

# Microbial physiology and Metabolism

Paper code 203

UNIT-V

## Topic-Nif genes and their regulation

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# Nif genes

- The complex of genes encoding enzymes involved in the fixation of atmospheric nitrogen.
- They are found in nitrogen-fixing bacteria. They occur as an operon in free-living anaerobic nitrogen-fixing bacteria such as *Klebsiella pneumoniae*, *Rhodospirillum rubrum*, and *Rhodobacter capsulatus*.
- These genes may also be found on plasmids (together with the other genes, e.g. *nod* genes) in symbiotic bacteria, such as in *Rhizobium* inhabiting the roots of leguminous plants.
- The ***nif* genes** are genes encoding enzymes involved in the fixation of atmospheric nitrogen into a form of nitrogen available to living organisms.

- The primary enzyme encoded by the *nif* genes is the nitrogenase complex which is in charge of converting atmospheric nitrogen ( $N_2$ ) to other nitrogen forms such as ammonia which the organism can use for various purposes.
- Nitrogen fixation is important because many living organisms are unable to metabolize directly the atmospheric nitrogen and would require the nitrogen fixation capability of certain bacteria in order to produce a form of nitrogen (e.g. ammonia) that can be readily utilized.
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- nif genes also encode a number of regulatory proteins involved in nitrogen fixation.

- The nif genes are found in both free-living nitrogen-fixing bacteria and in symbiotic bacteria associated with various plants.

# REGULATION

- In most bacteria, regulation of nif genes transcription is done by the nitrogen sensitive NifA protein.
- When there isn't enough fixed nitrogen available for the organism's use, NtrC triggers NifA expression, and NifA activates the rest of the nif genes.
- If there is a sufficient amount of reduced nitrogen or oxygen is present, another protein is activated.
- NifL inhibits NifA activity resulting in the inhibition of nitrogenase formation.

# EXAMPLE

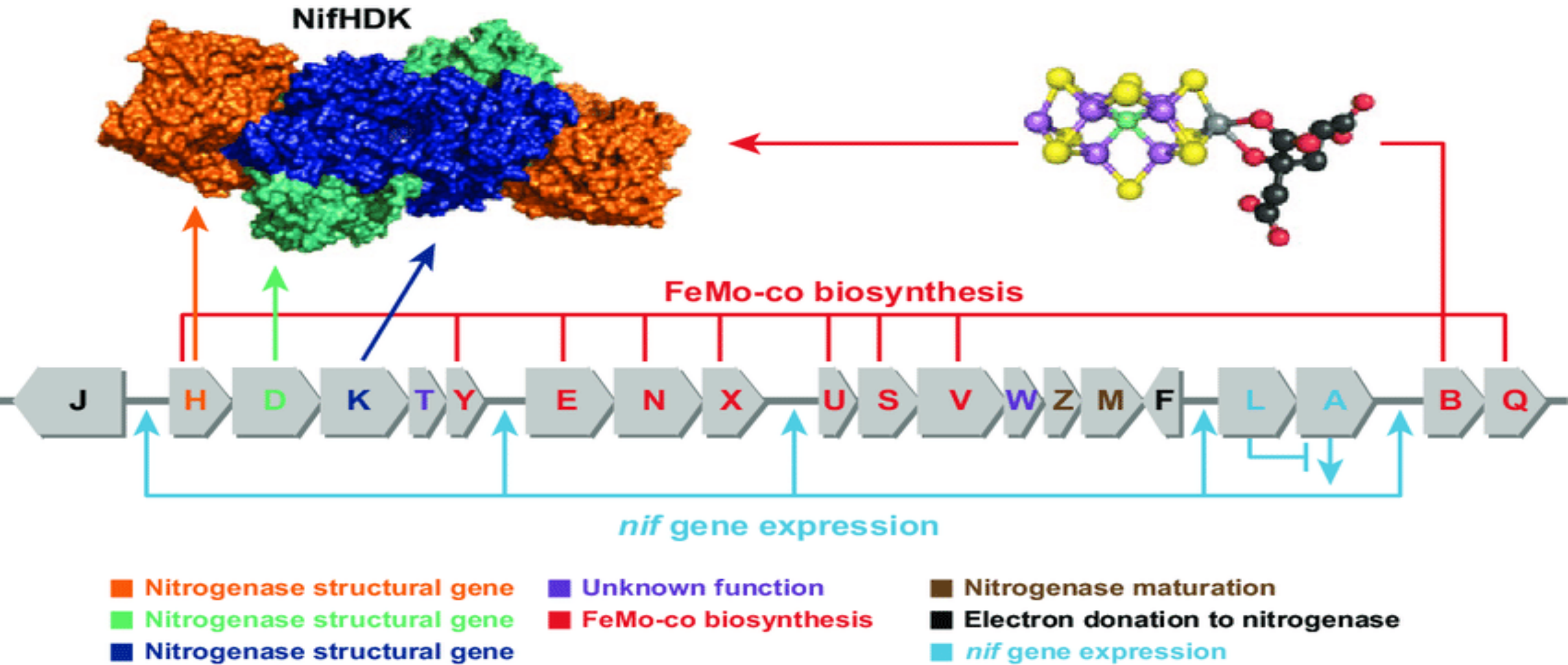
## *Klebsiella pneumonia*

- The N<sub>2</sub> fixation (nif) genes are organized into a regulon of 17 genes consisting of seven or eight operons each of which is transcribed into a single, usually polycistronic mRNA.
- Regulation of nif gene expression has Two elements: • an external system designated ntr(nitrogen regulatory) • an internal system mediated by nif A and nif L.
- The ntr system responds to conditions of nitrogen starvation by activating genes that enable the organism to utilize 'unusual' nitrogen sources such as arginine, proline, and histidine as well as N<sub>2</sub> itself.

- The ntr A gene product (NtrA) is a factor of RNA polymerase which recognize the nif and, other ntr - regulated genes.
- These promoters have a structure different from that of typical bacterial promoters.
- NtrA allows RNA polymerase to bind at the nif promoters and to initiate transcription.
- The ntrB gene product (NtrB) is an enzyme that functions both as a protein kinase and as a phosphatase, the substrate of which is NtrC (the ntrC gene product).

- Whether kinase or phosphatase activity predominates depends upon the nitrogen status of bacterium, and the consequence of this is that, under condition of starvation, NtrC-P acts as an activator of, nifL and nif A.
- The nif A product is an activator of transcription of other nif genes, whilst the nif L product, in the presence of either intermediate concentrations of fixed nitrogen or inactivate the nif A product, thereby preventing transcription of other nif genes.





Nitrogen fixation (nif) gene cluster of *Klebsiella pneumoniae*

## REGULATION OF NIF GENE EXPRESSION IN *KLEBSIELLA PNEUMONIAE*

