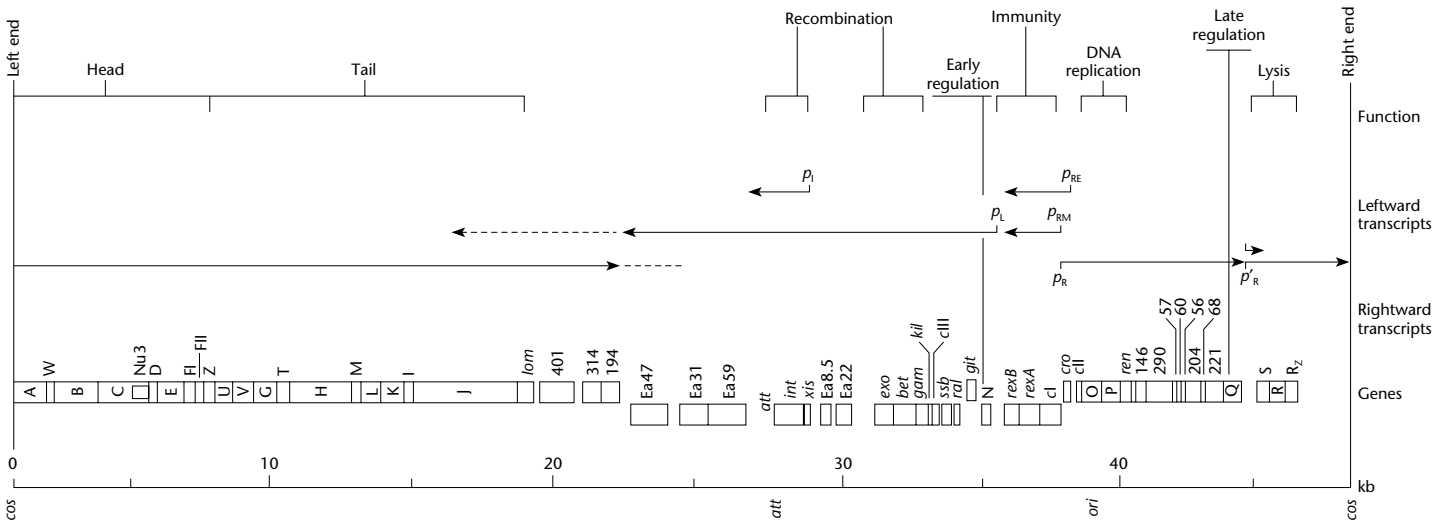

Left end
Right end
Head
Tail
Recombination
Immunity
Late regulation
Early regulation
DNA replication
Lysis
Function
p_I
p_{RE}
p_L
p_{RM}
p_R
p'_R
Leftward transcripts
Rightward transcripts
Genes
A W B C Nu3 D E FI FII Z U V G T H M L K I J lom 401 314 194 Ea47 Ea31 Ea59 att int xis Ea8.5 Ea22 exo bet gam kil cIII ssb ral git N rexB rexA cI cro cII O P ren 146 290 57 60 56 204 68 221 Q S R R_z
0 10 20 30 40 kb
cos att ori cos

Figure 8.2

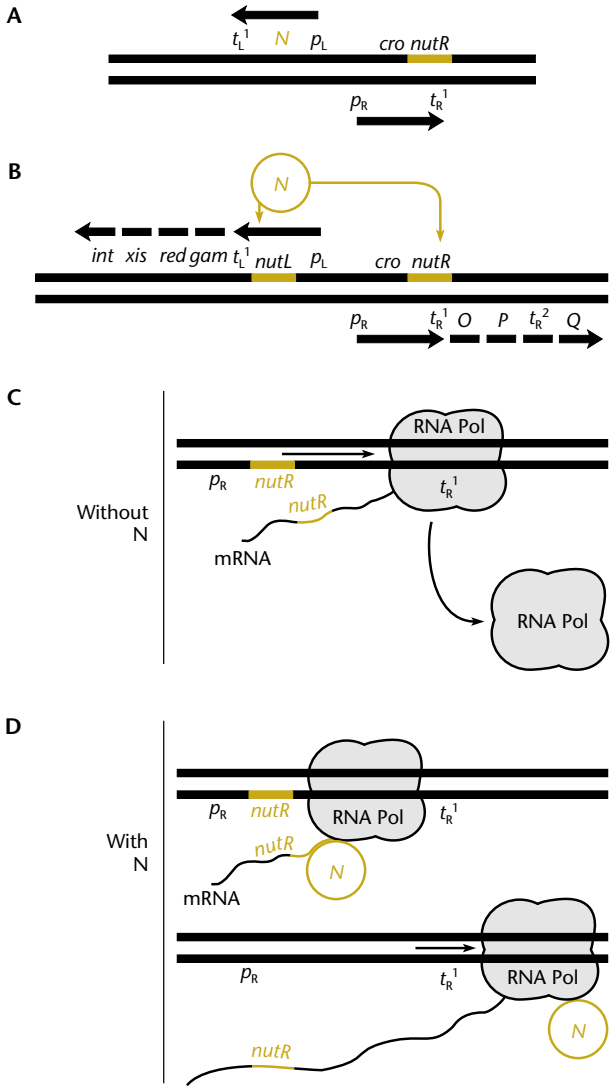

A
t_L^1 N p_L cro nutR
p_R t_R^1
B
N
int xis red gam t_L^1 nutL p_L cro nutR
p_R t_R^1 O P t_R^2 Q
C
Without N
RNA Pol
p_R nutR
nutR
t_R^1
mRNA
RNA Pol
D
With N
p_R nutR
RNA Pol
t_R^1
nutR
N
mRNA
p_R
t_R^1
RNA Pol
N
nutR

Figure 8.3

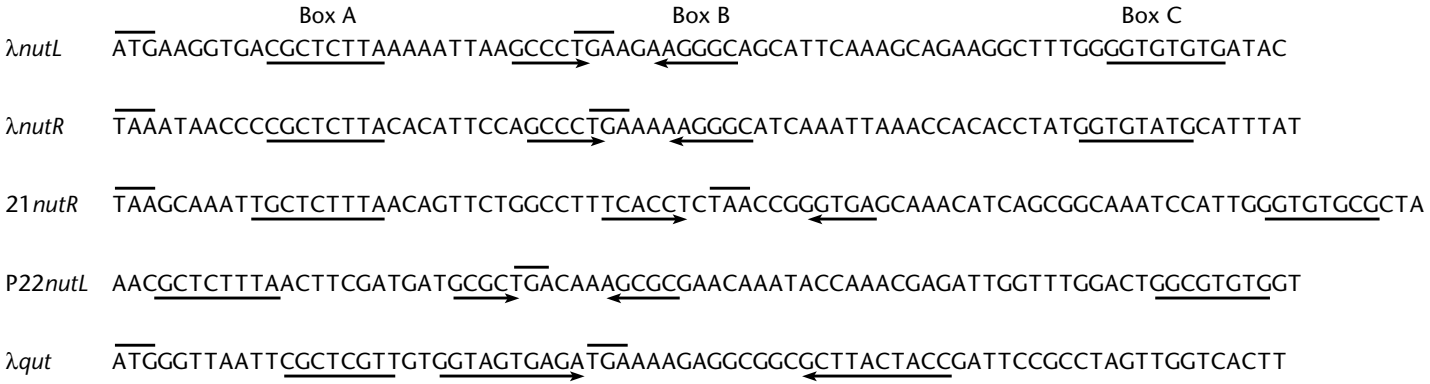

Box A
Box B
Box C
λnutL ATGAAGGTGACGCTCTTAAAAATTAAGCCCTGAAGAAGGGCAGCATTCAAAGCAGAAGGCTTTGGGGTGTGTGATAC
λnutR TAAATAACCCCGCTCTTACACATTCCAGCCCTGAAAAAGGGCATCAAATTAAACCACACCTATGGTGTATGCATTTAT
21nutR TAAGCAAATTGCTCTTTAACAGTTCTGGCCTTTCACCTCTAACCGGGTGAGCAAACATCAGCGGCAAATCCATTGGGTGTGCGCTA
P22nutL AACGCTCTTTAACTTCGATGATGCGCTGACAAAGCGCGAACAAATACCAAACGAGATTGGTTTGGACTGGCGTGTGGT
λqut ATGGGTTAATTCGCTCGTTGTGGTAGTGAGATGAAAAGAGGCGGCGCTTACTACCGATTCCGCCTAGTTGGTCACTT

Figure 8.4

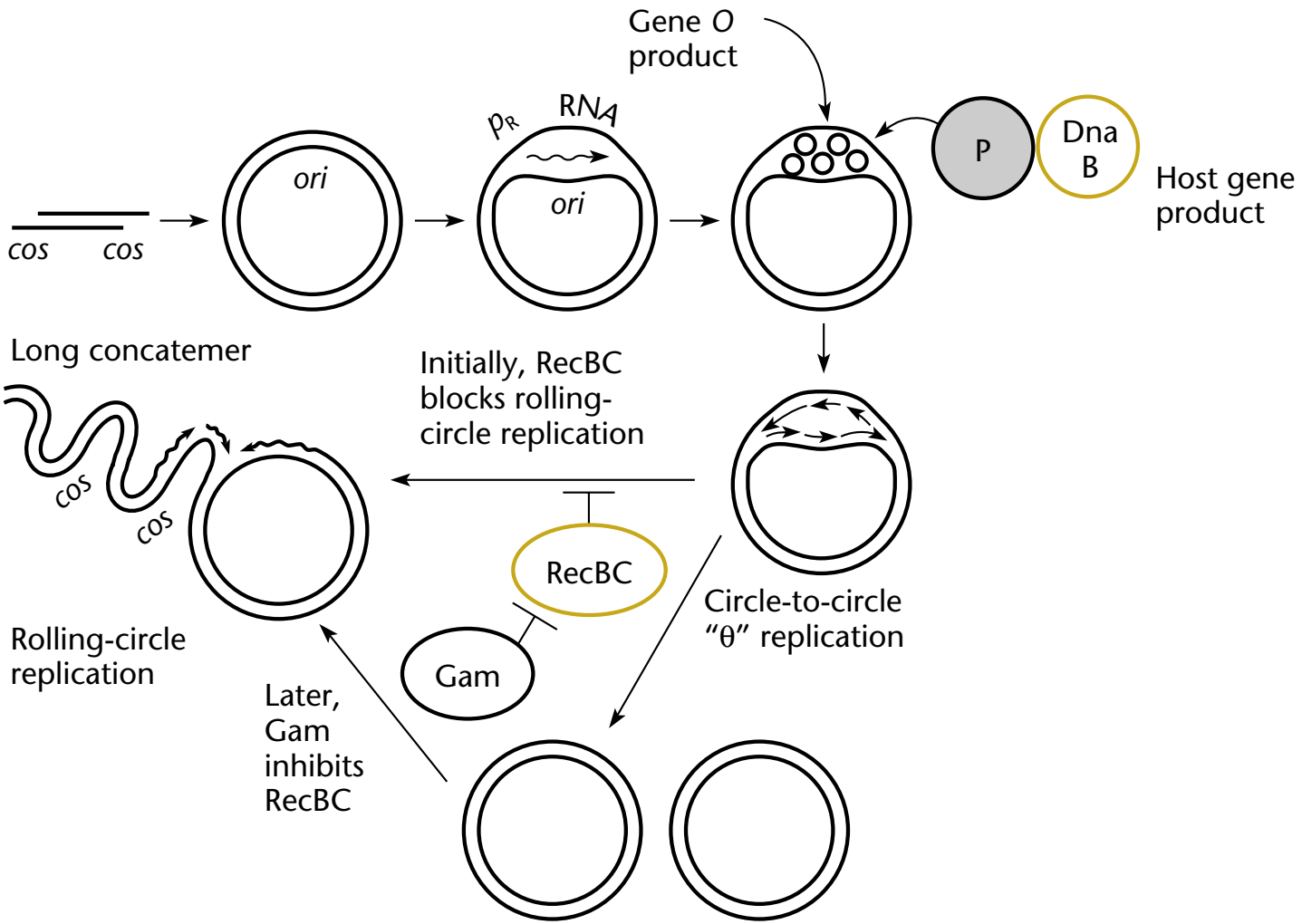

Gene O product
P
Dna B
Host gene product
p_R
RNA
ori
ori
cos
cos
Long concatemer
cos
cos
Initially, RecBC blocks rolling-circle replication
RecBC
Gam
Circle-to-circle "θ" replication
Rolling-circle replication
Later, Gam inhibits RecBC

Figure 8.5

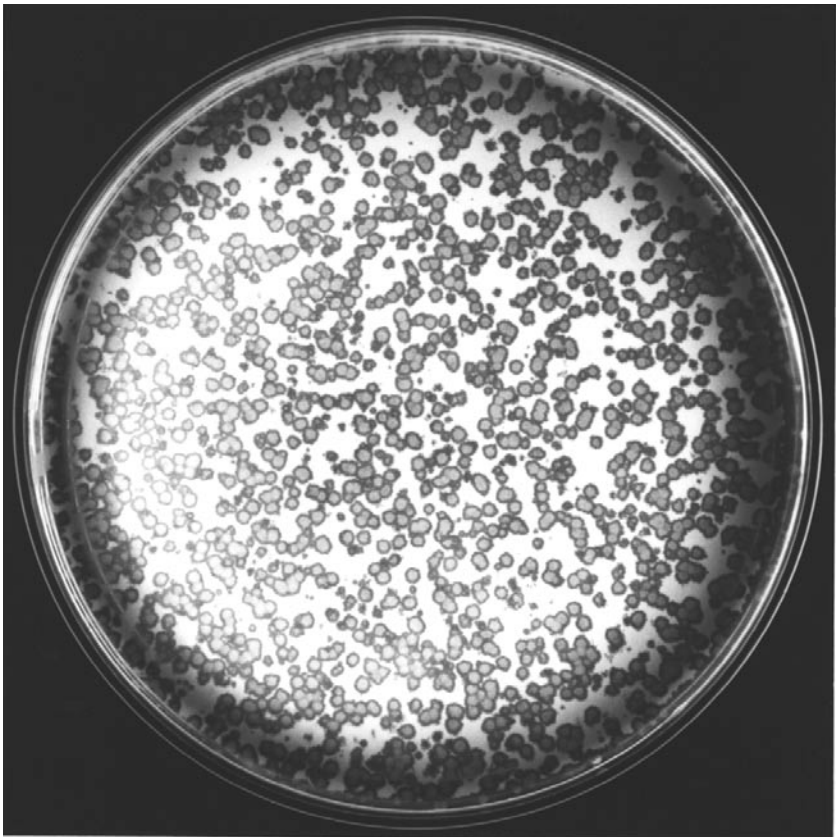


Figure 8.6

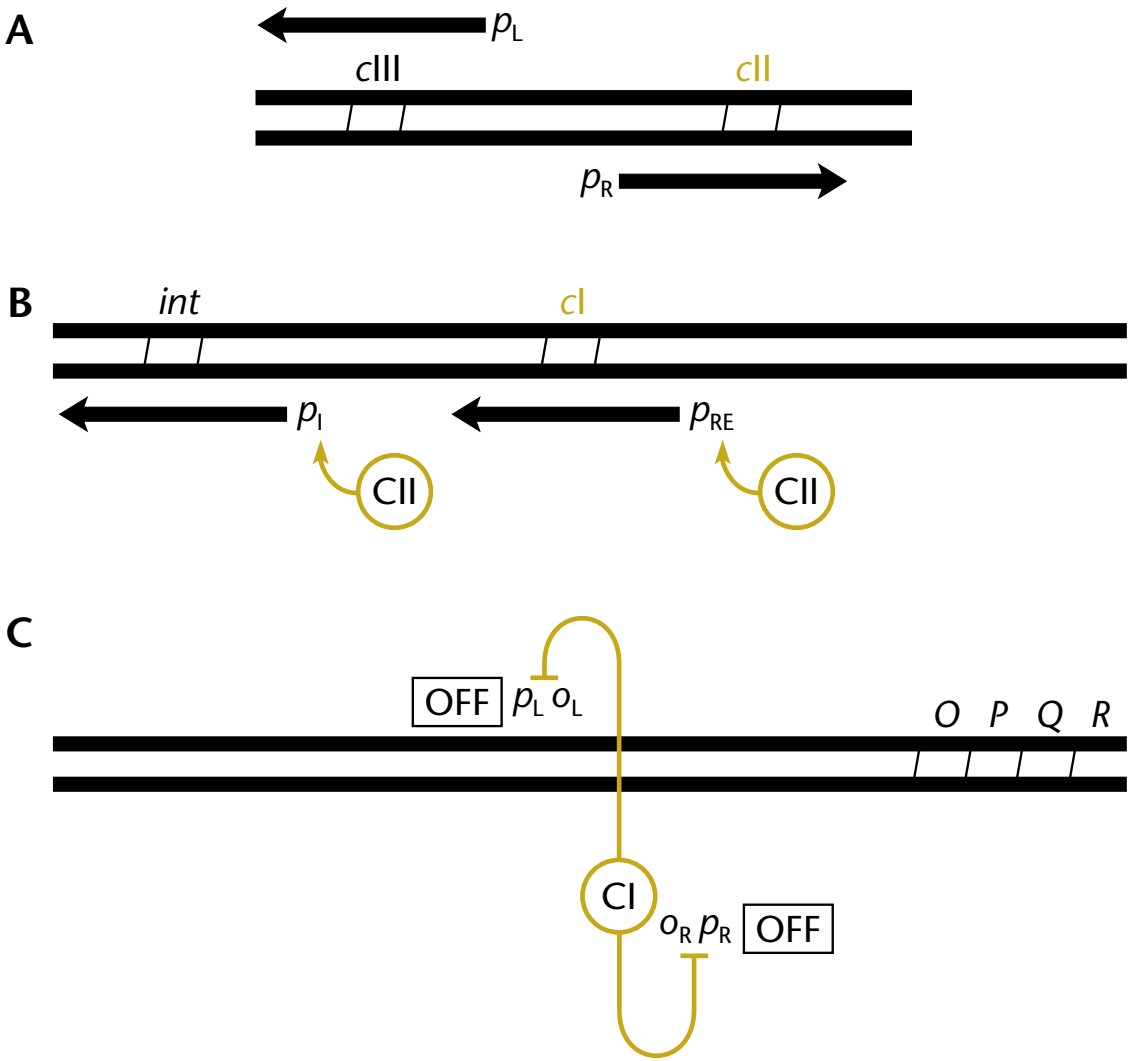

A
p_L
cIII
cII
p_R
B
int
cI
p_I
p_{RE}
CII
CII
C
OFF
p_L o_L
O P Q R
CI
o_R p_R
OFF

Figure 8.7

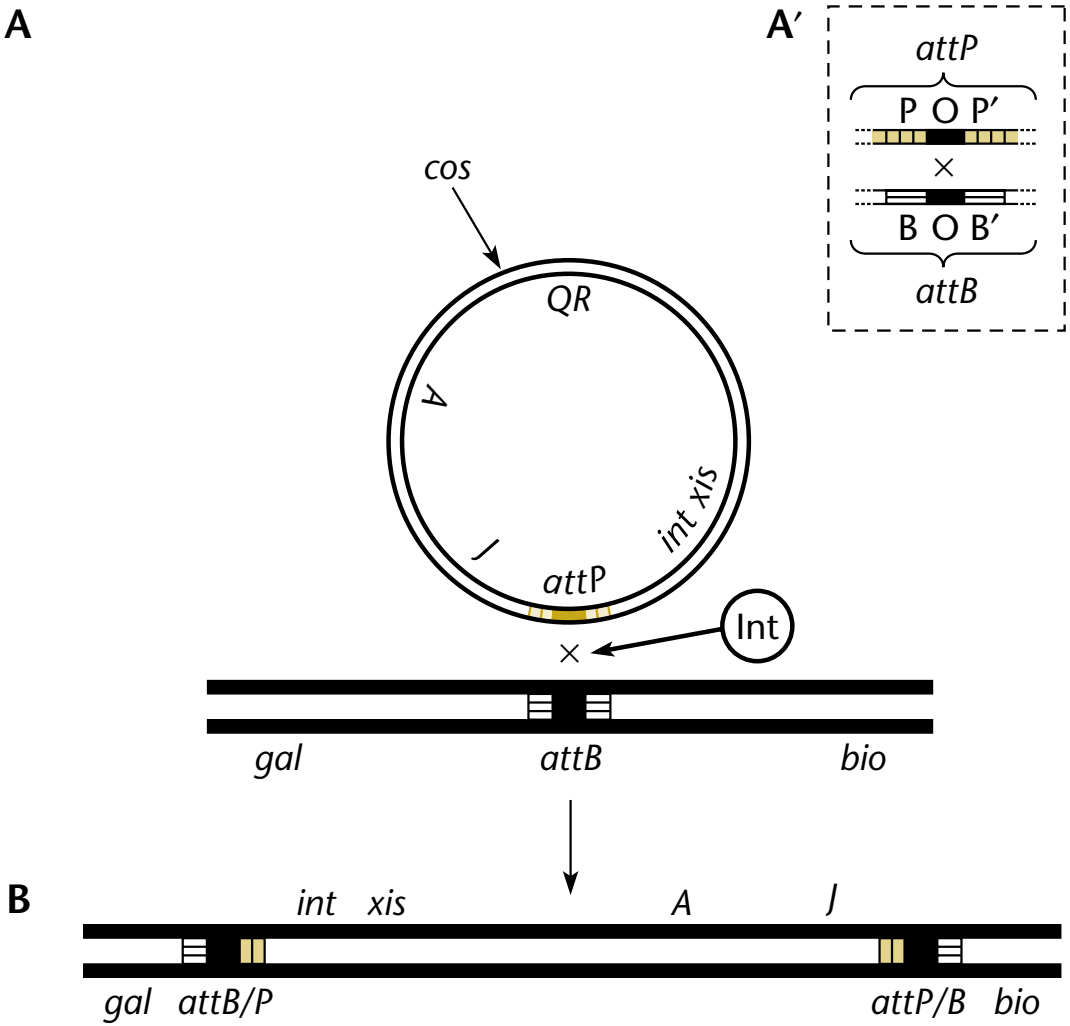

A
A′
attP
P O P′
×
B O B′
attB
cos
QR
A
int xis
J
attP
Int
×
gal
attB
bio
B
int
xis
A
J
gal
attB/P
attP/B
bio

Figure 8.8

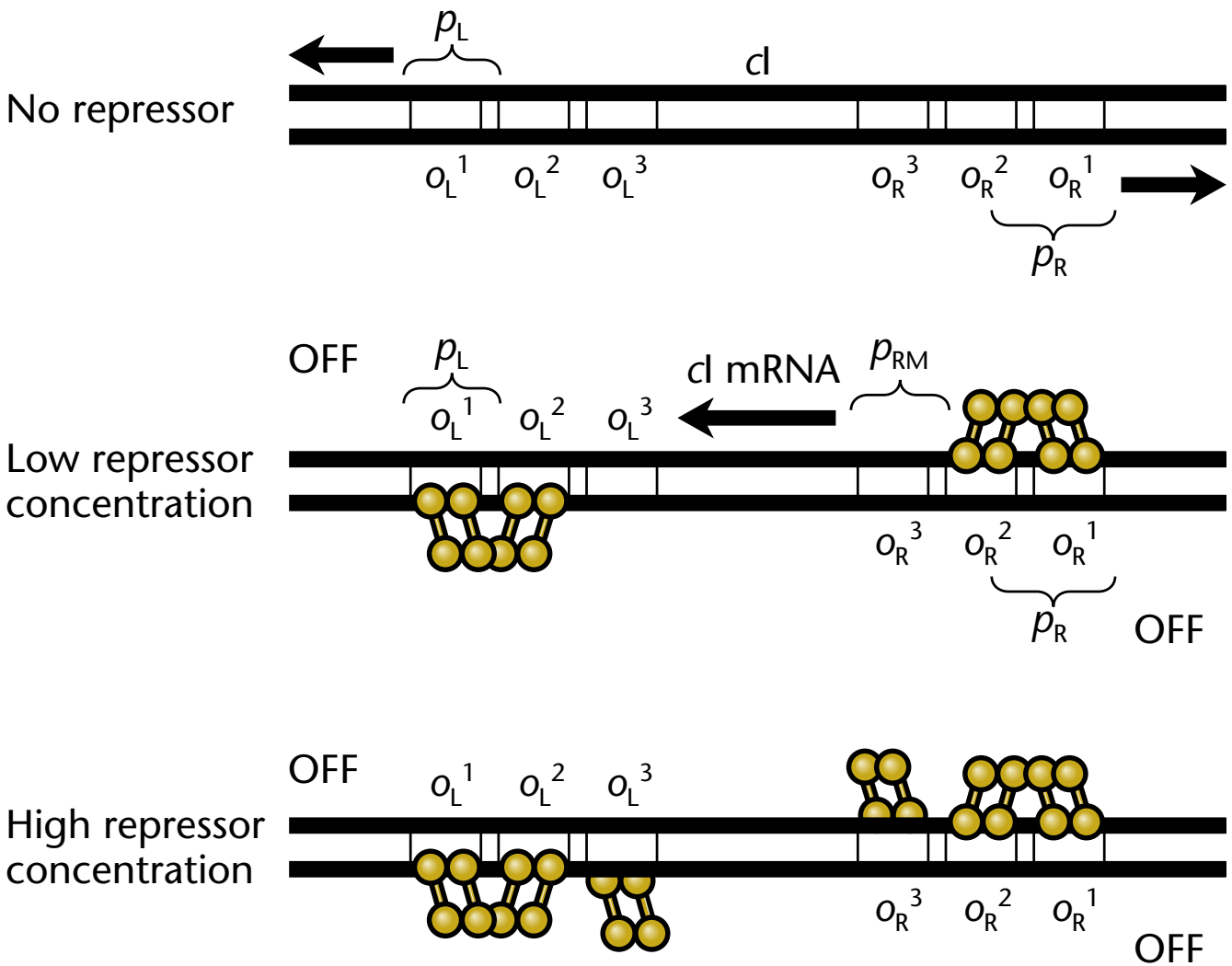

No repressor
p_L
cI
o_L^1 o_L^2 o_L^3
o_R^3 o_R^2 o_R^1
p_R
Low repressor concentration
OFF
p_L
cI mRNA
p_{RM}
o_L^1 o_L^2 o_L^3
o_R^3 o_R^2 o_R^1
p_R
OFF
High repressor concentration
OFF
o_L^1 o_L^2 o_L^3
o_R^3 o_R^2 o_R^1
OFF

Figure 8.9

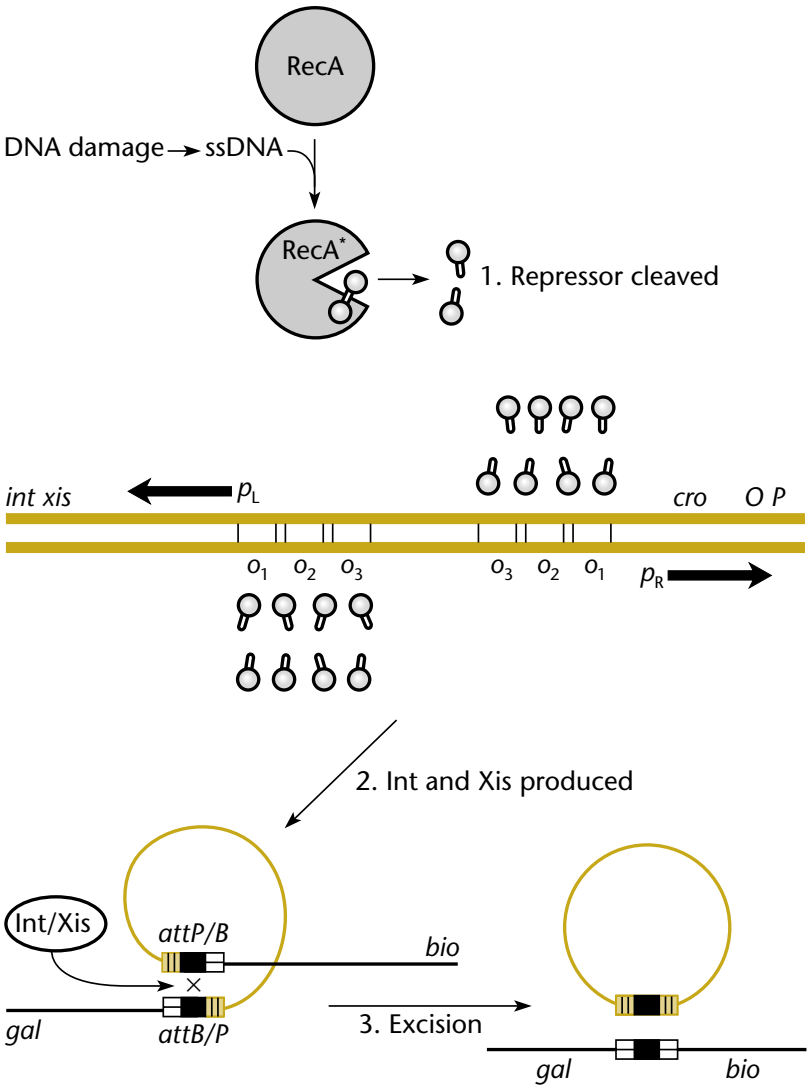
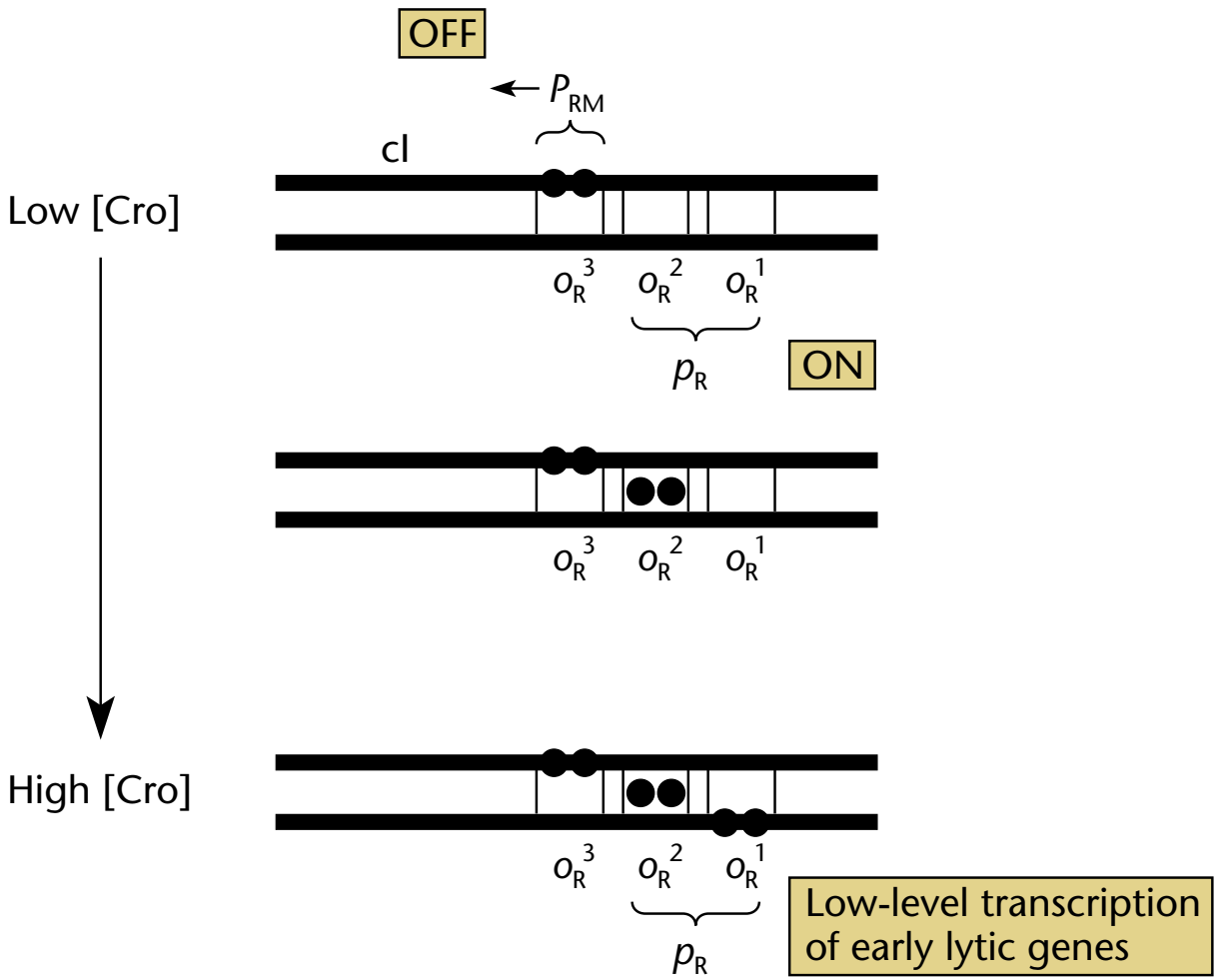

RecA
DNA damage → ssDNA
RecA*
1. Repressor cleaved
int xis
p_L
cro
O P
o_1 o_2 o_3
o_3 o_2 o_1
p_R
2. Int and Xis produced
Int/Xis
attP/B
bio
gal
attB/P
3. Excision
gal
bio

Figure 8.10



Affinity of o_R for Cro: $o_R^1 > o_R^2 = o_R^3$

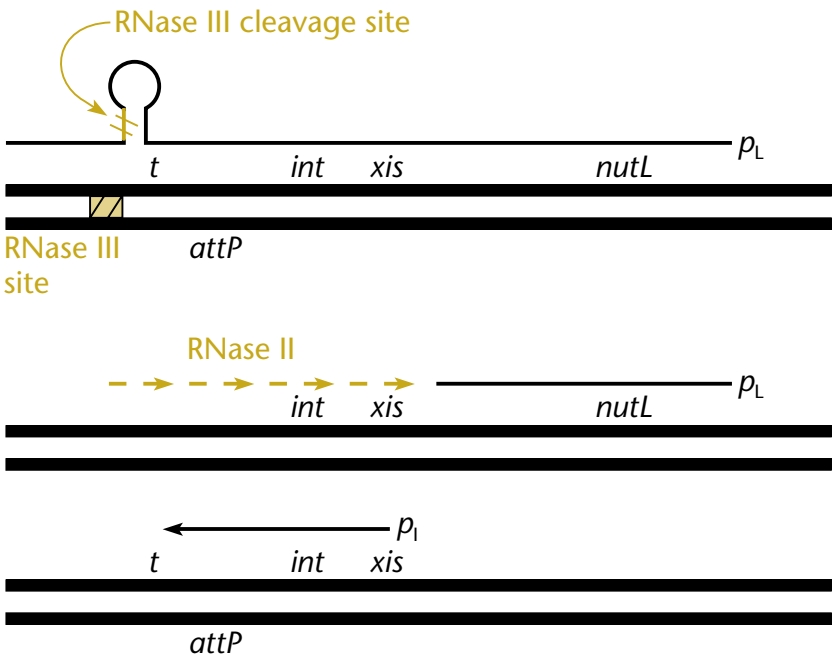
Table 8.3

TABLE 8.3 Steps leading to lytic growth and lysogeny

Steps leading to lytic growth	Steps leading to lysogeny
1. Transcription from p_L and P_R	1. Same as for lytic growth
2. N and Cro are made	2. Same as for lytic growth
3. N allows CII expression	3. Same as for lytic growth
4. **CII degraded**	4. **CII stable**
5. Low CII concentration means that little CI is made	5a. High CII concentration activates p_I, and so Int is made and λ DNA integrates
	5b. High CII concentration activates p_{RE}, and so CI is made
6. Cro binds at o_R^3 and o_L^3, blocking binding by any low level of CI that is made	6. CI outcompetes Cro, and so CI binding at o_R and o_L both represses p_L and p_R and positively autoregulates at p_{RM}, maintaining lysogeny
7. Meanwhile, N allows O and P replication gene transcription	
8. A second antiterminator, Q, allows late-gene transcription, and so λ phage particles are made	

Box 8.2

A After λ infection, *int* expressed from p_I



B After induction, *int* and *xis* expressed from p_L

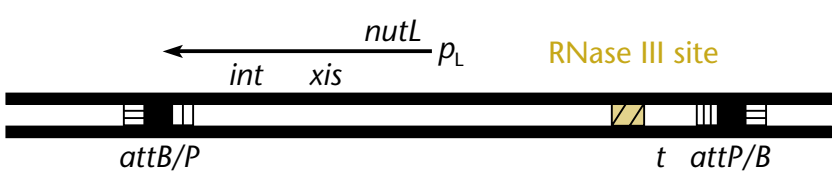


Figure 8.11

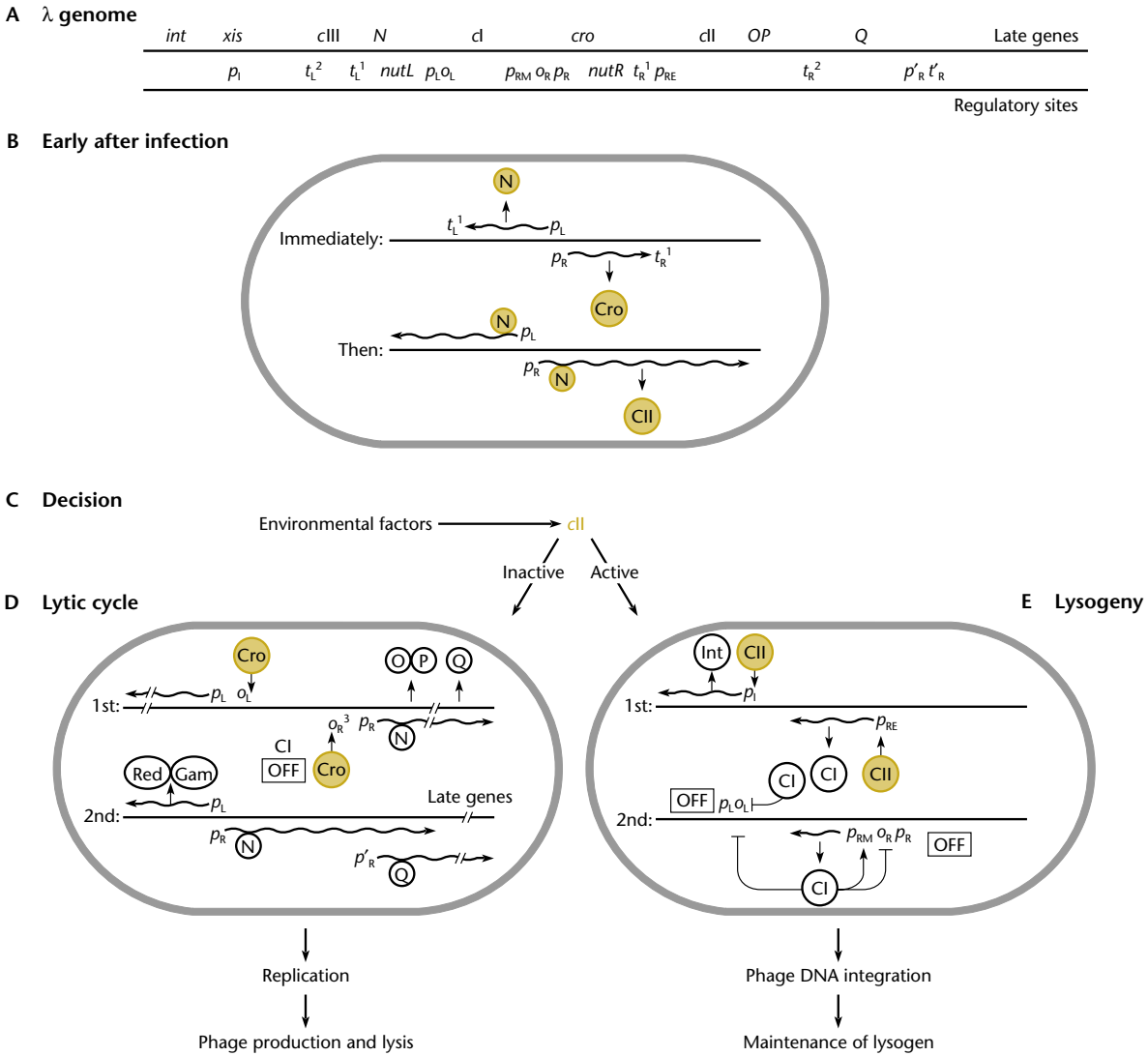

A λ genome
int xis cIII N cI cro cII OP Q Late genes
pI tL2 tL1 nutL pLoL pRM oR pR nutR tR1 pRE tR2 p′R t′R
Regulatory sites
B Early after infection
Immediately:
Then:
Cro
CII
C Decision
Environmental factors
cII
Inactive
Active
D Lytic cycle
1st:
2nd:
Red Gam
CI
OFF
Late genes
Replication
Phage production and lysis
E Lysogeny
Int
Phage DNA integration
Maintenance of lysogen

Figure 8.12

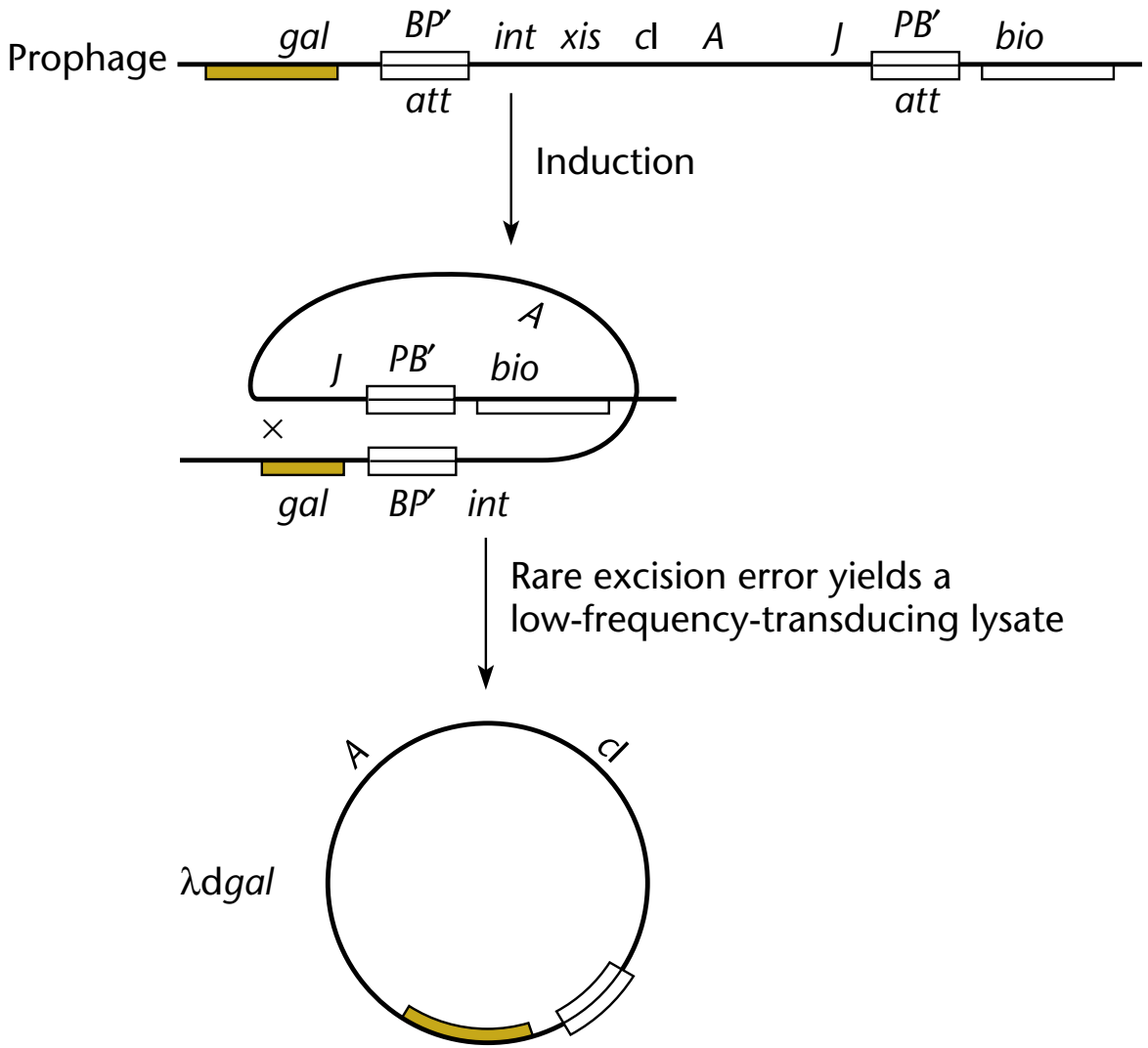

Prophage
gal
BP′
int
xis
cI
A
J
PB′
bio
att
att
Induction
A
J
PB′
bio
×
gal
BP′
int
Rare excision error yields a
low-frequency-transducing lysate
A
cI
λdgal

Figure 8.13

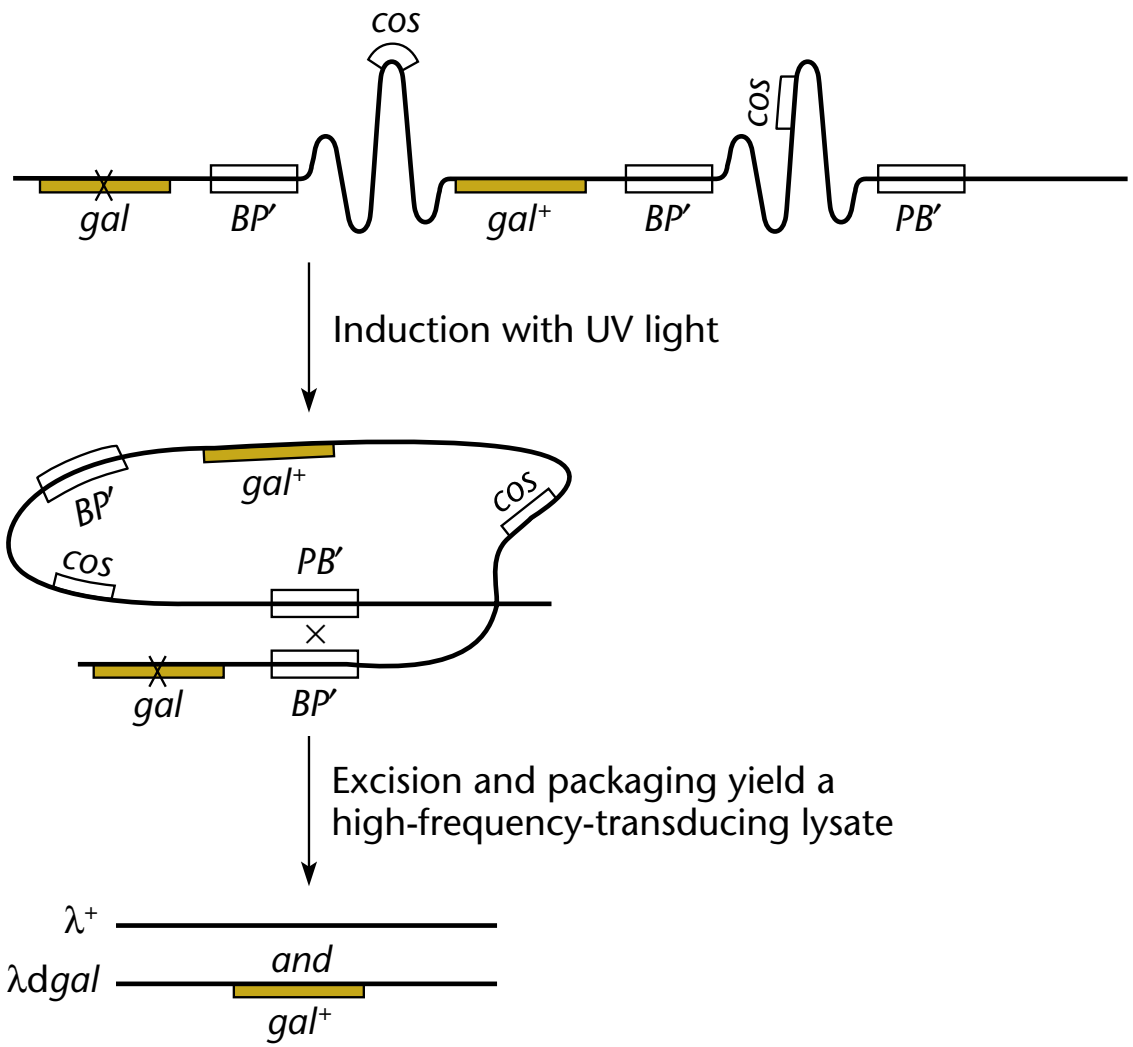

cos
cos
gal
BP′
gal+
BP′
PB′
Induction with UV light
BP′
gal+
cos
cos
PB′
gal
BP′
Excision and packaging yield a
high-frequency-transducing lysate
λ+
λdgal
and
gal+

Figure 8.14

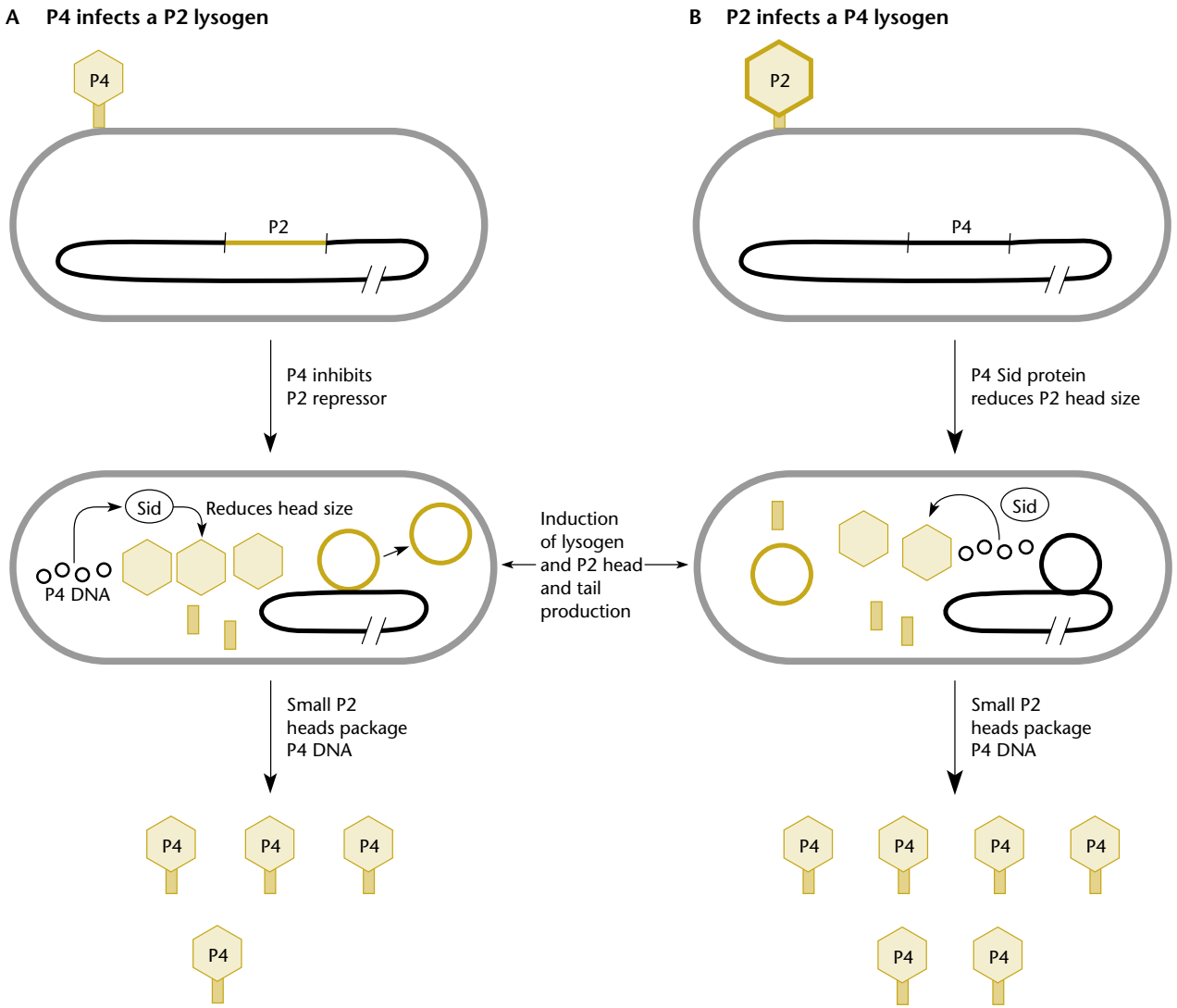

A P4 infects a P2 lysogen
P4
P2
P4 inhibits
P2 repressor
Sid
Reduces head size
P4 DNA
Small P2
heads package
P4 DNA
P4
P4
P4
P4
Induction
of lysogen
and P2 head
and tail
production
B P2 infects a P4 lysogen
P2
P4
P4 Sid protein
reduces P2 head size
Sid
Small P2
heads package
P4 DNA
P4
P4
P4
P4
P4
P4

Figure 8.15

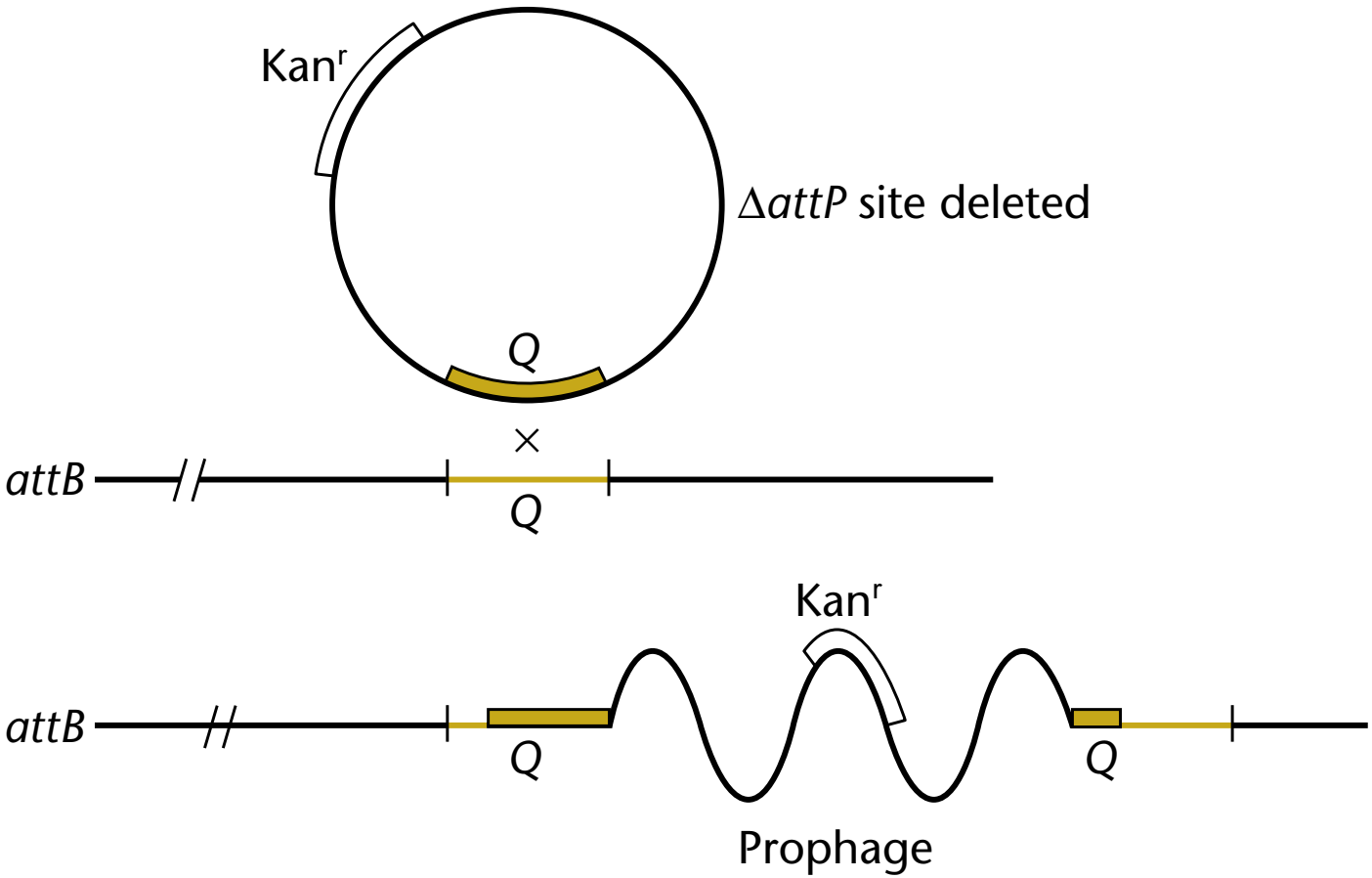


Figure 8.16

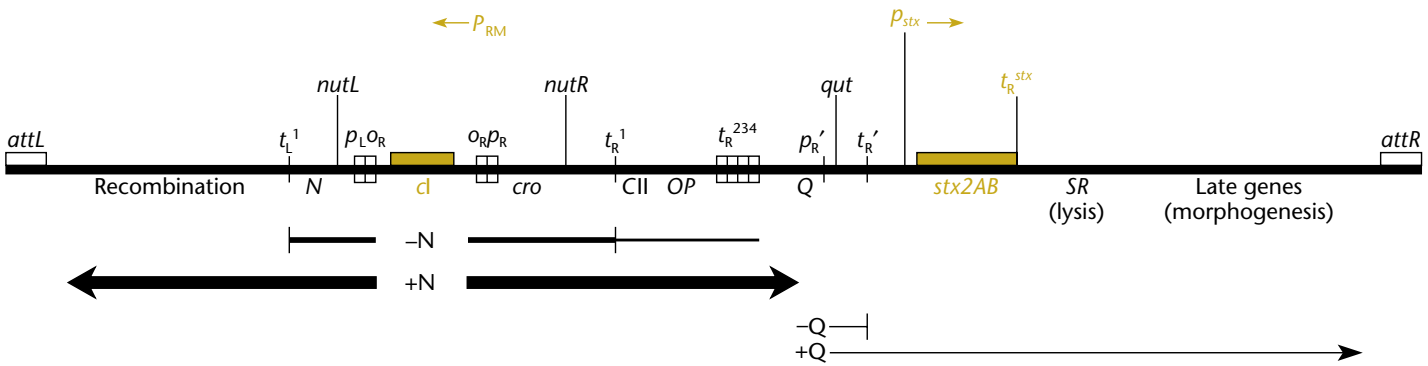

P_{RM}
p_{stx}
nutL
nutR
qut
t_R^{stx}
attL
t_L^1
$p_L o_R$
$o_R p_R$
t_R^1
t_R^{234}
p_R'
t_R'
attR
Recombination
N
cI
cro
CII
OP
Q
stx2AB
SR
(lysis)
Late genes
(morphogenesis)
–N
+N
–Q
+Q

Figure 8.17

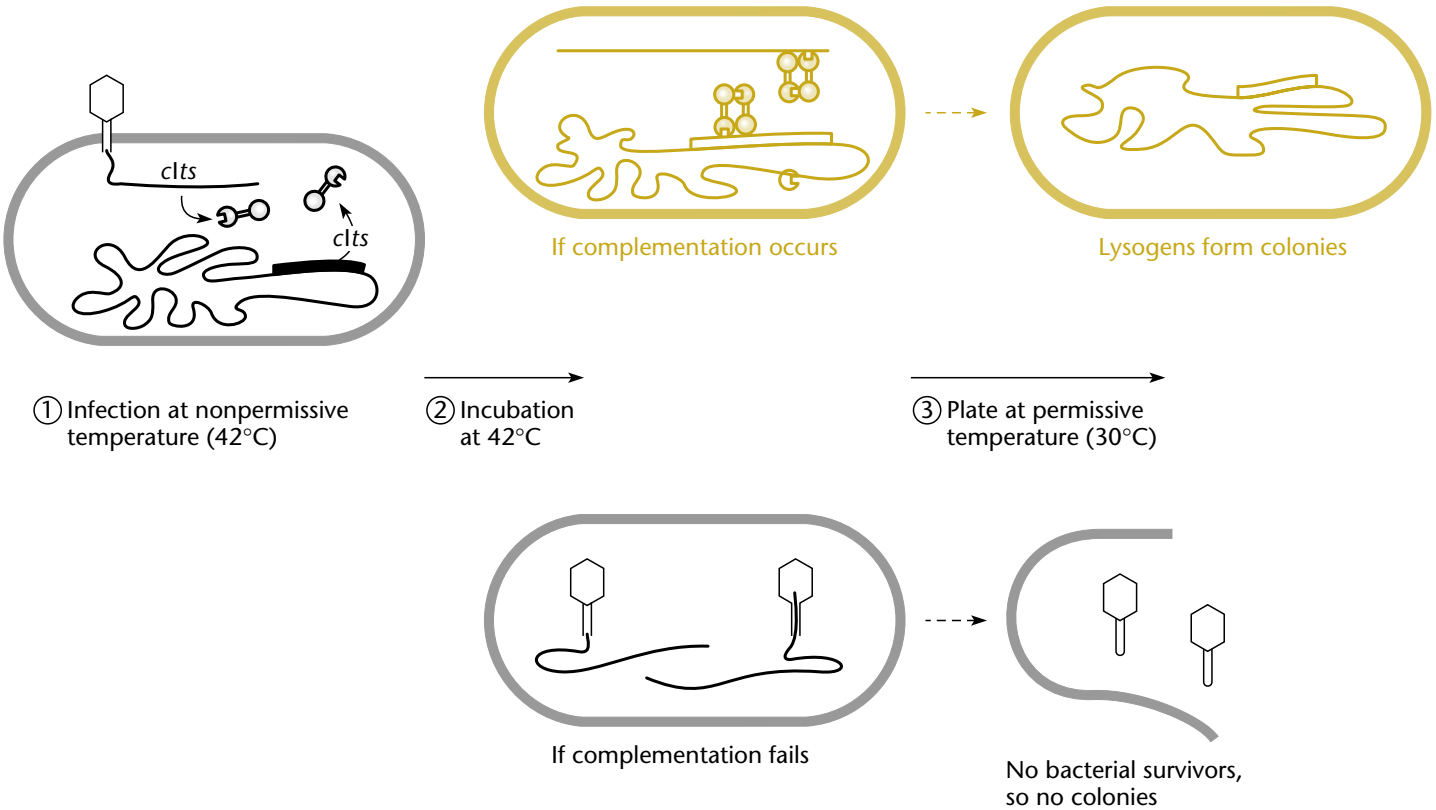

cIts
cIts
If complementation occurs
Lysogens form colonies
① Infection at nonpermissive temperature (42°C)
② Incubation at 42°C
③ Plate at permissive temperature (30°C)
If complementation fails
No bacterial survivors, so no colonies

Figure 8.18

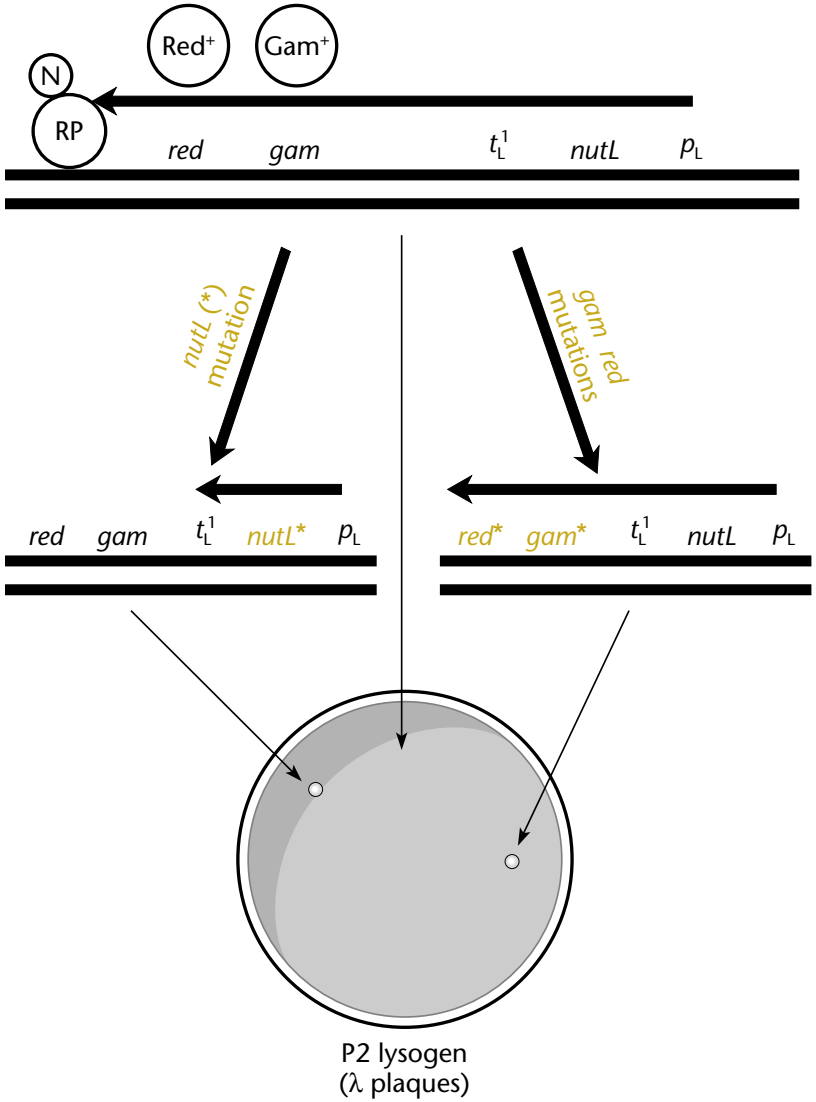
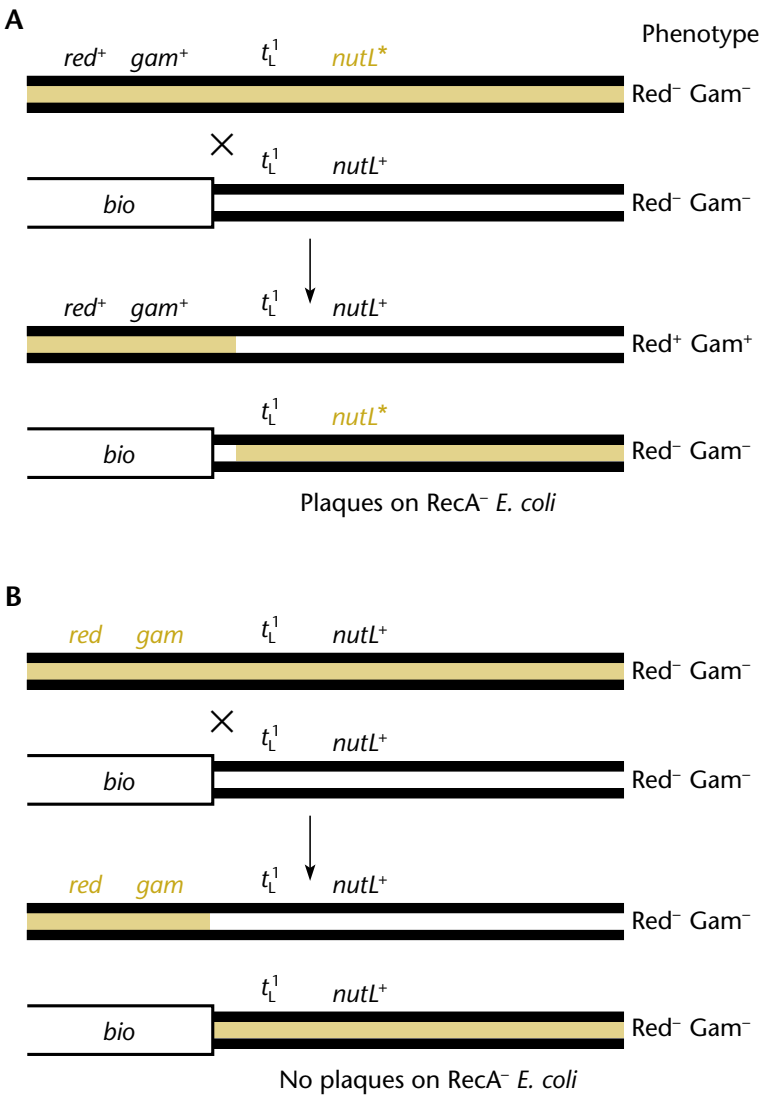

Red+
Gam+
N
RP
red
gam
t_L^1
nutL
p_L
nutL (*) mutation
gam red mutations
red
gam
t_L^1
nutL*
p_L
red*
gam*
t_L^1
nutL
p_L
P2 lysogen
(λ plaques)

Figure 8.19


A
Phenotype
red+ gam+ tL1 nutL*
Red− Gam−
tL1 nutL+
bio
Red− Gam−
red+ gam+ tL1 nutL+
Red+ Gam+
tL1 nutL*
bio
Red− Gam−
Plaques on RecA− E. coli
B
red gam tL1 nutL+
Red− Gam−
tL1 nutL+
bio
Red− Gam−
red gam tL1 nutL+
Red− Gam−
tL1 nutL+
bio
Red− Gam−
No plaques on RecA− E. coli