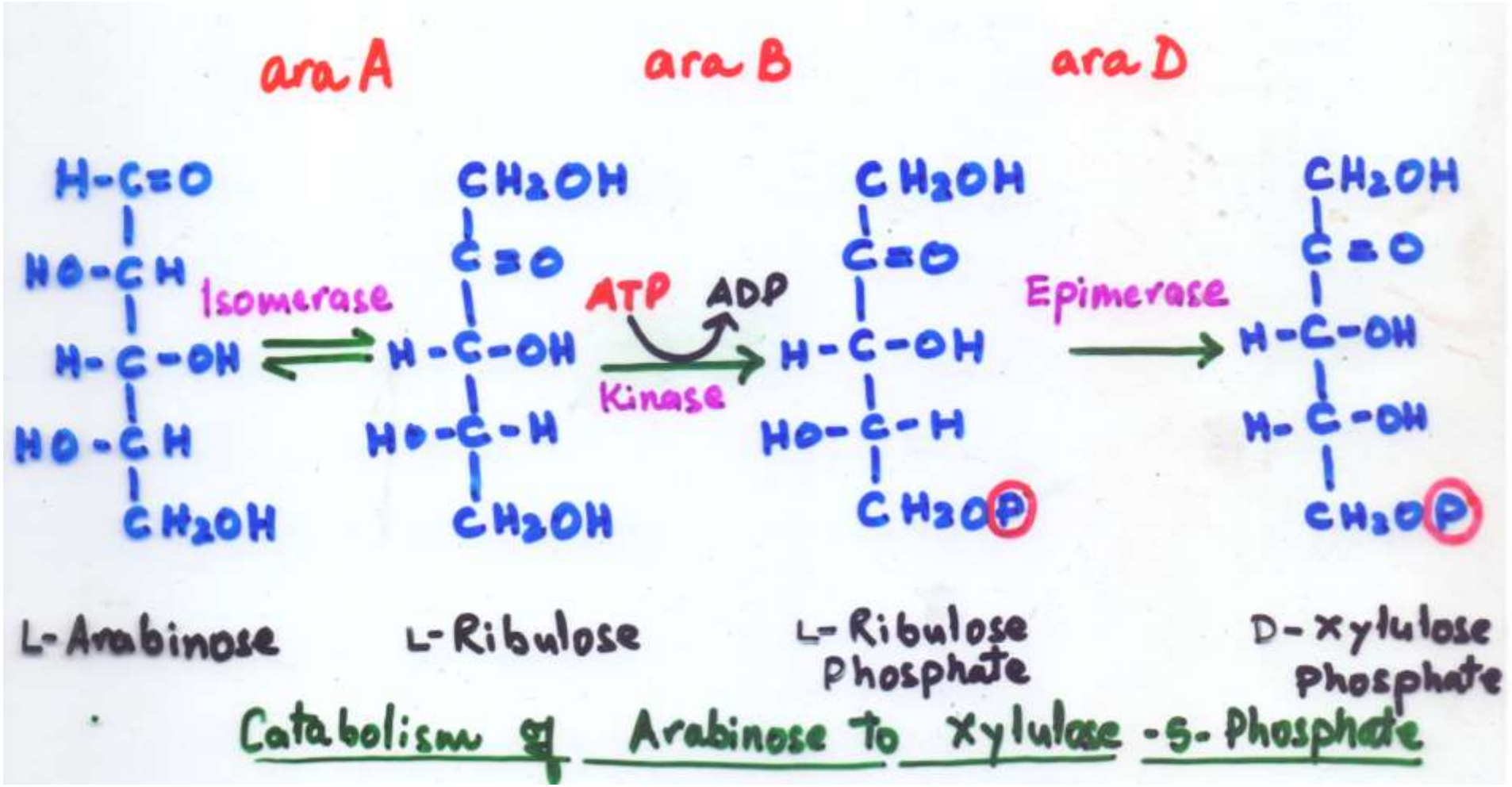
SOS in Biochemistry, Jiwaji University, Gwalior
M.Sc. II Semester (2019-20)
Paper BCH 201: Fundamentals of Molecular Biology (Unit III)

ara Operon

About Arabinose

- **A pentose sugar**
- **Found in the cell walls of many plants and is released in the human intestine after vegetable are eaten**
- **It is not absorbed in the intestine hence provide a source of carbon for bacteria**
- **Can be used as an alternate sugar by bacteria for energy production (in the absence of glucose)**
- ***E. coli* make three enzymes needed to break down arabinose**
- **These enzymes are only made (genes are only expressed) when the arabinose is present.**

Arabinose Catabolism



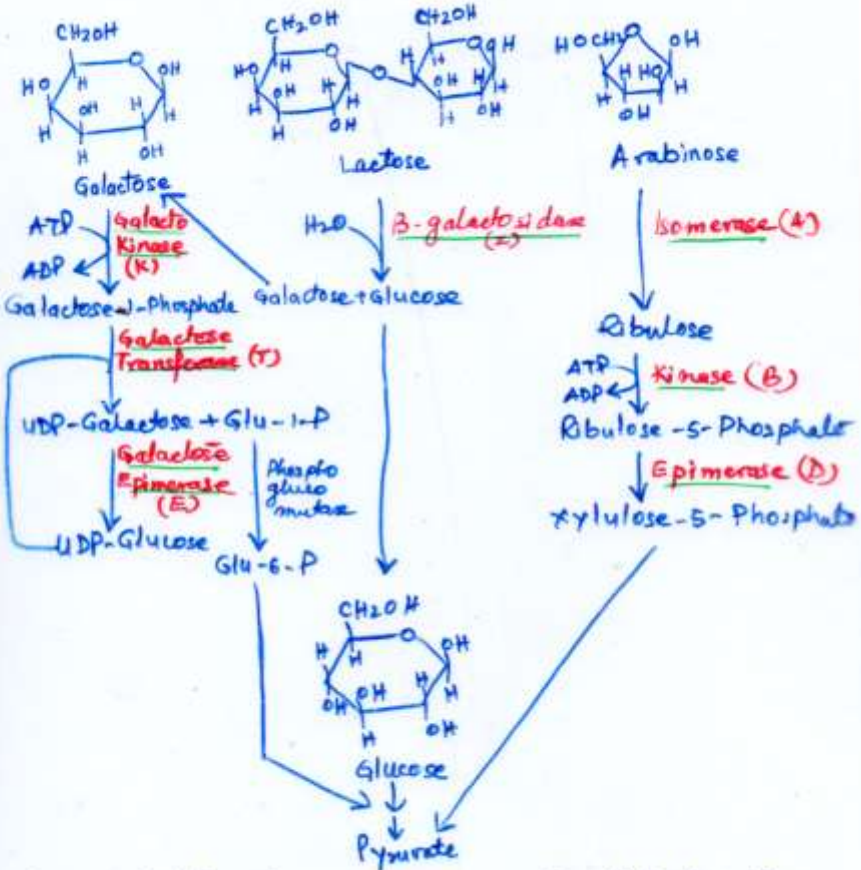


Fig.: Metabolic steps in three well studied pathways of sugar metabolism

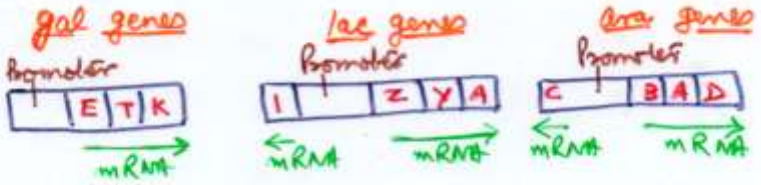


fig.: Each set of enzymes is encoded by a cluster of genes in a single operon

A pentose phosphate pathway intermediate

The *ara* Operon

- another example of operon that has both positive and negative regulation

- *araB*, *A*, and *D* encode the 3 arabinose metabolizing enzymes

- *araC* encodes the control protein AraC which is both a positive regulator (in the presence of arabinose) and a negative regulator (in the absence of arabinose).

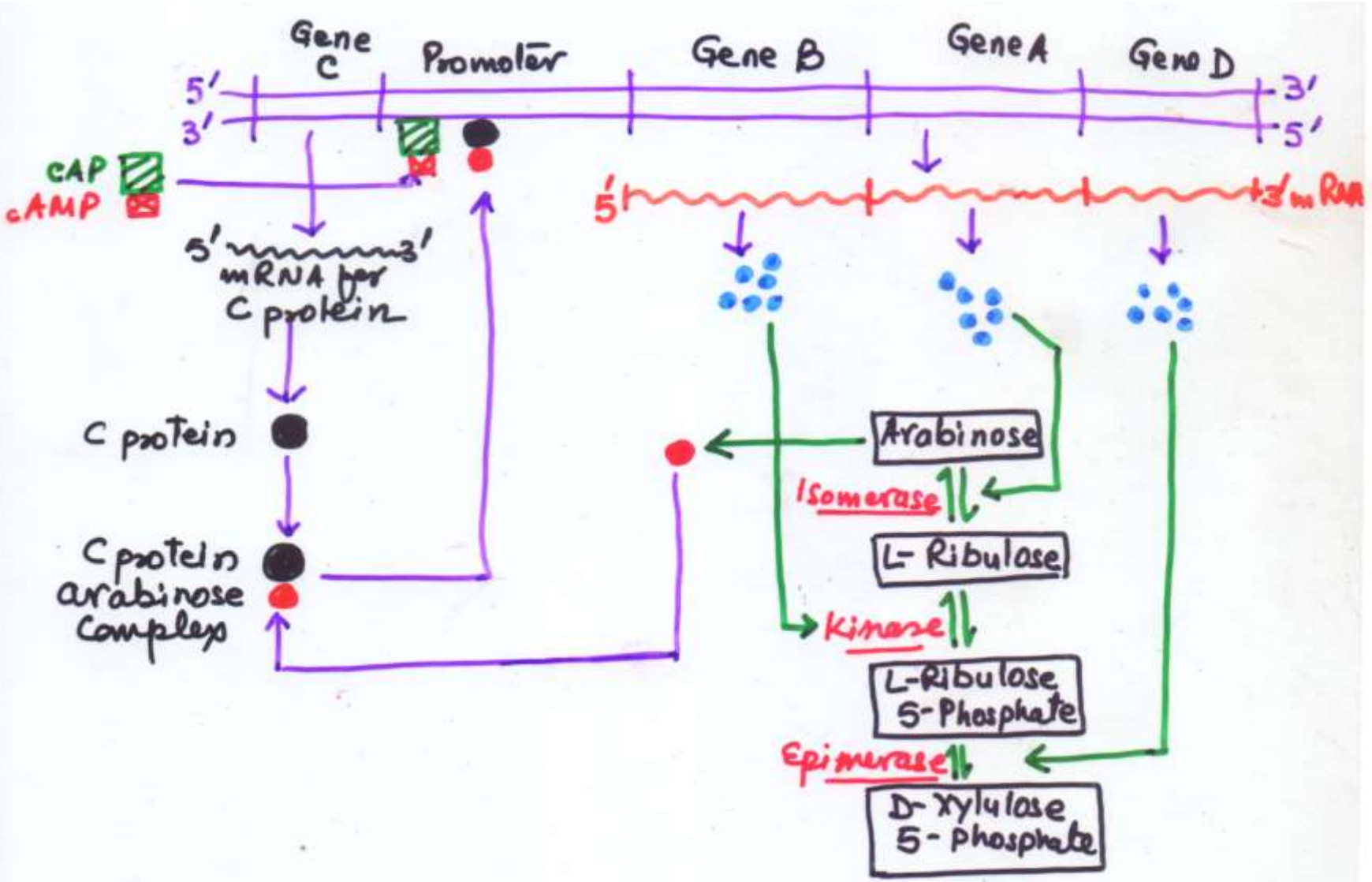
- cAMP-CAP complex also acts as a positive regulator

Dual natured araC gene product: araC < C^{rep} / C^{act}

1. In absence of arabinose araC protein acts as a repressor (C^{rep}) and binds to araO locus, which blocks transcription (Negative control).

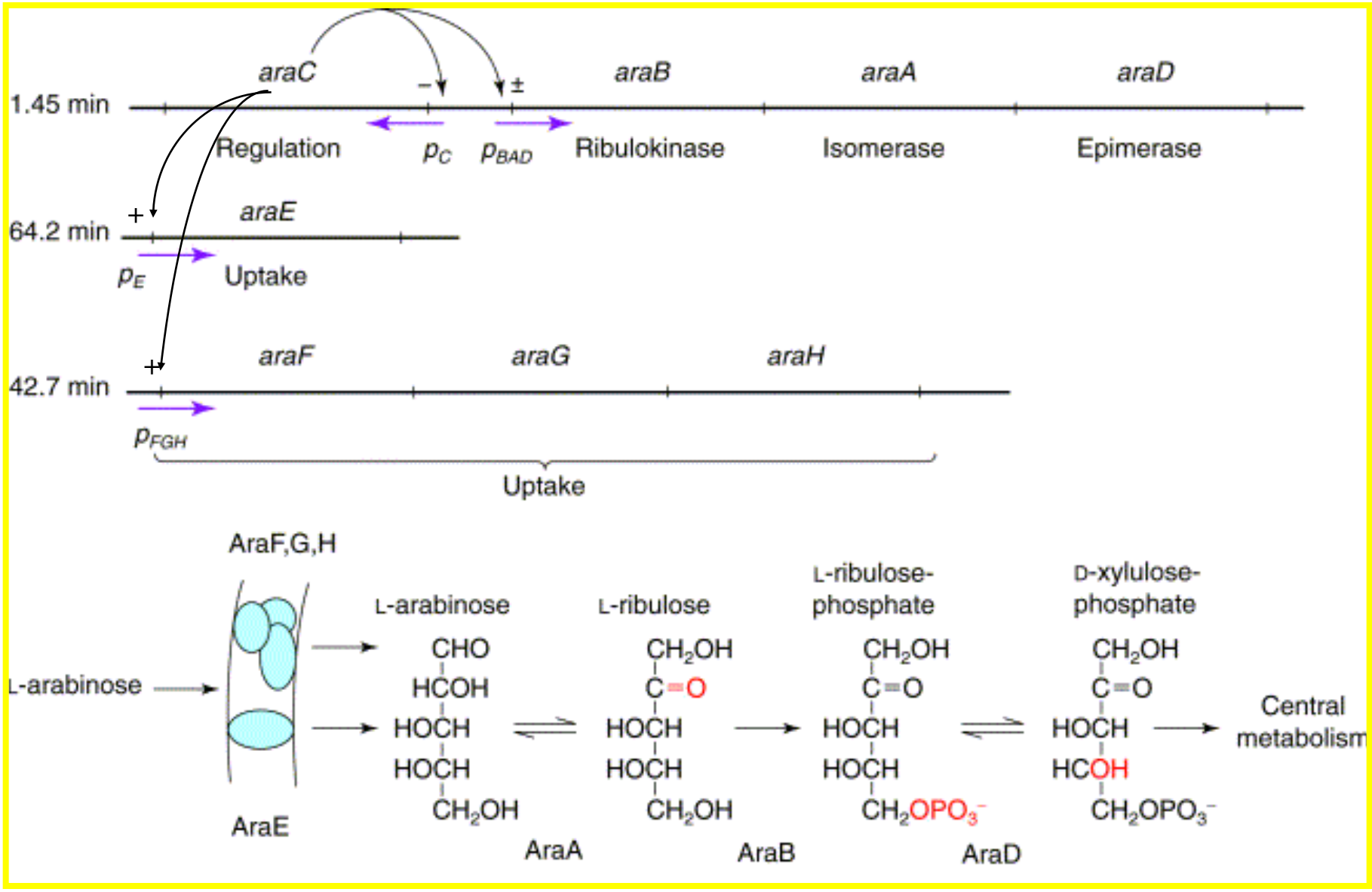
2. The addition of arabinose causes it to bind to the protein & convert it to an activator protein (C^{act}). This then binds to araI and stimulate transcription (Positive control).

Structure of L-arabinose operon

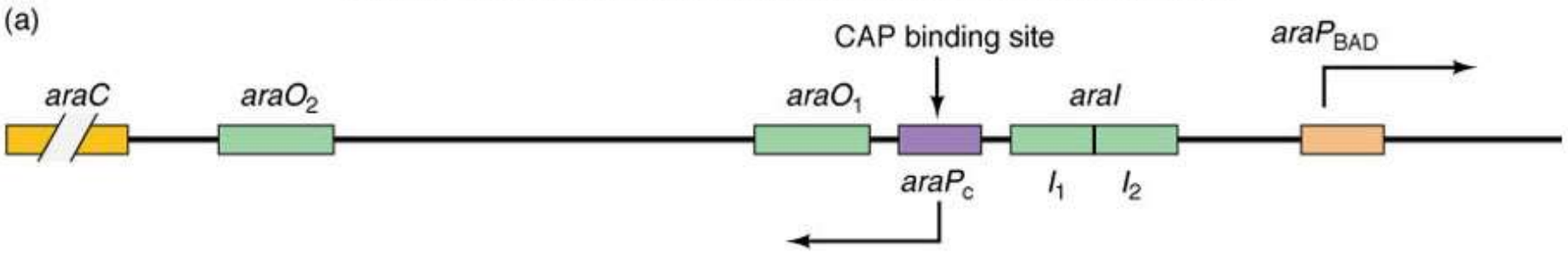


Arabinose Operon of E. coli : An example of positive control

The *E. coli* L-arabinose operon

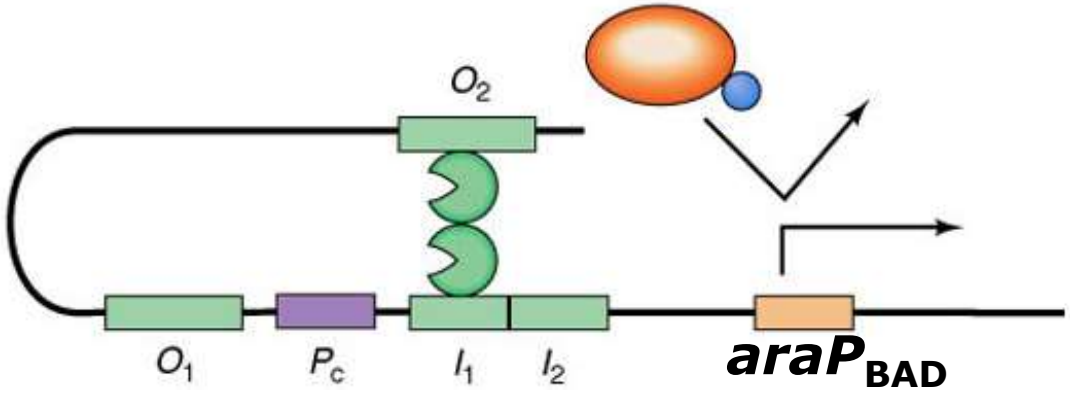


Organization of the *ara* Operon



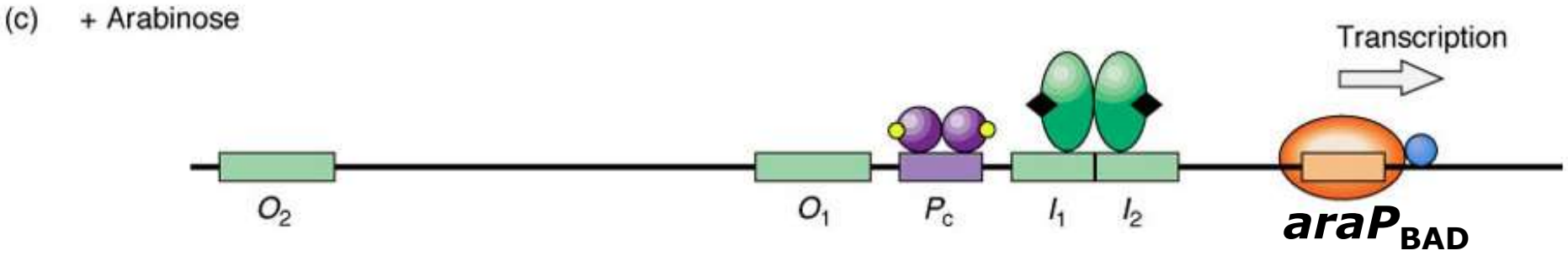
Control of the *ara* Operon I - Negative

(b) – Arabinose



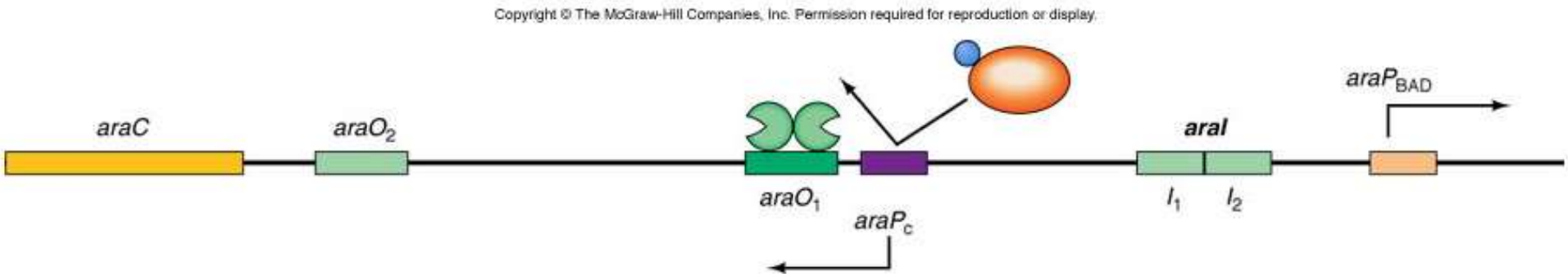
- **When arabinose is absent, the AraC protein acts as a negative regulator.**
- **AraC acts as a dimer, and causes the DNA to loop. Looping brings the I_1 and O_2 sites in proximity to one another.**
- **One AraC monomer binds to I_1 and a second monomer binds to O_2.**
- **Binding of AraC prevents RNA Pol from binding to the P_{BAD} promoter**

Control of the *ara* Operon II - Positive



- **When arabinose is present, it binds to AraC and changes AraC conformation**
- **An arabinose-AraC dimer complex binds preferentially to I_1 and I_2, and NOT to O_2 which causes 'opening' of the loop. This allows RNA Pol to bind to P_{BAD}.**
- **If glucose levels are low, cAMP-CAP complex binds to P_c.**
- **Active transcription occurs.**

Negative autoregulation of *araC* transcription

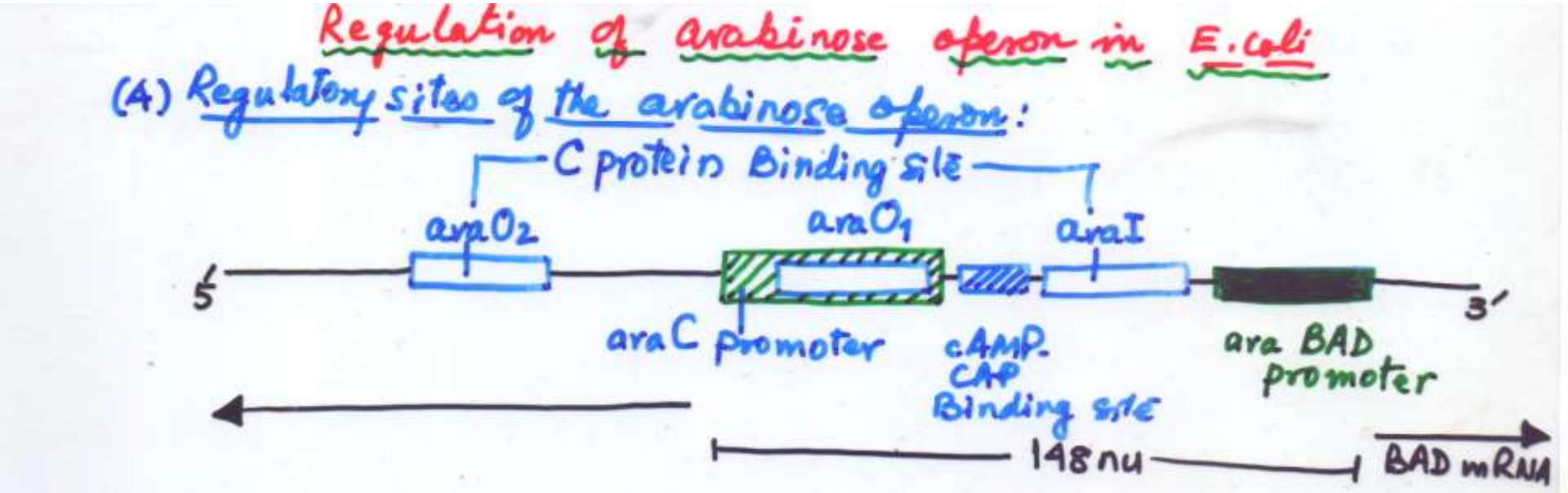


High levels of AraC cause the protein to bind to O_1 and inhibit transcription of the *araC* gene - negative autoregulation.

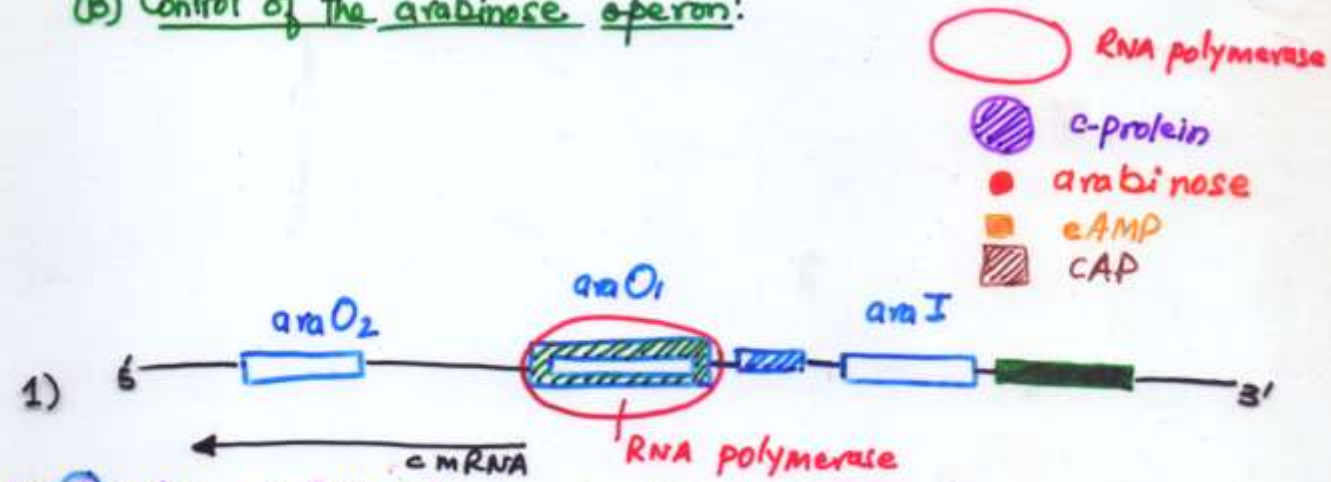
SUMMARY

Regulation of arabinose operon in E. coli

(4) Regulatory sites of the arabinose operon:

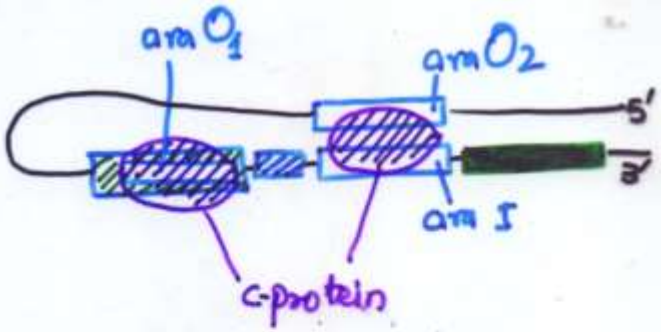


(B) Control of the arabinose operon:

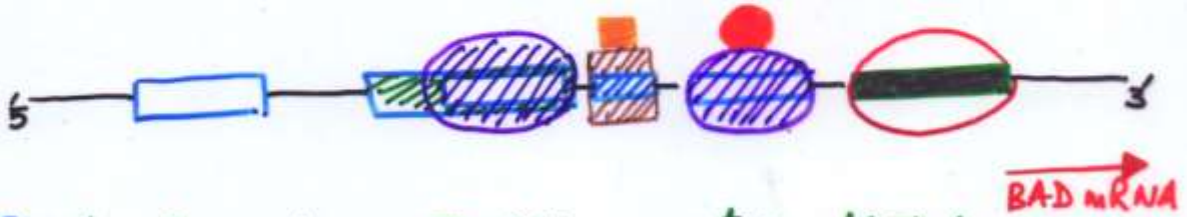


No C protein → RNA polymerase bind to araC promoter
- BAD promoter not activated
- C protein synthesis starts

2) C protein present with or without arabinose but low cAMP → ara BAD promoter repressed → C gene promoter repressed



(3)



C protein & arabinose present, high cyclic AMP present → - BAD promoter activated
- C gene promoter repressed

Arabinose Operon illustrates several general principles of gene regulation

1. **A protein can regulate its own synthesis by repressing the transcription of its gene**
2. **The binding of a single molecule to a protein can switch it from being an inhibitor of transcription to being an activator**

Arabinose Operon illustrates several general principles of gene regulation

3. **Protein binding regulatory sites on DNA need not to be contiguous with the gene controlled by them.**

   The *ara* operon provides a concrete example of how transcription can be modulated by a site at some distance from the transcribed gene?

Arabinose Operon illustrates several general principles of gene regulation

4. The changes induced by single molecule are readily reversed.

   Thus, the system responds continuously and rapidly to variations in the level of metabolites.