NutriOmics: A species- and tissue-specific nutrient signature database

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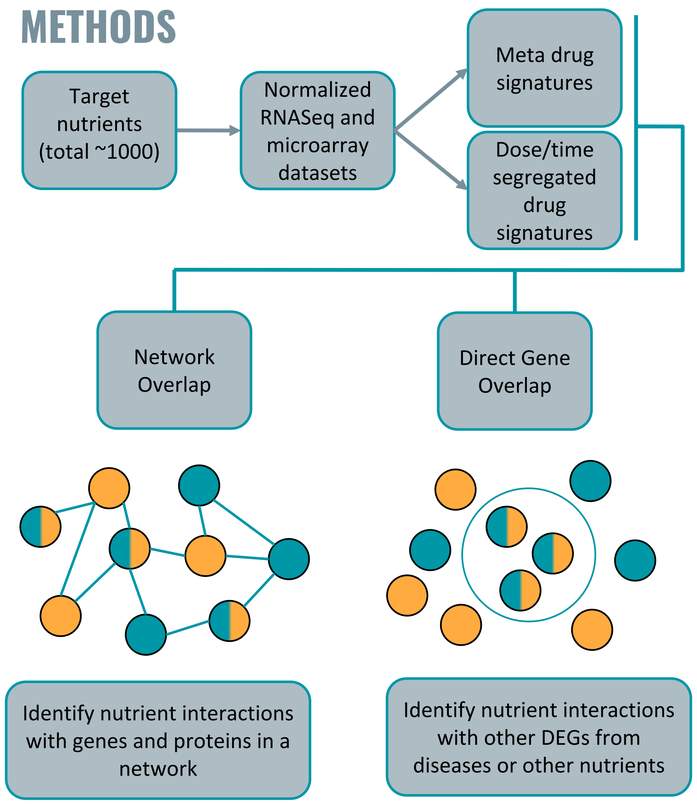
ABSTRACT

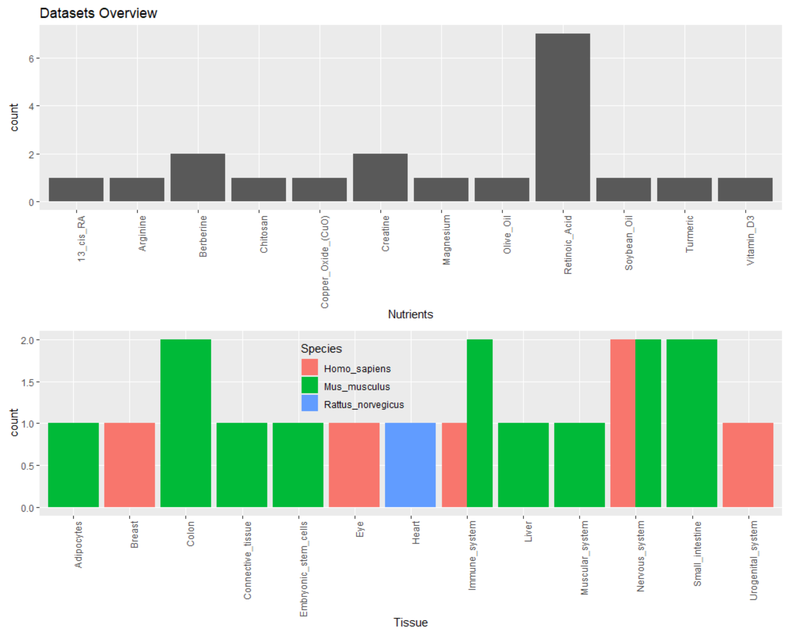
Nutrients are essential for human health, yet no consistent, well-structured, and easily queryable databases comprehensively detail the mechanisms underlying their beneficial or deleterious effects on the complex organ systems. Elucidating species- and tissue-specific effects of nutrients on gene expression can provide valuable molecular insights into their physiological or pathological effects on health. Here, we present NutriOmics, a nutrient knowledgebase and analytical platform hosted on an interactive web server. Leveraging transcriptome data from human, mouse, and rat curated from the Gene Expression Omnibus, we constructed a database that contains the gene signatures and pathways of individual nutrients, allowing both simple queries and more sophisticated gene overlap analysis and network-based nutrient matching for different disease conditions. We demonstrate the utility of NutriOmics in identifying shared gene targets between nutrients and diseases, thereby highlighting nutrients with potential to modify disease pathways networks. By integrating tissue- and species-specific nutrient signatures with gene networks, NutriOmics enhances our systematic understanding of how nutrients affect individual tissues and organ systems in different species and our ability to uncover data- and mechanism-driven personalized nutrition to improve health outcomes and prevent or mitigate various diseases.

BACKGROUND

- Currently no database specifically for nutrient gene signatures
- Gene Expression Omnibus (GEO) does not provide a framework for control vs. experimental tagging or clear experimental statistics such as dose, time, etc.
- No platform built to specifically compare nutrients with other differentially expressed genes (DEGs) from other sources

METHODS





Overview of currently included datasets in NutriOmics.

NUTRIENT-DISEASE GENE OVERLAP

Vitamin A (or Retinoic Acid) is known to help preserve eyesight, support growth, and maintain healthy immune function. Using genes from DisGeNET for various diseases correlated with Vitamin A, we conducted direct gene overlap with the nutrients currently in the database to validate gene overlap with existing literature.

Dry Eye (top 3 results)

Nutrient	Species	Tissue	P-Value	Jaccard Score	Odds Ratio	# DEG Overlap
Retinoic Acid	Homo sapiens	Nervous tissue	0.001017	0.002329	2.674403	20
Retinoic Acid	Rattus norvegicus	Heart	0.001614	0.004107	2.640965	20
Chitosan	Mus musculus	Immune System	0.006128	0.003347	2.287567	16

Autoimmune Diabetes (top 3 results)

Nutrient	Species	Tissue	P-Value	Jaccard Score	Odds Ratio	# DEG Overlap
Retinoic Acid	Homo sapiens	Nervous system	2.37E-06	0.004989	2.64005	43
Retinoic Acid	Mus musculus	Colon	0.000416	0.011494	3.239131	13
Chitosan	Mus musculus	Immune system	0.001679	0.007015	1.87577	34

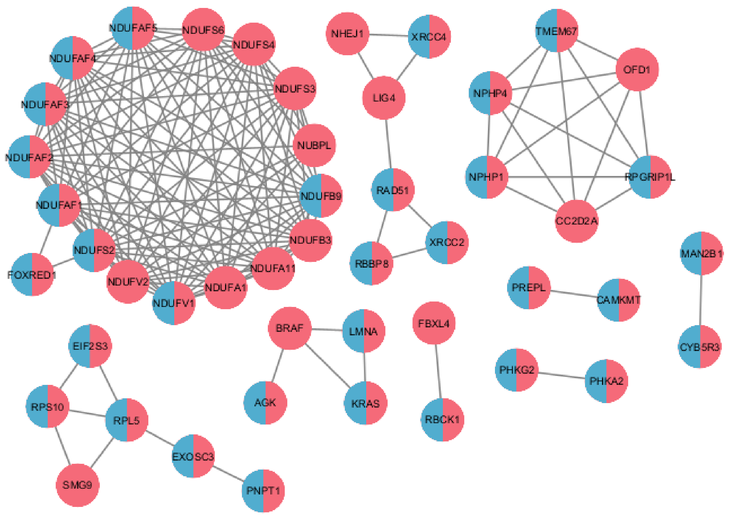
Hepatitis (top 3 results)

Nutrient	Species	Tissue	P-Value	Jaccard Score	Odds Ratio	# DEG Overlap
Retinoic Acid	Homo sapiens	Nervous system	2.60E-15	0.014305	2.620154	125
Chitosan	Mus musculus	Immune system	2.31E-11	0.021103	2.257283	106
Arginine	Homo sapiens	Eye	1.09E-8	0.013113	2.142515	88

NUTRIENT-DISEASE NETWORK OVERLAP

Growth Delay (top 3 results)

Nutrient	Species	Tissue	P-Value	Jaccard Score	Odds Ratio	# DEG Overlap
Arginine	Homo sapiens	Eye	6.21E-18	0.011086	4.243978	73
Retinoic Acid	Homo sapiens	Nervous system	4.75E-12	0.008557	3.092188	74
Retinoic Acid	Mus musculus	Embryonic Stem Cells	1.89E-05	0.009358	2.092772	51



Network overlap of retinoic acid DEGs and growth delay DEGS.

Our analysis shows results consistent with established scientific literature about Vitamin A. Significant gene overlap was found between retinoic acid and dry eye, autoimmune diabetes, and growth delay. Further investigation of the gene network overlap between vitamin A and growth delay revealed a strong overlap, further demonstrating a strong connection between Vitamin A and growth delay.

FUTURE WORK

- Adding datasets for different diets (western, chow, fructose, high fat high sucrose, etc.)
- More datasets across more tissues and nutrients, such as more vitamins (Bs, C, K, etc.) and minerals (calcium, sodium, potassium, etc.)
- More datasets with a focus on non-human primates
- Integration into other -omics datasets curated at the Yang Lab (Pharmomics and Toxiomics)