ONE-CARBON METABOLISM

One-carbon metabolism refers to a complex network of biochemical reactions involving the transfer of one-carbon (C1) units, primarily in the form of methyl groups (-CH3), within cells. It plays a crucial role in fundamental processes such as DNA synthesis, amino acid metabolism, neurotransmitter synthesis, and epigenetic modifications.

The significance of one-carbon metabolism lies in its involvement in critical cellular functions. For example, it is a crucial pathway in the synthesis of purines and pyrimidines, the building blocks of DNA and RNA. Furthermore, one-carbon metabolism provides essential methyl groups for DNA methylation, a crucial epigenetic modification in gene regulation and cellular differentiation.

Additionally, one-carbon metabolism is intricately linked to the availability and metabolism of nutrients such as folate, vitamin B12, choline, and methionine. These nutrients serve as co-factors or substrates for the enzymes involved in one-carbon metabolism, influencing the balance of one-carbon units and methyl group transfers. Disruptions in one-carbon metabolism have been associated with various human diseases and conditions. For example, deficiencies in folate or vitamin B12 can impair DNA synthesis, leading to megaloblastic anemia or neural tube defects during fetal development. Changes in one-carbon metabolism have also been linked to an increased risk of cardiovascular diseases, neurodegenerative disorders, and certain types of cancer.

Understanding and analyzing one-carbon metabolism is crucial for unraveling the intricate molecular mechanisms underlying these diseases.

FOLATE-DEPENDENT ONE-CARBON METABOLISM

Folate, also known as vitamin B9, is a key cofactor in one-carbon metabolism. Folate is converted to its active form, tetrahydrofolate (THF), which serves as a carrier of one-carbon units. In this pathway, one-carbon units are transferred from THF to various acceptor molecules, including nucleotides, amino acids, and coenzymes.

METHIONINE CYCLE

Methionine, an essential amino acid, serves as a major source of one-carbon units in the form of S-adenosylmethionine (SAM). SAM is involved in numerous methylation reactions, including the methylation of DNA, RNA, proteins, and other biomolecules. During these reactions, SAM donates its methyl group and is converted to S-adenosylhomocysteine (SAH), which is subsequently hydrolyzed to homocysteine.

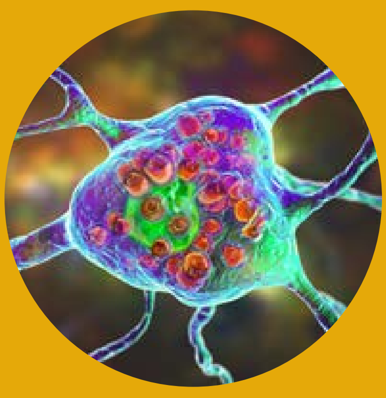
HOMOCYSTEINE METABOLISM

Homocysteine, generated from the methionine cycle, can be remethylated to form methionine or undergo transsulfuration to form cysteine. The remethylation pathway requires vitamin B12 as a cofactor and involves the transfer of a methyl group from 5-methyl-THF to homocysteine. The transsulfuration pathway involves the conversion of homocysteine to cystathionine, which is then cleaved to produce cysteine.

SERINE METABOLISM

Serine, an amino acid, can be converted to glycine through the serine hydroxymethyltransferase (SHMT) reaction. This reaction generates one-carbon units in the form of 5,10-methylene-THF, which can be used for nucleotide synthesis or remethylation reactions. Glycine can also serve as a source of one-carbon units through the glycine cleavage system.

APPLICATIONS OF ONE-CARBON METABOLISM ANALYSIS



CANCER RESEARCH

Aberrations in one-carbon metabolism are closely linked to cancer development and progression. Analyzing these pathways in cancer cells unveils metabolic routes crucial for tumor growth, metastasis, and drug resistance, facilitating the identification of novel therapeutic targets.

NEUROLOGICAL DISORDERS

Analyze single-carbon metabolic pathways in neurological disorders such as Alzheimer's disease and schizophrenia to gain insight into underlying metabolic dysregulation and identify potential therapeutic targets.

DRUG DEVELOPMENT

One-carbon metabolism is critical in drug development, impacting drug metabolism, efficacy, and toxicity. Studying its interplay with drug metabolism enhances drug optimization, predicts interactions, and enables the design of safer and more effective pharmaceuticals.

NUTRITION RESEARCH

One-carbon metabolism is linked to nutrition and metabolism. Analyzing one-carbon metabolism enables the evaluation of nutritional deficiencies and overnutrition's impact on the body. It also helps uncover the mechanisms underlying diseases associated with nutritional metabolism.

AGRICULTURAL SCIENCES

Understanding the metabolic pathways involved in plant growth and development can help improve crop yields, nutrient utilization, and stress tolerance.

DNA METHYLATION RESEARCH

Explore the sources of single-carbon transfers and methyl donors involved in DNA methylation and understand the mechanism regulation and its role in health and disease.

ONE-CARBON ANALYSIS IN CREATIVE PROTEOMICS

Metabolite profiling: Qualitative and quantitative analysis of metabolites involved in the one-carbon metabolic pathway, providing a comprehensive understanding of the composition and concentration of various metabolites, such as nucleotides, amino acids, coenzymes and other small molecules. By comparing the metabolic profiles of different samples, metabolic changes associated with specific conditions or diseases can be identified.

Enzyme analysis: identify and quantify key enzymes involved in one-carbon metabolic pathways. Gain insight into the regulation and function of enzymes in the pathway by characterizing enzyme activity and expression levels.

Pathway analysis: Integrate metabolite and enzyme data to construct and analyze metabolic networks of one-carbon metabolic pathways. This involves mapping interactions between different metabolites and enzymes, identifying metabolic intermediates, and deciphering the flow of carbon units within the pathway. By examining overall pathway dynamics and identifying key regulatory points and potential metabolic bottlenecks, it helps to gain a deeper understanding of the biological significance of the pathway.

Data Interpretation and Reporting: Provides comprehensive data interpretation and reporting services, including statistical analysis, pathway visualization, and identification of significant metabolite and enzyme alterations.

TECHNOLOGY PLATFORMS

Targeted Metabolomics using Triple Quadrupole Mass Spectrometry:

- Instrument models: Agilent 6460 Triple Quadrupole LC/MS system, Thermo Scientific TSQ series, AB SCIEX QTRAP series.
- Advantages: These instruments offer exceptional sensitivity, selectivity, and dynamic range for targeted analysis and quantification of specific metabolites in the one-carbon metabolism pathway. They are well-suited for detecting and measuring low-abundance metabolites with high precision.

Untargeted Metabolomics using Time-of-Flight Mass Spectrometry (TOF-MS):

- Instrument models: Waters Xevo G2-XS QTof, SCIEX TripleTOF series.
- Advantages: TOF-MS instruments provide accurate mass measurements and high-resolution data, enabling comprehensive profiling of metabolites in complex samples. They are particularly useful for identifying unknown metabolites and exploring the metabolic pathways within the one-carbon metabolism network.

High-Resolution Mass Spectrometry using Orbitrap Technology:

- Instrument models: Thermo Scientific Orbitrap series (e.g., Q Exactive, Orbitrap Fusion).
- Advantages: Orbitrap instruments combine high-resolution accurate mass measurements with excellent sensitivity. They are versatile for both targeted and untargeted metabolite analysis, enabling the identification and quantification of metabolites in complex biological samples with exceptional precision.

CONTACT US

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