International Research Journal of Innovations in Engineering and Technology (IRJIET)

ISSN (online): 2581-3048

Volume 5, Issue 9, pp 41-45, September-2021

https://doi.org/10.47001/IRJIET/2021.509006

Nitrogen Metabolism and Its Flow in the Ecosystem

Dr. Ashwani kumar Gupta

Assistant Professor in Zoology, Regional Institute of Education, Ajmer, Rajasthan, India

Abstract - **All living organisms are basically composed of carbon, hydrogen, oxygen, nitrogen and many other types of elements. To maintain the essential requirements it is necessary a proper ecological system, which is known as ecosystem. In this system to maintain the ecosystem the metabolism is necessary. With the flowing of nitrogen, the nitrogen metabolism is also running in the ecosystem.**

Keywords: Metabolism, Nitrogen fixation, Ammonia, Synthesis, Regulation.

I. INTRODUCTION

The metabolism of organisms (or of a cell) may be defined as the sum total of all the enzyme - catalyzed reactions that occur in an organism (or in a cell). The various processes constituting metabolism may be divided somewhat arbitrarily into catabolism and anabolism. Those processes, whose major function is the generation of chemical energy in forms suitable for the mechanical and chemical processes of the cell, are termed as catabolism. Whereas those processes, which utilize the energy generated by catabolism for the biosynthesis of cell components are termed as anabolism. Some processes be either catabolic or anabolic, depending on the energy conditions in the cell. These are referred to as amphibolism.

Catabolism
Fuels (carbohydrates, fats) ⟶ - CO_2+H_2
Useful Energy
+
Complex Molecules ⟵ Small Molecules
Anabolism

In all cells metabolism enable the cell to perform its vital functions. Metabolism performs following:-

(i) To obtain chemical energy from the degradation of energy-rich nutrients or from Capture solar energy.
(ii) To convent nutrient molecules into precursors of cell macromolecules.
(iii) To assemble these precursors into proteins, lipids, polysaccharides, nucleic acids and other cell components.
(iv) To form and degrade bio-molecules required in specialized functions of cell,

All the living organisms are basically composed of carbon, hydrogen, oxygen, nitrogen and many other forms of chemical elements. These elements contribute to finally organize various biomolecules present in a cell. Nitrogen is next to carbon in importance in living organisms. In a living cell, nitrogen is an important constituent of amino acids, proteins, enzymes, vitamins, alkaloids and some growth hormones.

II. METABOLISM OF NITROGENOUS COMPOUNDS

Utilization of Inorganic Nitrogen

Nitrogen, an essential element for all living organisms has a more complicated cycle. The main reservoirs of nitrogen are deposits, atmospheric air and the living organisms. Biological nitrogen fixation carried on by some bacteria and blue green algae brings the nitrogen of the atmosphere into soil or aquatic bodies from where it is to taken up in the biosphere. A biological nitrogen fixation also provides some nitrogen to the living system. Decay and decomposition of plant and animal wastes and dead organic matter yield ammonia which is converted to nitrite by bacteria, Nitrosamines and then nitrates by the activity of bacteria like Nitrobacteria The process of gentrification, brought about by the activity of bacteria such as Pseudomonas, Thiobacillus, Micrococcus denitrifications etc., converts nitrates to elemental nitrogen which is finally added to the atmospheric pool. The cyclic flow of nitrogen in ecosystems involves a precise balance of activity of a few species of bacteria so that adequate level of nutrient nutrients is maintained without excessive accumulation of inorganic and organic compounds of nitrogen which are,

ISSN (online): 2581-3048
Volume 5, Issue 9, pp 41-45, September-2021
https://doi.org/10.47001/IRJIET/2021.509006

beyond a certain concentration, harmful to a living system. Life on this planet could bar be drastically affected if only a few dozen species involved in nitrogen cycle are eliminated.

Biological Nitrogen Fixation

Although nitrogen gas makes up about 80% of the earth's atmosphere, its reduction to ammonia occurs in relatively few living systems - some free - living soil bacteria, such as klebsiella and Azotobacter, & cyanobacteria (blue-green algae) and symbiotic nodules on the roots of leguminous plants, such as beans of that have been infected with certain bacteria, notably of the genus Rhizobium. The infecting bacterium assumes a modified form called a bactericide, inside the cells of infected some trees such as alder, also form nitrogen fixing nodules and thus have the capacity to fix nitrogen.

The tripal bonded Nitrogen (N_2) molecule, NEN, with bond energy of about 940 kl/mol, is extraordinarily difficult to reduce, industrially; the reduction is done by the Haber process, a low yield catalytic hydrogenation carried out at very high temperature and pressure. This process is used in the manufacture of ammonia based fertilizers.

Biological Nitrogen (N_2) reduction is catalyzed by the enzyme nitrogenise of which. The most abundant and widely studied nitrogenise, of which four types are known. The most abundant and widely studied nitrogenise is the molybdenum (Mo)-dependent enzyme, such as the found in Azotobacter vinelandi. The stoichiometry of overall reaction is as follows:

$$N_2+8H^++16MgATP+8e^- \longrightarrow 2NH_3+H_2+16Mg\ ADP+16P$$

Nitrogen fixation is a very expensive process requiring hydrolysis of two ATPs as per electron transferred. The ATP is generated through energy - yielding pathways of the organism, primarily carbohydrate catabolism. Although eight total electrons are required reduction of Nitrogen (N_2) to $2NH_3$ is a six-electron process. The other two electrons as 'wasted' in the formation of Hydrogen (H2) a by product of nitrogen reduction. Electrons for Nitrogen (N_2) reduction are derived from low - potential carriers, either reduced ferred oxin or flarodoxine, a low- potential flavoprotein.

The Mo-dependent nitrogenase consists of two seperate metalo protein, one is called molybdenum-iron (MoFe) protein, clinitrogenase, or component I-catalyzes the reduction of Mitrogen (N_2). The other called iron (Fe) protein, dinitrogenase reductase or component II transfers electrons and protons, one at a time, to the MoF protein, in a process compiled to the hydrolysis of two Mg. ATPs, Both proteins contain iron-sulphur clusters, and more protein also contain molybdenum I'm the form of a tightly bound iron-molybdenum cofactor (Fe Mo-co). Nitrogen (N_2) binds to this cofactor during its reduction.

Nitrate utilization: The ability to reduce nitrate to ammonia is common to virtually all plants, fungi and bacteria. The first step reduction of nitrate to nitrite is catalysed by nitrate reductase. The eukaryotic enzyme contains bound FAD, molybdenum, and a cytochrome b3. The enzyme carries out the overall a reaction.

$$NO_3^- + NAD(P)\ H + H^+ \longrightarrow NO_2 + NAD(P)^+ + H_2O$$

The electrons are transferred from NADH or NADPH to enzyme bound FAD, then to cytochrome b_3, then to molybdenum, and finally to the substrate. Reduction of nitrite to ammonia is carried out in three steps by one enzyne, nitrite reductase.

$$NO_2^- \longrightarrow No^-(1) \longrightarrow NH_2OH(2) \longrightarrow NH_3(3)$$

Higher plants, algae, and cynobacteria use ferredoxin as the electron donor in the size-electron electron reaction.

Biogenesis of organic Nitrogen

(Utilization of Ammonia)

Ammonia in high concentrations is quite toxic, but at lower levels it is a central metabolite, serving as substrate for four enzymes that convert it to various organic nitrogen compounds. At physiological pH the dominant ionic species is ammonium ion, whit NH_4^+ (pK_a =9.2). However the four reactions involve the unshared electron pair of NH_3, which is therefore the reactive species.

All organ in his assimilate ammonia via reactions leading to glum glutamine, asparagine, and carbamoyl phosphate. Carbarmyoyal phosphate is used only in the biosynthesis of arginine, urea, and the pyrimidine nucleotides. This most of the

International Research Journal of Innovations in Engineering and Technology (IRJIET)
ISSN (online): 2581-3048
Volume 5, Issue 9, pp 41-45, September-2021
https://doi.org/10.47001/IRJIET/2021.509006

nitrogen that finds its way from ammonia to amino acids and other nitrogenous compounds does so via the three amino acids glutamate, glutamine, and asparagine. The α-amino nitrogen of glutamate and the side - chain amide nitrogen of glutamine are both primary sources of N (Nitrogen) in biosynthetic pathways.

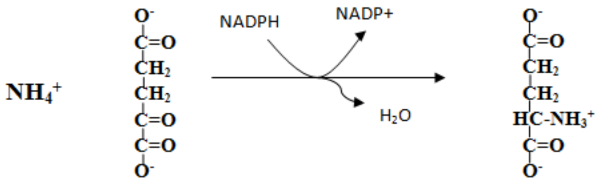
Glutamate de hydrogenase

(Reductive Amination of x-ketoglutarate)

Glutamate dehydrogenase (GDH) catalyzes the reductive amination of a-ketoglutarate to yield glutamate. Reduced pyridine nucleotides (NADH or NADPH) provide the reducing power:

$$NH_4^+ + \alpha\text{-ketoglutarate} + NADPH + H^+ \longrightarrow \text{Glutamate} + NADP^+ + H_2O$$

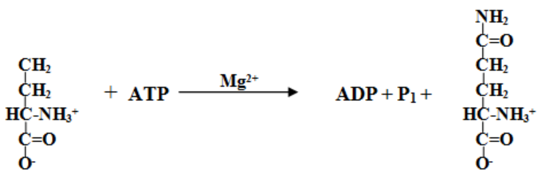
In vertebrates, GDH is an α_o type multimeric enzyme localized in the mitochondrial matrix that uses NADPH as electron donor when operating in the biosynthetic direction (the direction of glutamate synthesis). In contrast, when GDH acts in the catabolic direction to generate α-ketoglutarate from glutamate, NAD^+, not $NADP^+$, is usually the electron accepter. The catabolic activity is allosterically activated by ADP and inhibited by GTP.



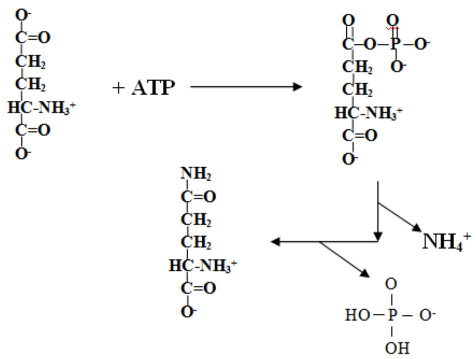
Glutamine Synthetase (GS)

Catalyzes the ATP-dependent amidation of the *y* carbonyl group of glutamate to form glutamine. The reaction proceeds via a r-glut amyl-phosphate intermediate, and GS activity depends on the presence of divalent cations such as Mg^{2+} Glutamine is a major nitrogen (N) donar in the biosynthesis of many organic Nitrogen (N) compounds such as. purine, pyrimidines and other amino acids, and GS activity is tightly regulated. The amide-N of glutamine provides the nitrogen atom in these biosynthesis.

(a) The enzymatic reaction.
Catalyzed by glutamine synthesase



(b) The reaction proceeds by (i) activation of the r-carboxyal of Glu by ATP followed by (ii) amidation by NH_4^+



ISSN (online): 2581-3048
Volume 5, Issue 9, pp 41-45, September-2021
https://doi.org/10.47001/IRJIET/2021.509006

III. NITROGEN CYCLE

Nitrogen of the air, in order to available for plant use, must be fixed as a soluble salt in the soil, from whence it may be extracted in solution by plant roofs. From plants where it is incorporated in proteins, it passes via the good chain through animals and other dependent organisms.

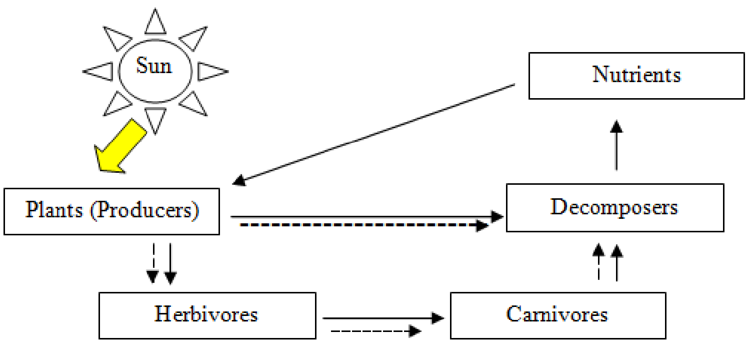
Nitrogen of the proteins of living organisms is returned to the inorganic state through metabolic wastes or by saprophytic decay Both are complex processes in which the nitrogen bars passes through a series of chemical transformations that and either in releasing nitrogen into the air on fixing it as nitrate in the soil. Nitrogen may also a be released into the air by fires which burn materials containing proteins, or by war fare in which many of the explosive contain nitrogen,

The air may be considered as a great reservoir of surplus nitrogen, from which it is very difficult to extract. Agencies that release nitrogen into the air are usually considered wasteful. It is rescued from the air by nitrogen fixing bacteria, by lightning possibly sunshine’s changing the air molecules, and artificially by means of factories.

Ecosystem: Smith (1966) emphasized the following general characteristics of most ecosystems:-

(i) The ecosystem is a major structural and functional unit of ecology,
(ii) The structure of an ecosystem is related to its specific diversity, the more complex ecosystems have high specific diversity.
(iii) The Junction of the ecosystem is related to energy flow and material cycling through and within the system.
(iv) The relative amount of energy needed to maintain an ecosystem depends on its structure. The more complex the structure the lesser the energy it needs to maintain itself.
(v) Ecosystems mature by passing from fewer complexes to more complex states, early stages of such succession have an excess of potential energy and a relatively high energy flow per unit biomass, Later (nature) stages have less energy accumulation and its flow through more diverse components.
(vi) Both the environment and the energy fixation in any given ecosystem care limited and can't be exceeding without causing serious undesirable effects.
(vii) Alterations in the environments represent the selective pressures upon population selective to which it must adjust, organisms which are unable to adjust to the changed environment must needs vanish,

The ecosystem is an integrated unit or zone of variable size, comprising vegetation and the fauna, microbes and the environment. Most ecosystems characteristically possess a well-defined soil, climate, flora and fauna and have their own potential for adaptation, change and tolerance. The functioning of any ecosystem involves a series of cycles e.g. the water cycle and the cycles of various nutrients. These cycles are driven by energy. How, the energy being the solar energy a Continuation of life demands a constant exchange and return of nutrients to and amongst the different components of the ecosystem.



IV. CONCLUSION AND RECOMMENDATIONS

It is concluded that with the studies of nitrogen metabolism, nitrogen cycle and ecosystem, the nitrogen metabolism & is also continuing of flowing with nitrogen cycle in the food chain and food web of the ecosystem. Energy and materials are the basic requirements of an organism for which no organism is independent Green plants being the nature's procedures need not take food from the environment, but after all need raw materials for the production of food come from the atmosphere (CO_2) and the soil (H_2O & inorganic). Animals are the Consumers of different orders. Relationships between producers and the consumers of orders make up what we call different good web or good cycles in the ecosystem.

ISSN (online): 2581-3048
Volume 5, Issue 9, pp 41-45, September-2021
https://doi.org/10.47001/IRJIET/2021.509006

The rapid advances in science and technology have put the scientists and technologists on their heels to cope up with the simultaneous changes that have occurred during the past decades. Various types of revisions, rectifications as well as modifications and sometimes even together innovated ideas that developed in numerous fields of specializations have required to be incorporated with the advanced to the concerning fields of the study. The innovative techniques have but the researches on consistent think and rethink" level on to entertain high concepts related to the life Science. The study of such concept as nitrogen in the be considered with a nitrogen cycle as well ecosystems of land, aquatic (fresh water as marine water resources, mountains, desert and air etc. and interrelationship in between plants animals.

REFERENCES

[1] Appling Dean R., Anthony Cahill Spencer J. Mathews Christopher K. Biochemistry Concepts and connections. Pearson· NOIDA, U.P. (India) (2017).

[2] Asthana D. K., Asthana Meera, Environment problems and Solutions. S. Chand and Company Ltd. Ram Nagar, New Delhi (1999).

[3] Garrett Reginald H., Grisham Charles M. Biochemistry. Brooks/ cole CENGAGE Learning, Boston, MA 02210, USA. (2010).

[4] Gupta A. K. Study of Effectiveness of local resources in conservation of Phenomena of life and programme of Biology Education, Ph.D. Thesis submitted to the H.N.B. Garhwal University Srinagar - Dist-Pauri -(1992).

[5] Jain J.L., Jain Sanjay, Jain Nitin, Fundamentals of Biochemistry. S. Chand and company Limited, Ram Nagar, New Delhi (2016).

[6] Kumar H.D. Modern Concepts of Ecology Vikas Publishing House Pvt. Ltd., Jangpura, New Delhi (1999).

[7] Mathews Christopher K., Van Holde K.E., Ahern Kevin G. Biochemistry. Pearson Education. Dorling Kindersley (India) Pvt. Ltd., Putpurganj, Delhi (India) 2007.

[8] Nigam, H. C., Biology of Chordates, Vishal Publishing Co Old Railway Road. Jalandhar (2001).

[9] Wood Bury Angus M. Principles of General Ecology. McGraw Hill Book Company, INC., New York (1953).

[10] Yadav, R.S. (1980). An experimental study of comparison between lecture and discovery methods on VII grade students J-Edu-Res. Ext. 17: 51-57.

[11] nios.ac.in/media/documents/Sr.sec.314 New E/Lesson-10pdf

Citation of this Article:

Citation of this Article:

Dr. Ashwani kumar Gupta, “Nitrogen Metabolism and Its Flow in the Ecosystem” Published in *International Research Journal of Innovations in Engineering and Technology - IRJIET*, Volume 5, Issue 9, pp 41-45, September 2021. Article DOI https://doi.org/10.47001/IRJIET/2021.509006

****