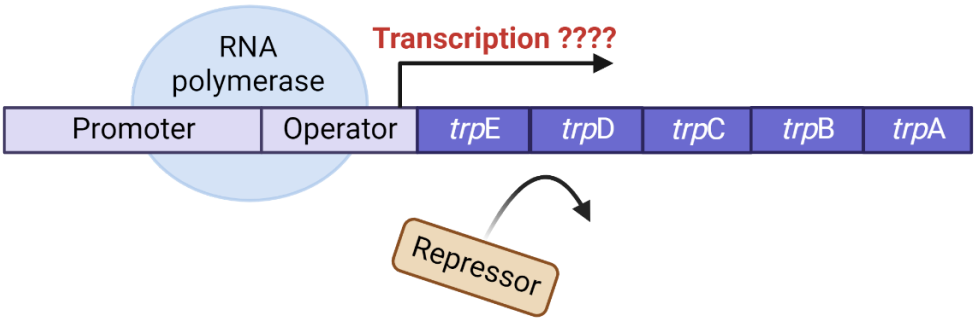
Features of Genetic Circuits

Genetic circuits are systems of genes and regulatory elements that can produce specific behaviours or responses in cells. These circuits are built based on the principles of molecular biology and are designed to mimic or extend the functionality of natural genetic networks found in living organisms.

1. Could you provide some instances of biological regulatory mechanisms?
2. What are your thoughts on the significance of the concept of "control" within biological systems?
3. Why is it necessary to implement a control system when engineering a cell?

Understanding Simple Genetic Circuits

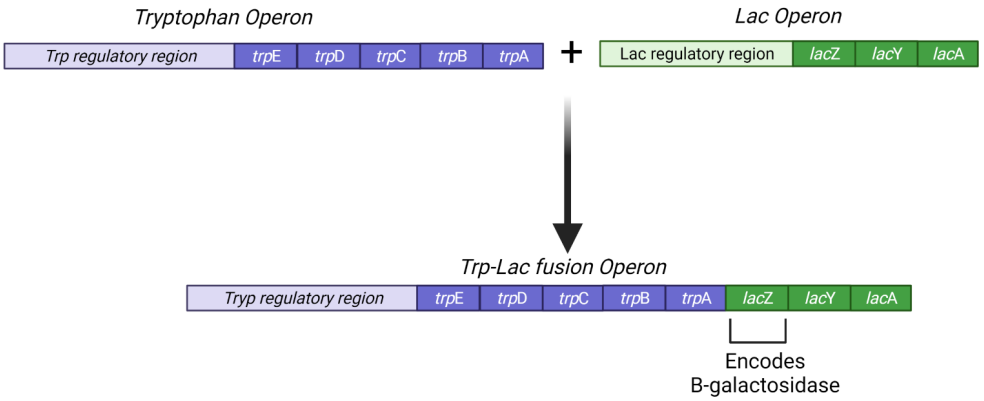
1. Bacterial cells can take up the amino acid tryptophan from their surroundings, or, if the external supply is insufficient, they can synthesise tryptophan from small molecules in the cell. The tryptophan repressor inhibits transcription of the genes in the tryptophan operon, which encodes the tryptophan biosynthetic enzymes. Upon binding tryptophan, the tryptophan repressor binds to a site in the promoter of the operon.



   a. Why is tryptophan-dependent binding to the operon a useful property for the tryptophan repressor?
   b. What would you expect to happen to the regulation of the tryptophan biosynthetic enzymes in cells that express a mutant form of the tryptophan repressor that (i) cannot bind to DNA or (ii) binds to DNA even when no tryptophan is bound to it?
   c. What would happen in scenarios (i) and (ii) if the cell produced a normal tryptophan repressor from a second, unmutated copy of the gene?

d. Can you identify the “control”, the “feedback mechanism,” and the “logic” here?

1. Imagine that you have created a fusion between the Trp operon, which encodes the enzymes for tryptophan biosynthesis, and the Lac operon, which encodes the enzymes necessary for lactose utilisation (see fig above). Under which set of conditions (i–Vi) below) **Will β-galactosidase be expressed in the strain that carries the fused operon?**



i. Only when lactose and glucose are both absent.

ii. Only when lactose and glucose are both present.

iii. Only when lactose is absent, and glucose is present.

iv. Only when lactose is present, and glucose is absent.

v. Only when tryptophan is absent.

vi. Only when tryptophan is present.