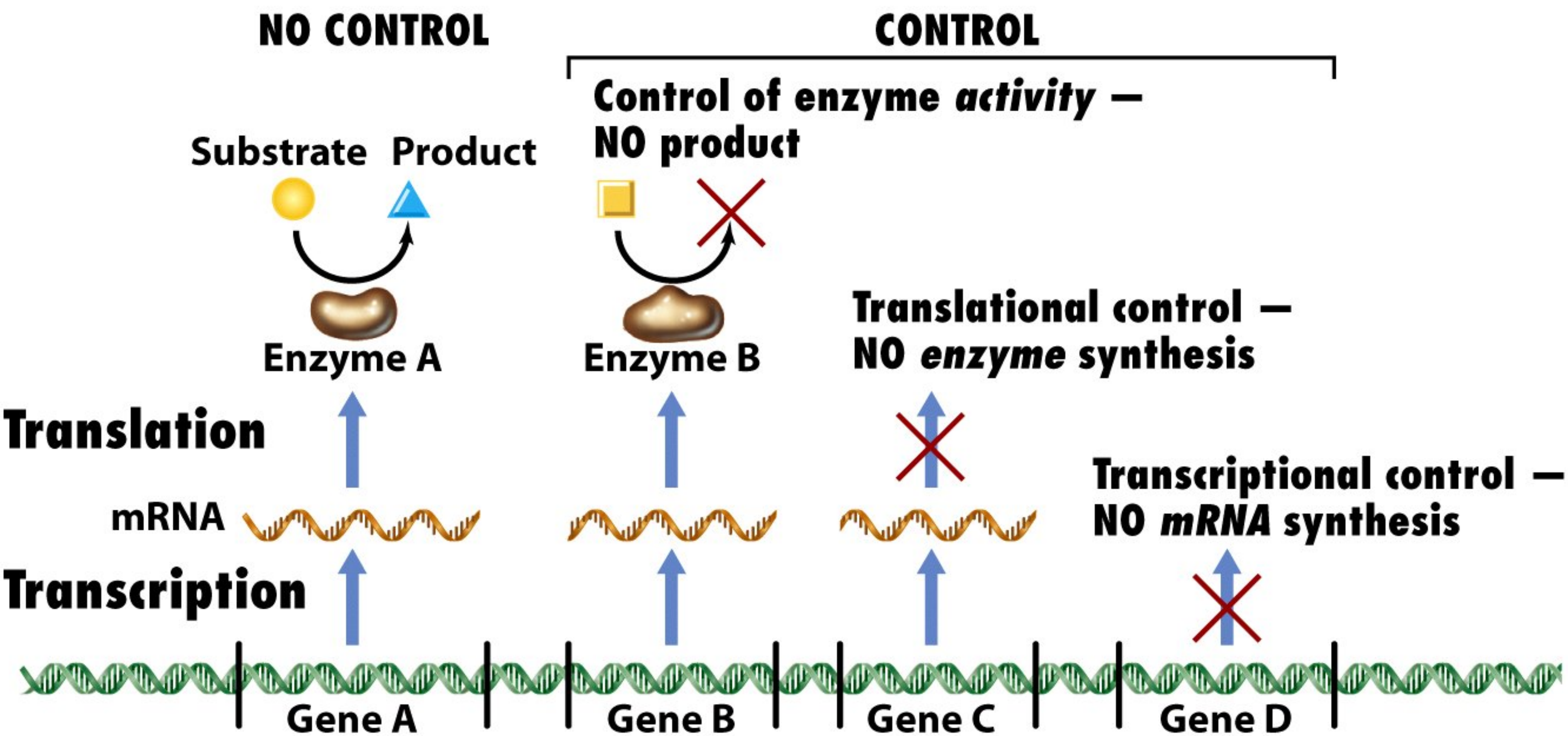
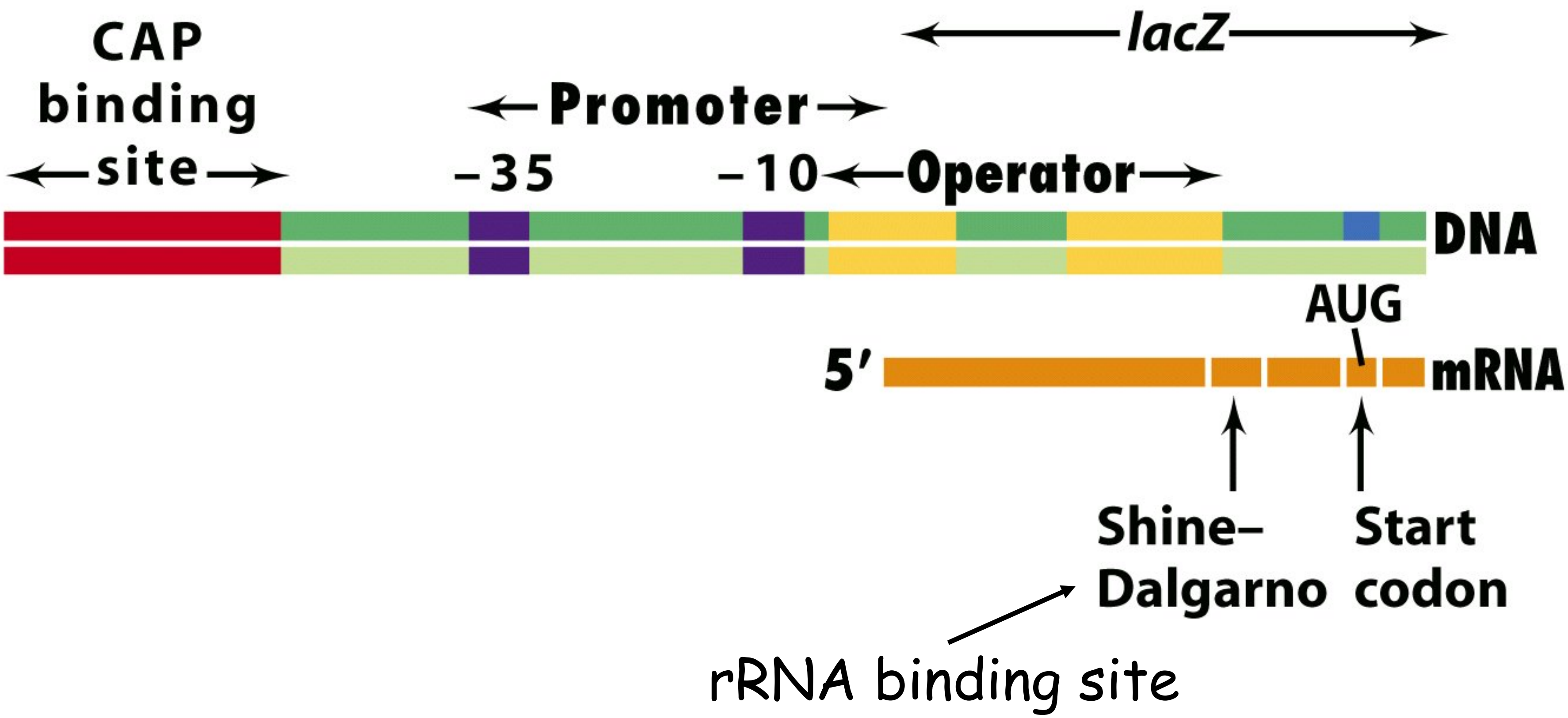
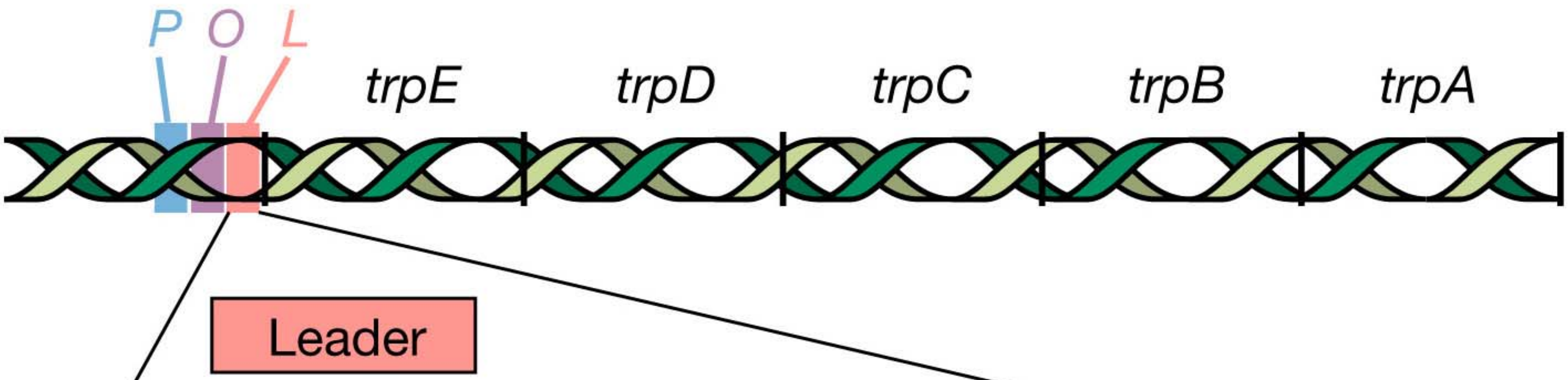
An Overview of Gene Regulation



Genetic elements involved in regulation of the lac operon



Attenuation: fine scale control after initiation of transcription



Met-Lys-Ala-Ile-Phe-Val-Leu-Lys-Gly-Trp-Trp-Arg-Thr-Ser

Leader peptide rich in pathway AAs

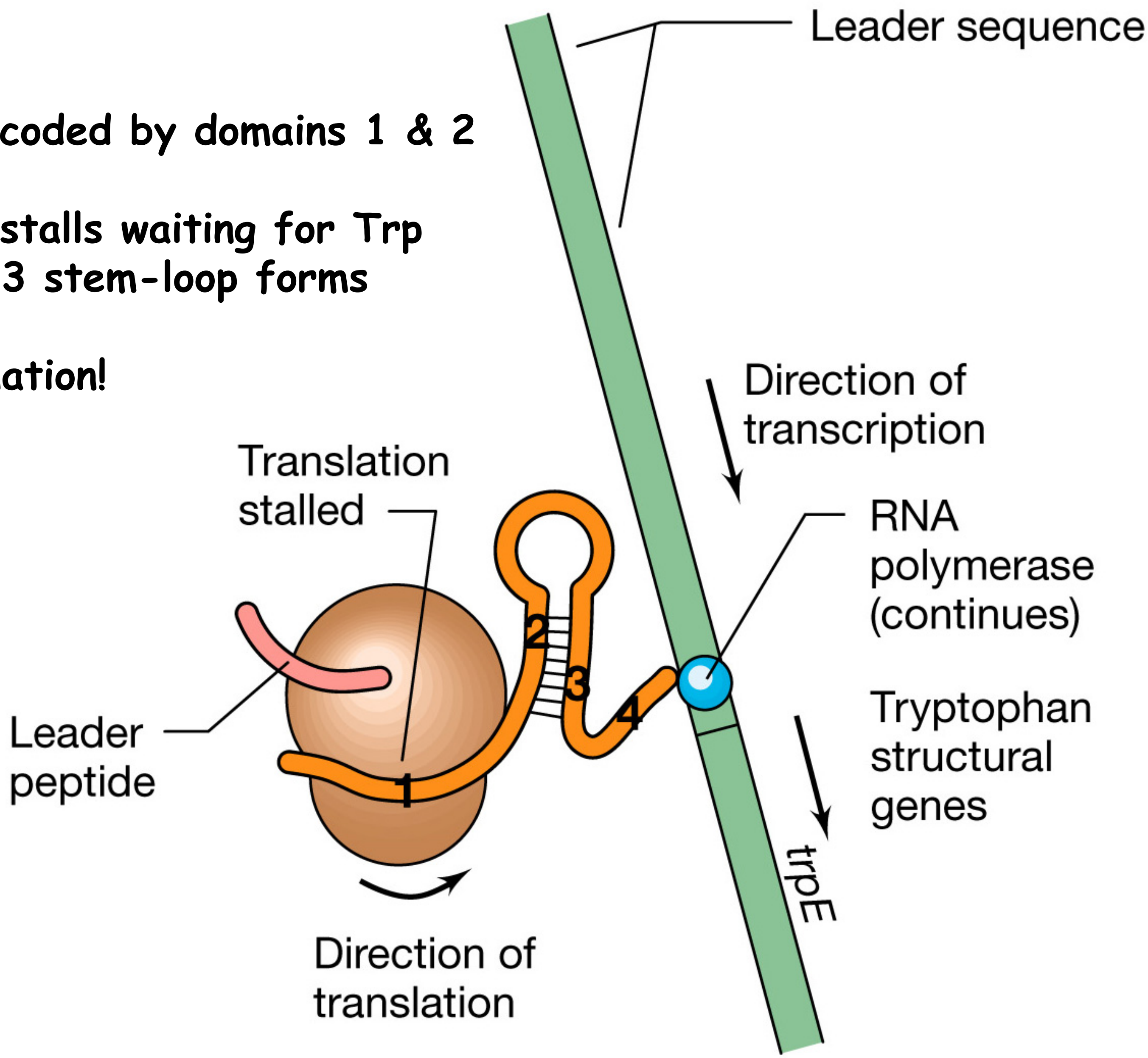
Threonine	Met-Lys-Arg-Ile-Ser-Thr-Thr-Ile-Thr-Thr-Thr-Ile-Thr-Ile-Thr-Thr-Gly-Asn-Gly-Ala-Gly
Histidine	Met-Thr-Arg-Val-Gln-Phe-Lys-His-His-His-His-His-His-His-Pro-Asp
Phenylalanine	Met-Lys-His-Ile-Pro-Phe-Phe-Phe-Ala-Phe-Phe-Phe-Thr-Phe-Pro

Tryptophan-starved: transcription not terminated

Leader encoded by domains 1 & 2

Ribosome stalls waiting for Trp
Domain 2:3 stem-loop forms

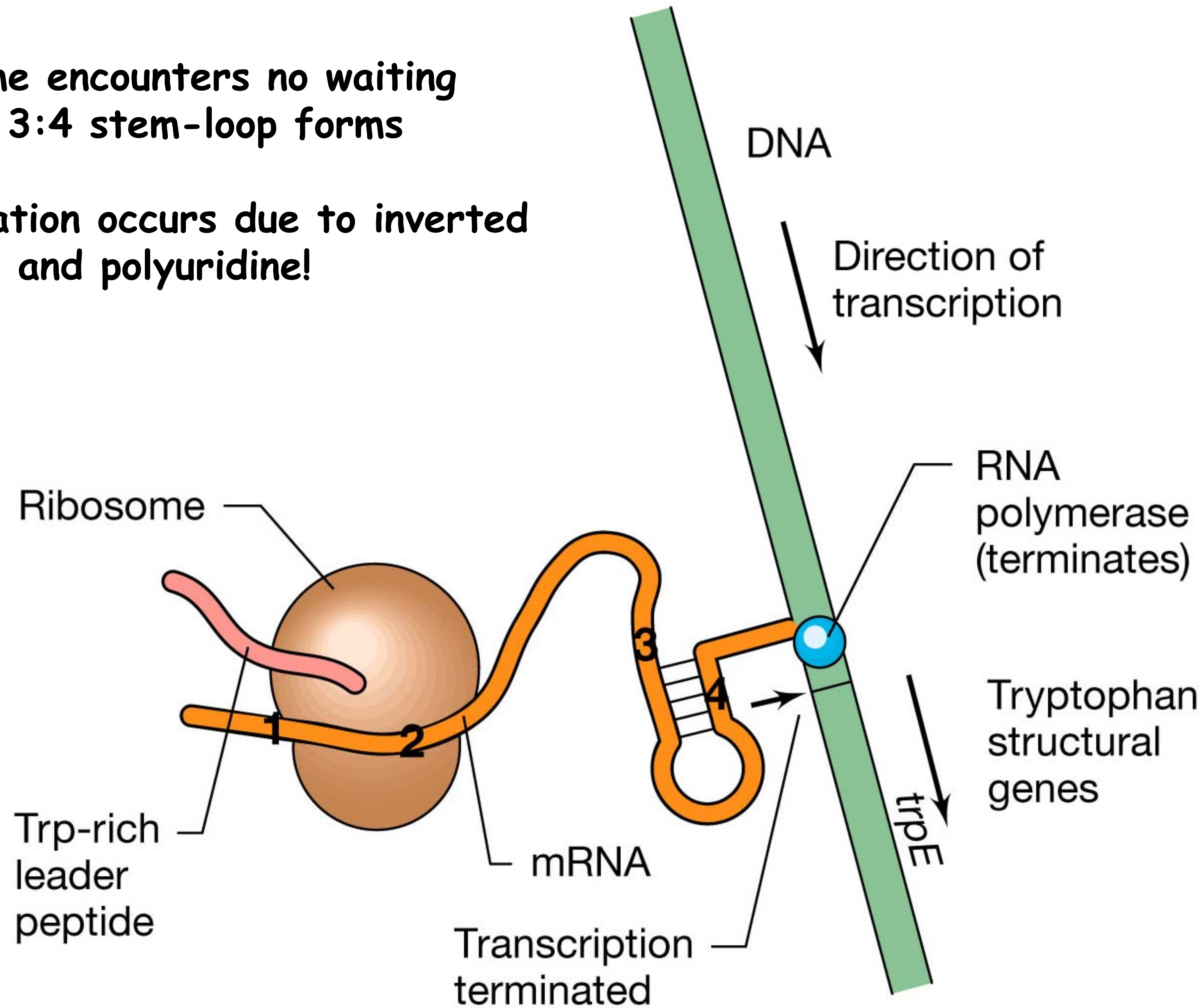
No termination!



Excess tryptophan: transcription terminated

Ribosome encounters no waiting
Domain 3:4 stem-loop forms

Termination occurs due to inverted repeats and polyuridine!



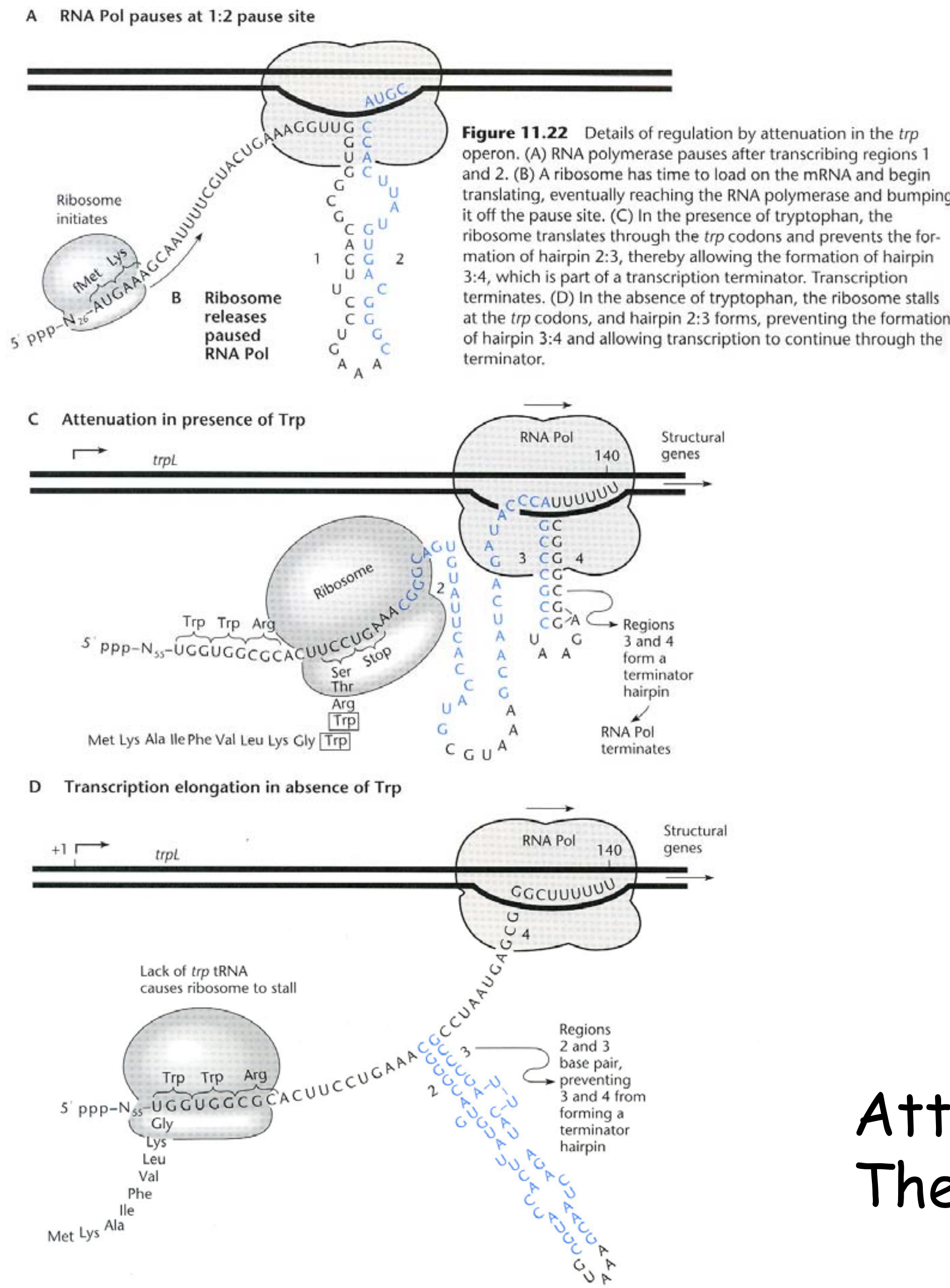


Figure 11.22 Details of regulation by attenuation in the *trp* operon. (A) RNA polymerase pauses after transcribing regions 1 and 2. (B) A ribosome has time to load on the mRNA and begin translating, eventually reaching the RNA polymerase and bumping it off the pause site. (C) In the presence of tryptophan, the ribosome translates through the *trp* codons and prevents the formation of hairpin 2:3, thereby allowing the formation of hairpin 3:4, which is part of a transcription terminator. Transcription terminates. (D) In the absence of tryptophan, the ribosome stalls at the *trp* codons, and hairpin 2:3 forms, preventing the formation of hairpin 3:4 and allowing transcription to continue through the terminator.

Attenuation: The rest of the story

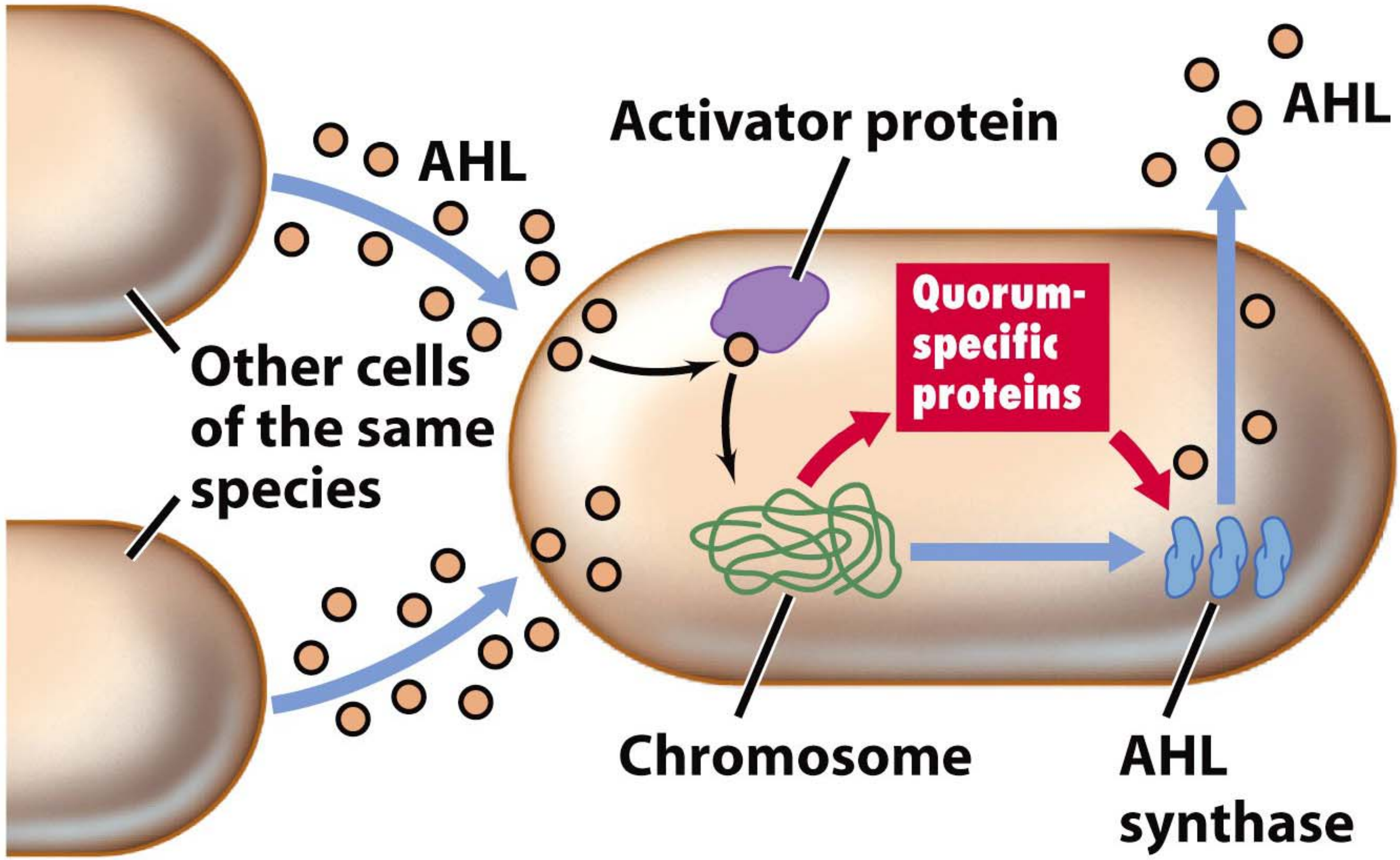
Global Control Systems

Table 8.1 Examples of global control systems known in *Escherichia coli*[a]

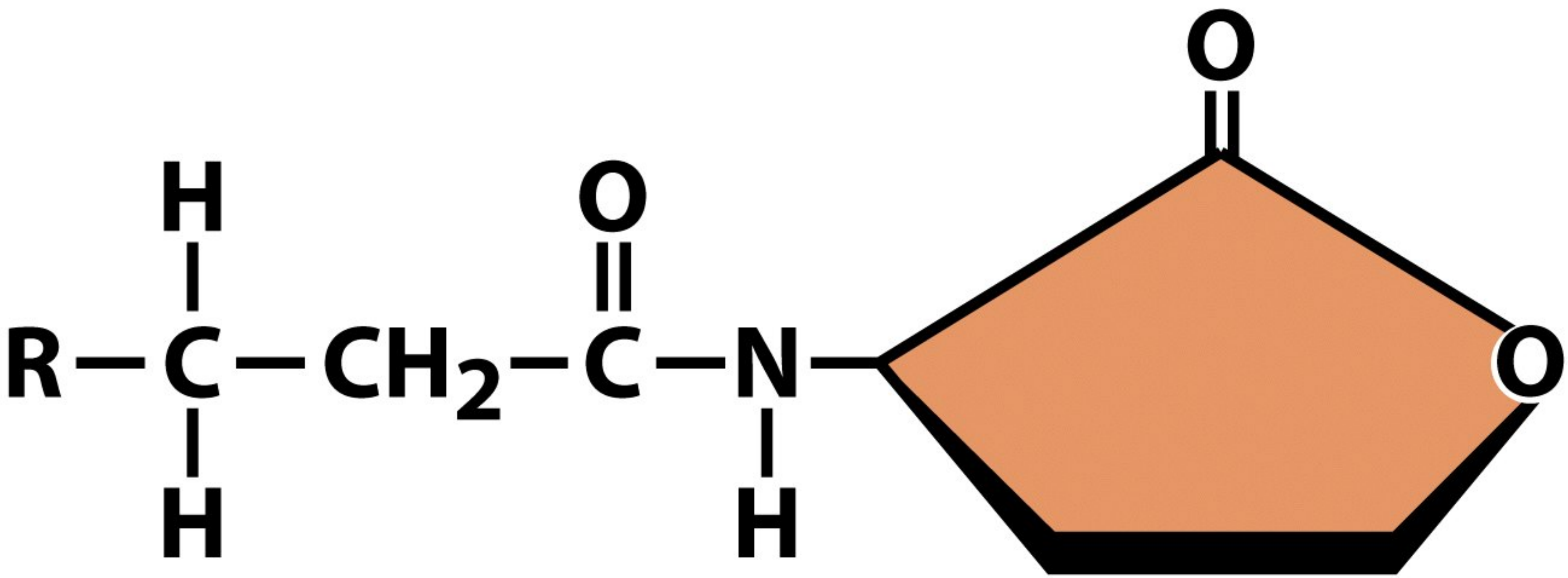
System	Signal	Primary activity of regulatory protein	Number of genes regulated
Aerobic respiration	Presence of O_2	Repressor (ArcA)	50+
Anaerobic respiration	Lack of O_2	Activator (FNR)	70+
Catabolite repression	Cyclic AMP concentration	Activator (CAP)	300+
Heat shock	Temperature	Alternative sigma (σ^{32})	36
Nitrogen utilization	NH_3 limitation	Activator (NR_I)/alternative sigma (σ^{54})	12+
Oxidative stress	Oxidizing agent	Activator (OxyR)	30+
SOS response	Damaged DNA	Repressor (LexA)	20+

[a] For many of the global control systems, regulation is complex. A single regulatory protein can play more than one role. For instance, the regulatory protein for aerobic respiration is a repressor for many promoters but an activator for others, whereas the regulatory protein for anaerobic respiration is an activator protein for many promoters but a repressor for others. Regulation can also be indirect or require more than one regulatory protein. Some of the regulatory proteins involved are members of two-component systems (see Section 8.12). Many genes are regulated by more than one global system. (For a discussion of the SOS response, Section 10.4.)

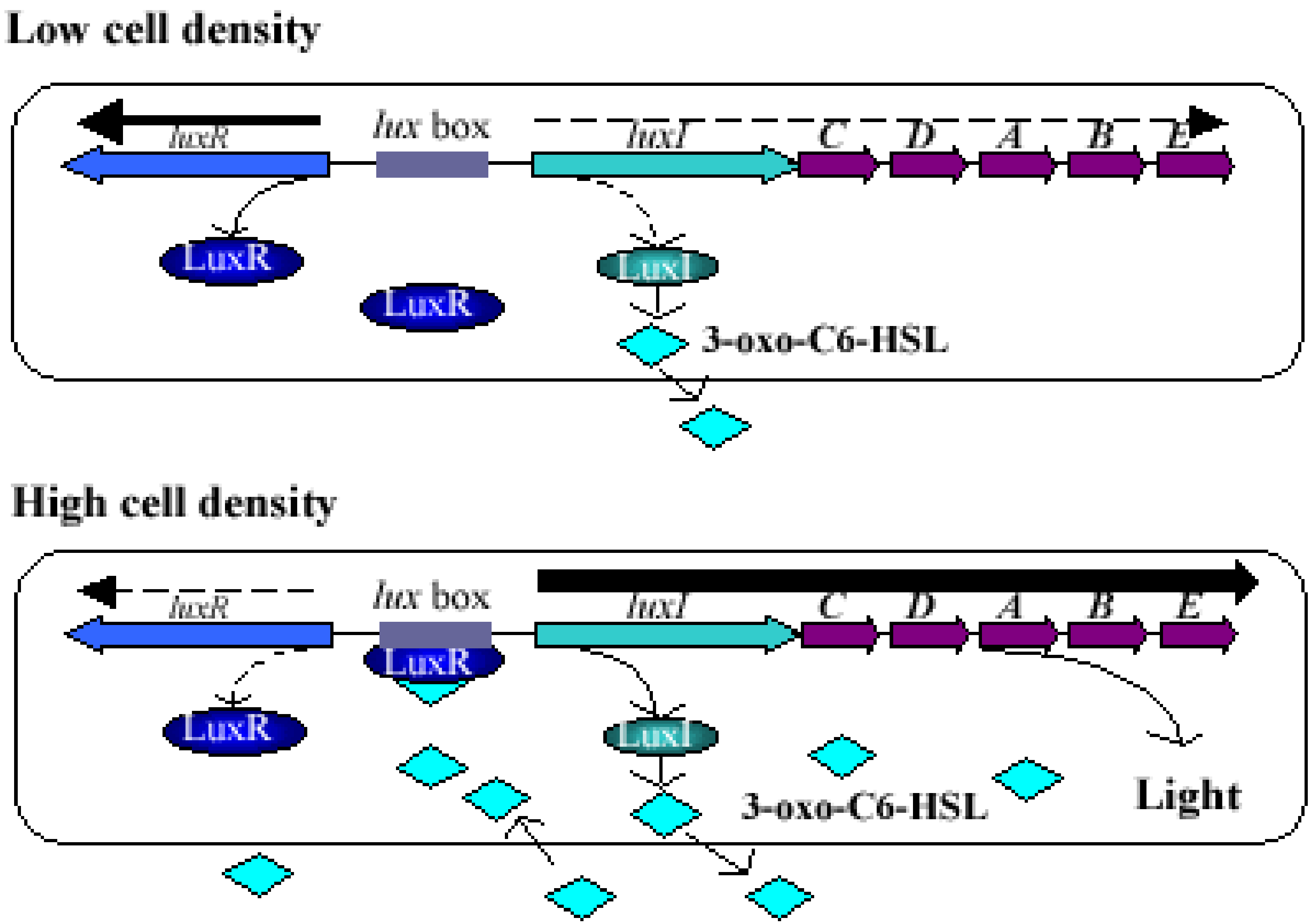
Quorum Sensing



Diffusible autoinducer = AHL

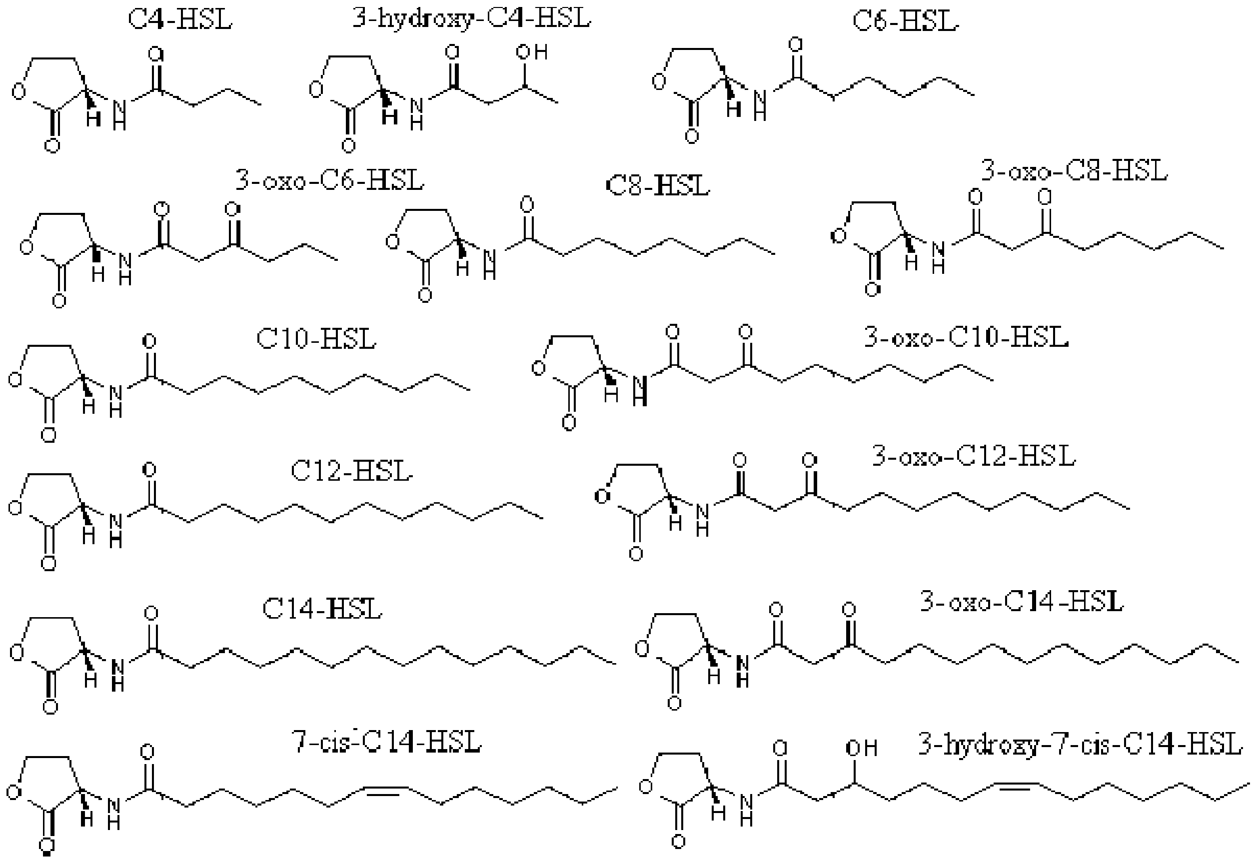


Acyl homoserine lactone (AHL)



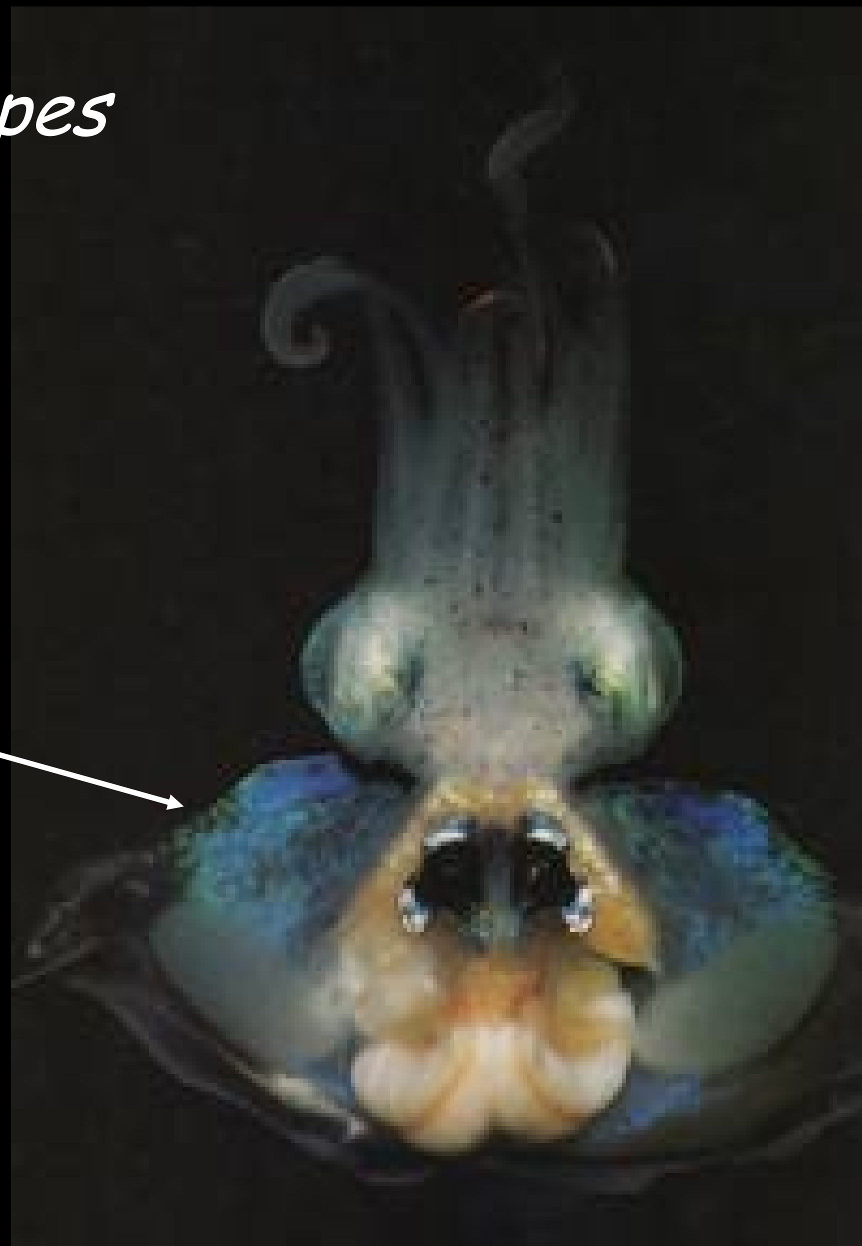
Luciferin/Luciferase reaction made possible by the lux operon

Examples of AHLs (N-acyl-L-homoserine lactones)



Used with *Vibrio fisheri*

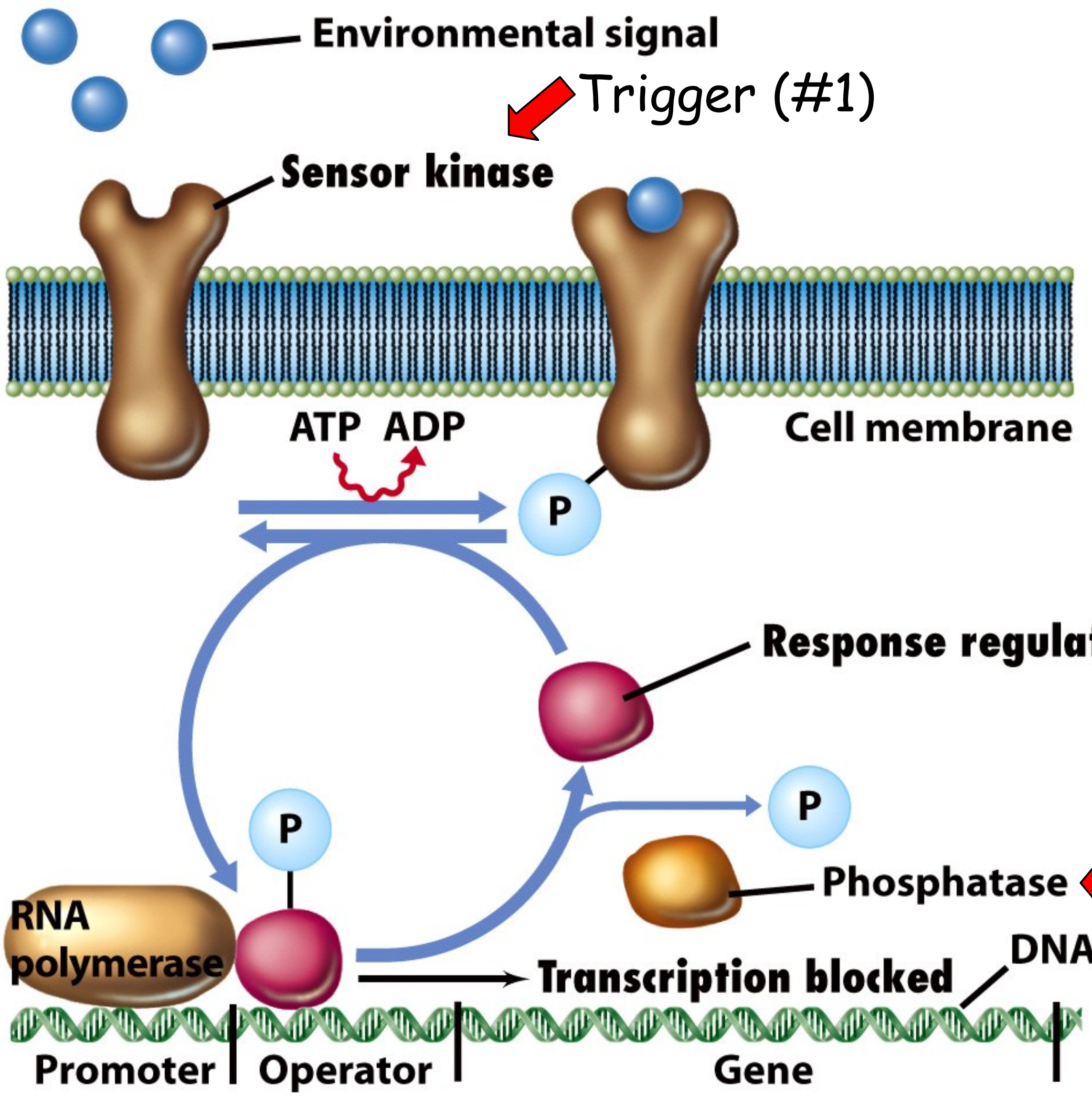
Eupryma scolopes



Vibrio fisheri

Two component system of **Signal Transduction**

Where environmental cues are transmitted to cellular machinery



Serves as a repressor in this system (#2)

Recycles response regulator

Two-Component Regulatory Systems

Table 8.3 Examples of two-component regulatory systems that regulate transcription in *Escherichia coli*

System	Environmental signal	Sensor kinase	Response regulator	Activity of response regulator[a]
Arc system	O_2	ArcB	ArcA	Repressor/Activator
Nitrate and nitrite anaerobic regulation (*Nar*)	Nitrate and nitrite	NarX and NarQ	NarL NarP	Activator/Repressor Activator/Repressor
Nitrogen utilization (*Ntr*)	NH_4^+	NR_{II}, the product of *glnL*	NR_I, the product of *glnG*	Activates RNA polymerase at promoters requiring σ^{54}
Pho regulon	Inorganic phosphate	PhoR	PhoB	Activator
Porin regulation	Osmotic pressure	EnvZ	OmpR	Activator/Repressor

[a] Note that several of the response regulator proteins act as both activators and repressors depending on the genes being regulated. Although ArcA can function as either an activator or a repressor, it functions as a repressor on most operons that it regulates.