Cell biology

1 A gene regulatory protein called HisP regulates the enzymes for histidine biosynthesis in the bacterium E. coli. HisP is an allosteric protein whose activity is modulated by histidine. Upon binding histidine, HisP alters its conformation, dramatically changing its affinity for the regulatory sequences in the promoters of the genes for the histidine biosynthetic enzymes.

A. If HisP functions as a gene repressor, would you expect that HisP would bind more tightly or less tightly to the regulatory sequences when histidine is abundant? Explain Answer.

If HisP functions as a gene repressor, I would expect to bind more tightly to the regulatory sequences in the presence of abundant histidine. As a suppressor, HisP would function to downregulate the expression of the histidine biosynthetic enzymes in the presence of ample histidine, since the cell does not need to synthesis histidine under those conditions.

B. If HisP functions as a gene activator, would you expect that HisP would bind more tightly or less tightly to the regulatory sequences when histidine levels are low? Explain answer.

If HisP functions as a gene activator, I would expect it to bind more tightly to the regulatory sequences under conditions with low levels of histidine. As a gene activator, HisP would function to increase the expression of genes necessary for the biosynthesis of histidine. This would be more necessary and beneficial to the cell under conditions of low histidine.

2. In class we talked about how bacterial cells can take up the amino acid tryptophan from their surroundings, or if the external supply is insufficient, they can synthesize trytophan by using enzymes in the cell. In some bacteria, the control of glutamine synthesis is similar to that of tryptophan synthesis, such that the glutamine repressor is used to inhibit the

transcription of the glutamine operon, which contains the genes that code for the enzymes required for glutamine synthesis. Upon binding to cellular glutamine, the glutamine repressor binds to the site of the promoter of the operon.

A. Why is glutamine-dependent binding to the operon a useful property for the glutamine repressor?

By repressing the expression of the glutamine operon in the abundance of glutamine, as when the repressor molecule is bound to glutamine, the cell can conserve energy by not synthesizing a molecule that is already in abundance in its environment. When the supply of glutamine drops, the number of repressor molecules bound to glutamine, and hence repressing the expression of the glutamine operon, drops as well. This allows the cell to express the glutamine operon in order to raise levels of glutamine through its own biosynthetic pathway.

B. What would you expect to happen to the regulation of the enzymes that synthesize glutamine in cells that express a mutant form the glutamine repressor that cannot bind to DNA?

The regulatory mechanism would fail because no allosteric (or other) changes induced by glutamine binding to the repressor molecule would allow it to bind to the glutamine operon promoter and cease synthesis of it. As a result, assuming no other regulatory mechanisms prevented it, the cell would continuously synthesize the glutamine operon, even in the presence of abundant glutamine.

C. What would you expect to happen to the regulation of the enzymes that synthesize glutamine in cells that express a mutant form of the glutamine repressor that binds to DNA even when no glutamine is bound to it?

Once again the normal regulatory mechanisms control the expression of the glutamine operon would fail. If the repressor was continuously bond to the promoter region, even in the absence of glutamine, the cell would not synthesize sufficient glutamine in its absence in the cell’s environment.

3. We have discussed how the lac operon (see figure) is controlled by both the CAP activator protein and the lac repressor. You create cells that are mutant in the gene coding for the lac repressor so that now these cells lack the lac repressor protein under all conditions. For these mutant cells, state whether the lac operon will be ON or OFF under the following situations.

A. In the presence of glucose and lactose.

Off

B. In the presence of glucose and the absence of lactose.

Off

C. In the absence of glucose and the absence of lactose.

On

D. In the absence of glucose and the presence of lactose.

On

4. The gene for a hormone necessary for insect development contains binding sites for three gene regulatory proteins called A, B, and C. Because the binding sites for A and B overlap, A and B cannot bind simultaneously. You make mutations in the binding sites for each of the proteins and measure the hormone productions in cells that contain equal amounts of the A, B, and C proteins. The results of your studies are summarized in the figure. In each of the following sentences, choose one of the phrases within square brackets to make the statement consistent with the above results.

A. Protein A binds to its DNA binding site [more tightly/less tightly] than protein B binds to its DNA binding site.

B. Protein A is a [stronger/weaker] activator of transcription than protein B.

C. Protein C is able to prevent activation by [protein A only/protein B only/both protein A and protein B].