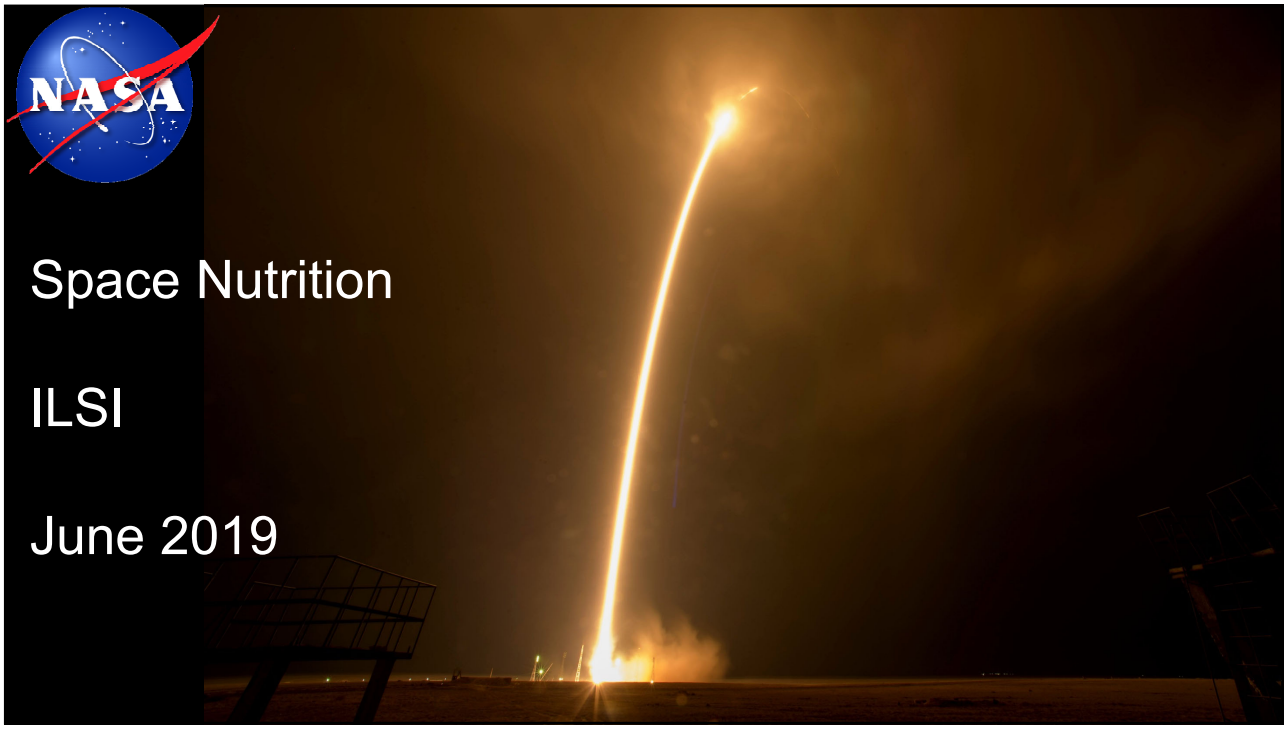
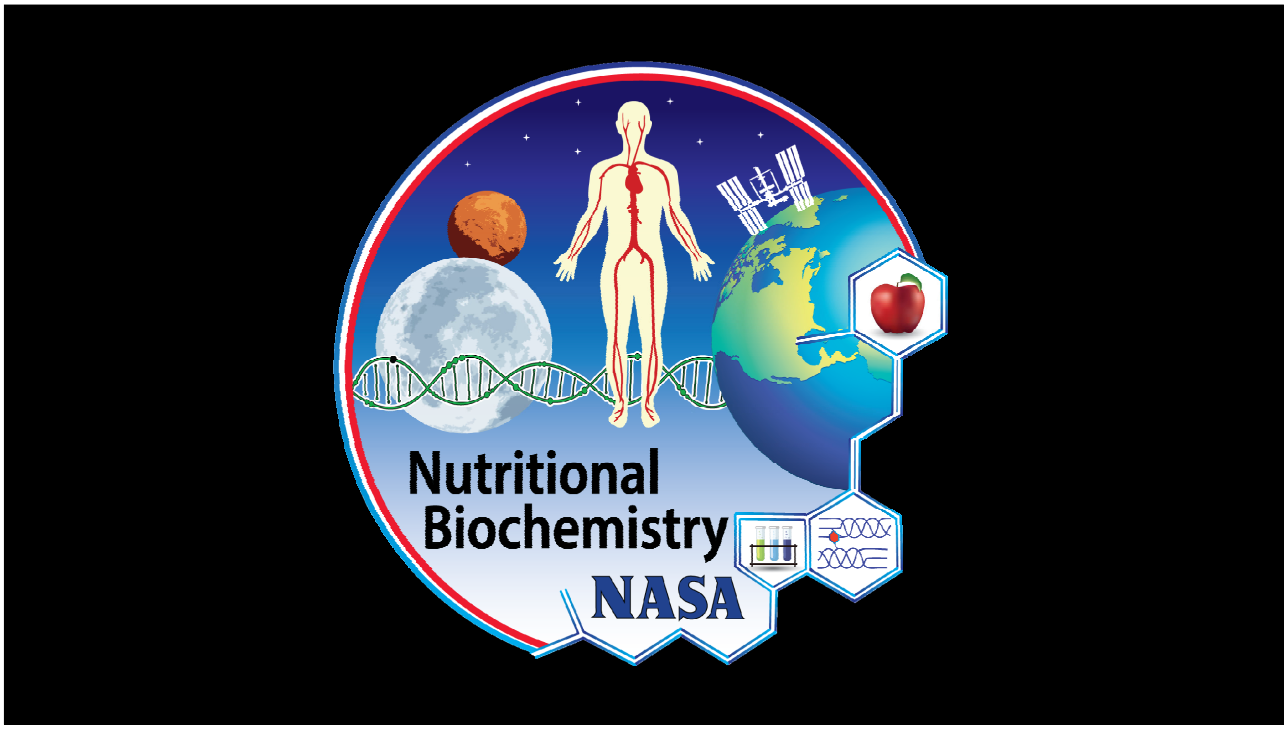
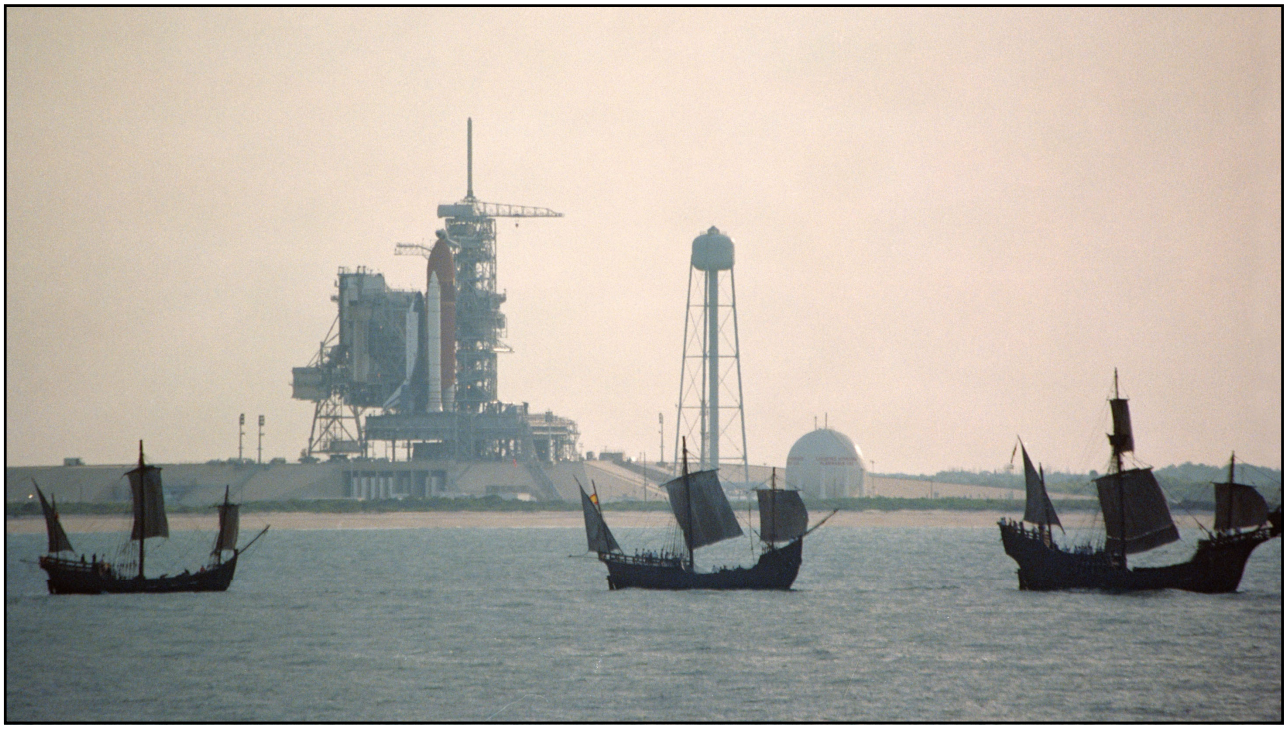


Space Nutrition

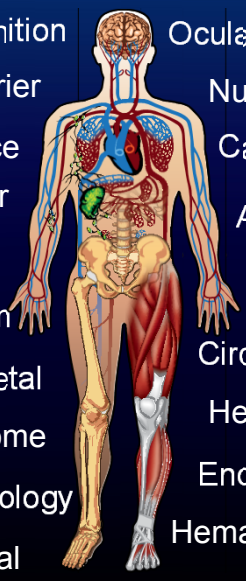
ILSI

June 2019


Nutritional
Biochemistry
NASA



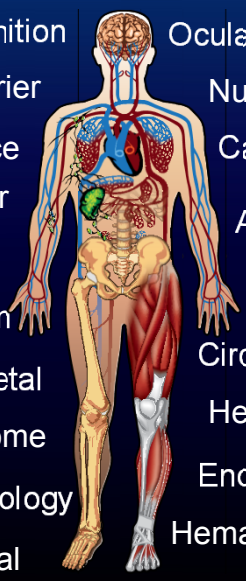
Nutrition and Exploration Systems Biology



Genome
Cognition
Ocular
Blood-brain barrier
Nutrient Requirements
Performance
Cardiovascular
Neurovestibular
Antioxidant Protection
Immune
Sleep
Stress and inflammation
Circadian rhythm
Musculoskeletal
Hepatic
Microbiome
Endocrinology
Pharmacology
Hematology
Renal

Radiation
Microgravity
Confinement
Isolation
Food (and H_2O) System
Waste System
Environment
Partial Gravity

Nutrition and Disease



Genome
Cognition
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Circadian rhythm
Musculoskeletal
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Pharmacology
Hematology
Renal

Cancer
Dementia
Neuropathy
Osteoporosis
Cataracts
Atherosclerosis
Stroke
Sarcopenia

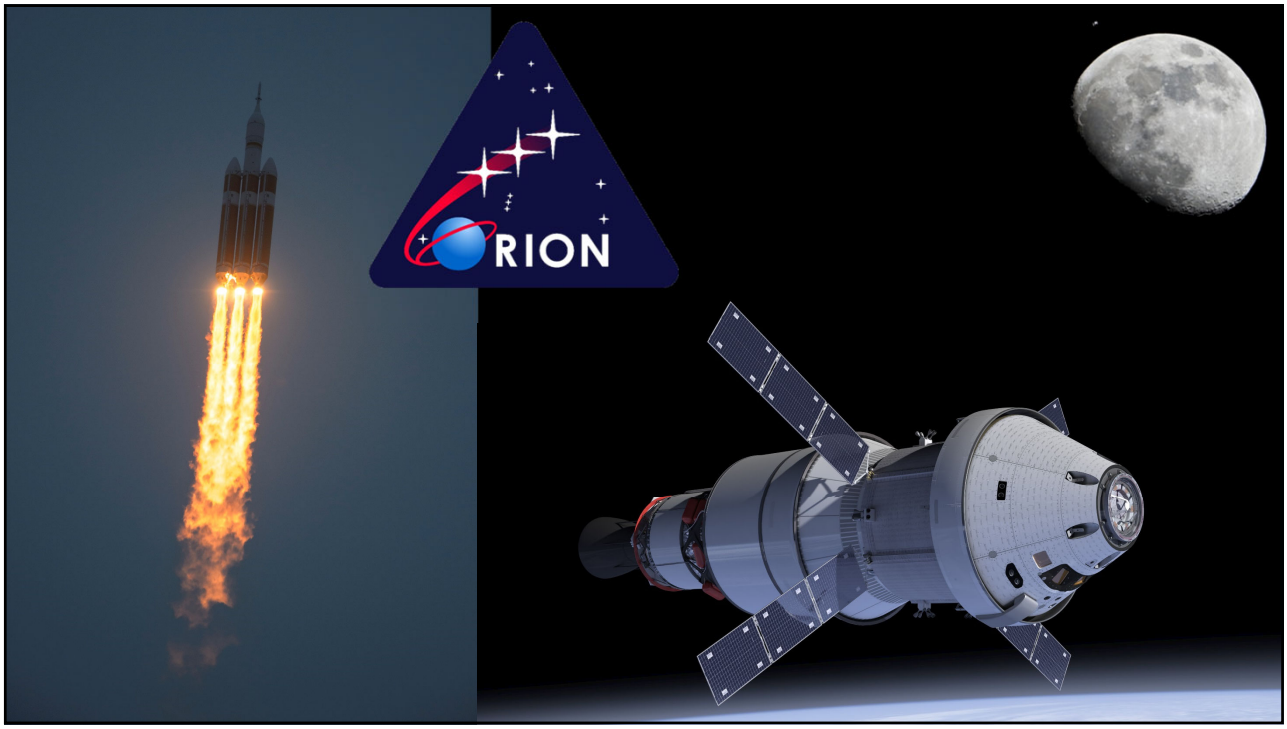
Operations

Clinical Nutritional Assessment

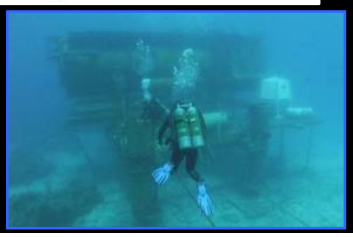
- Biochemical testing (pre, postflight)
- Crew briefings
- Inflight food intake and body mass

FMC Dietitian Consult

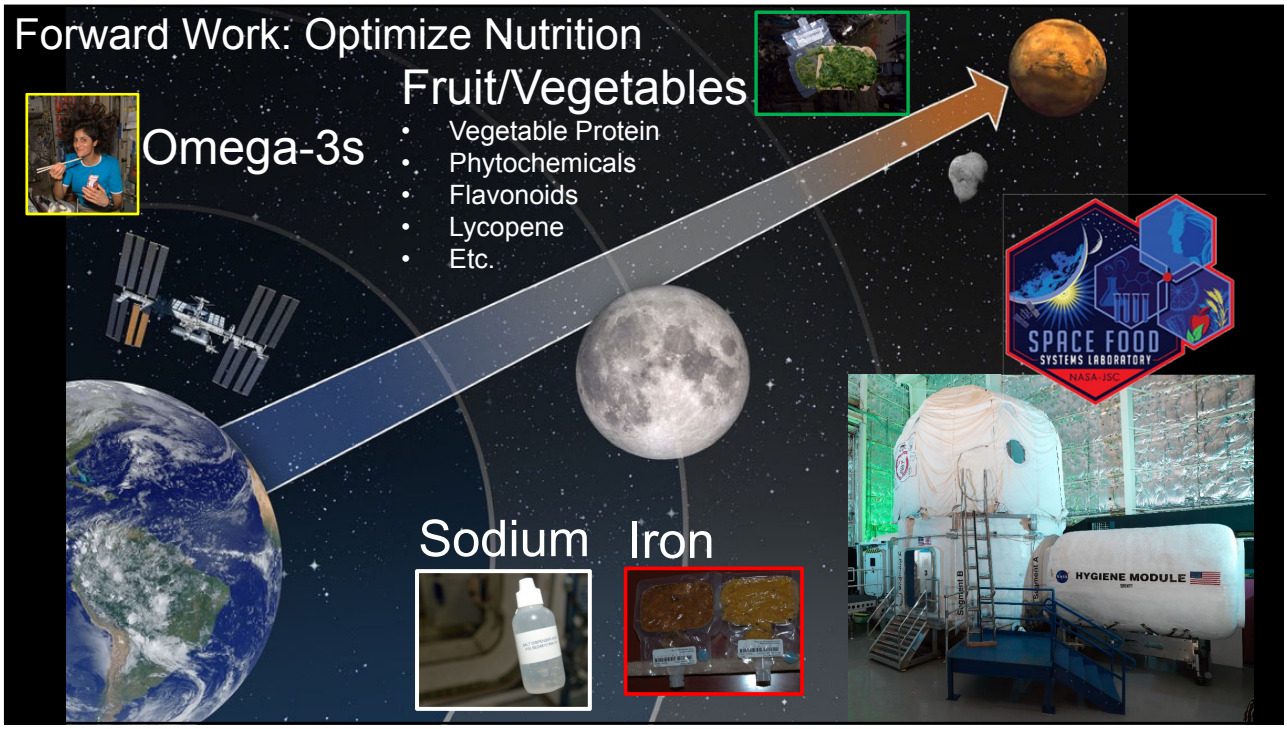
Nutrition requirements input (programs, vehicles, suits, etc.)

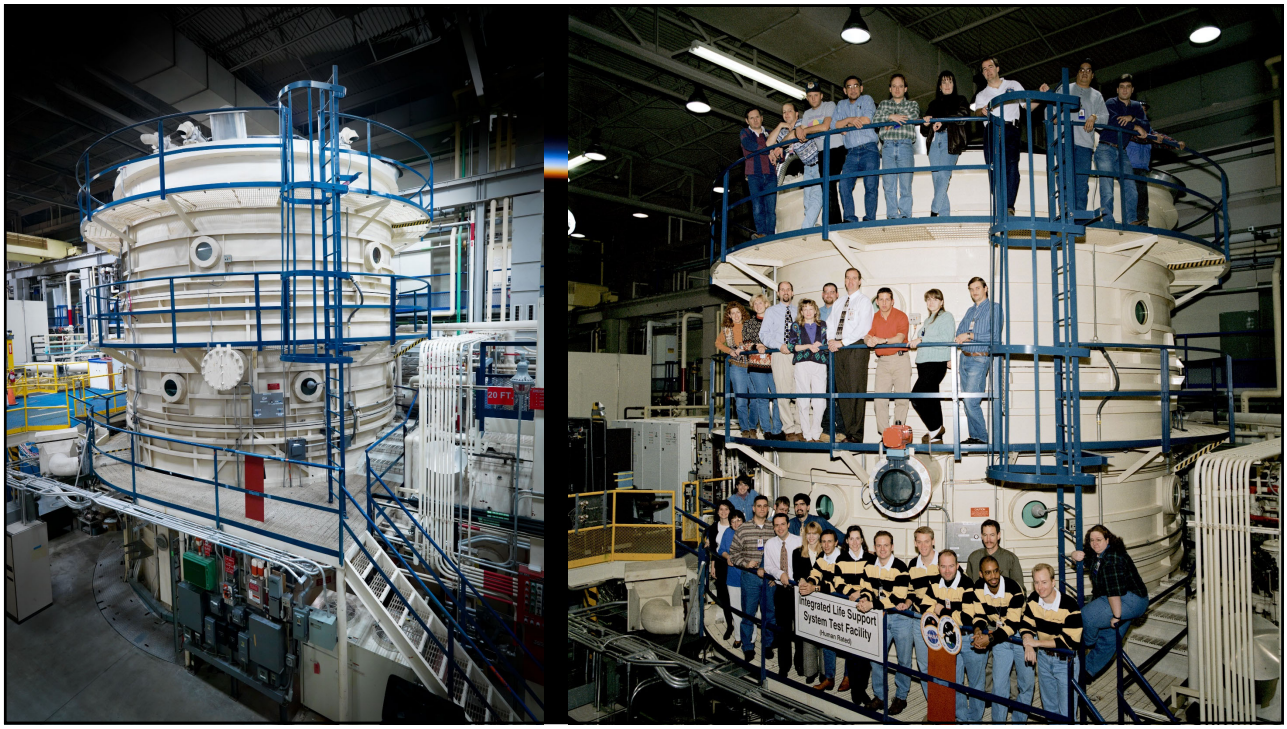


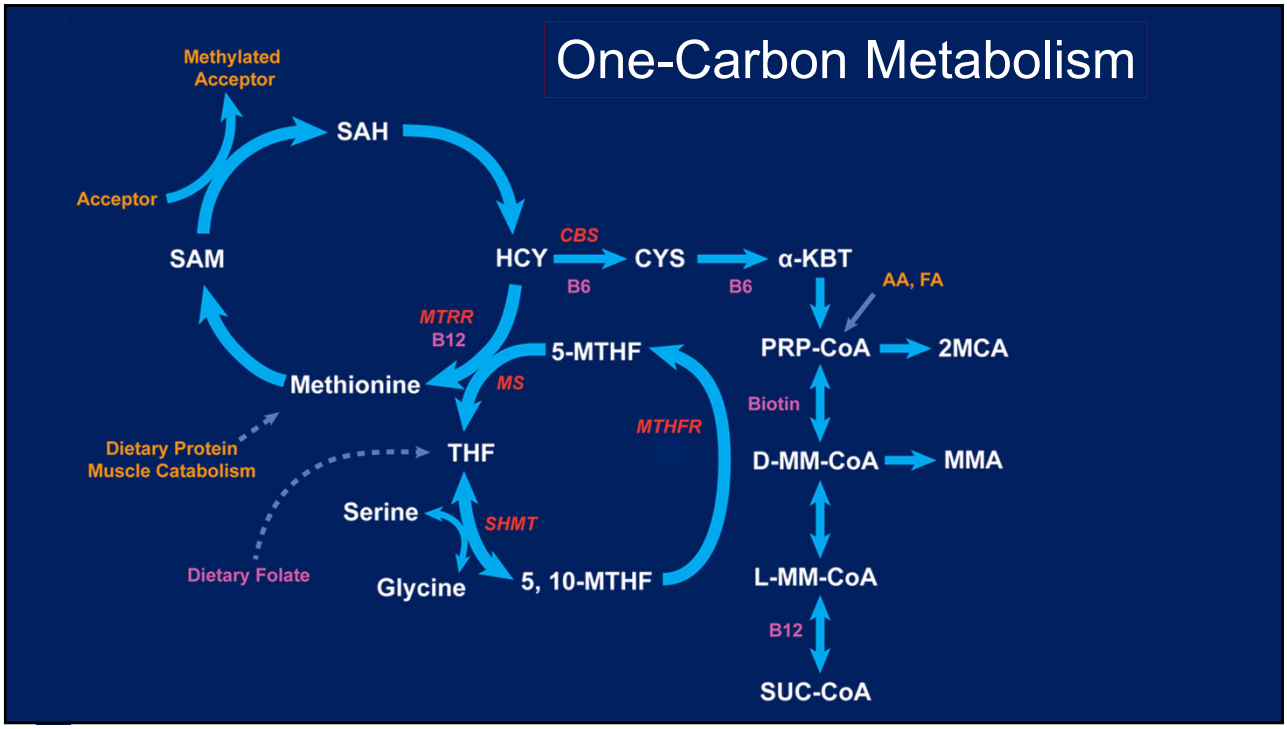
Research
Ground Analogs



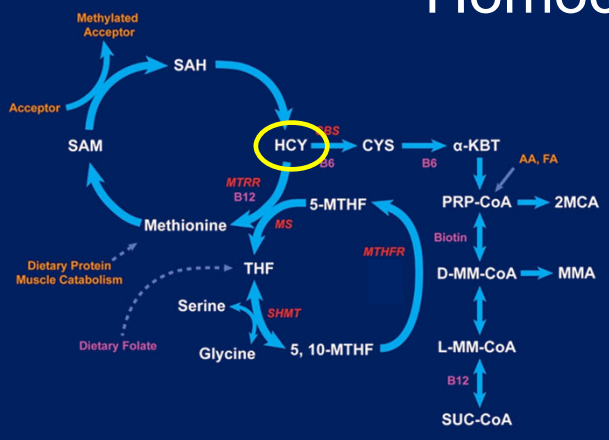
Flight Research

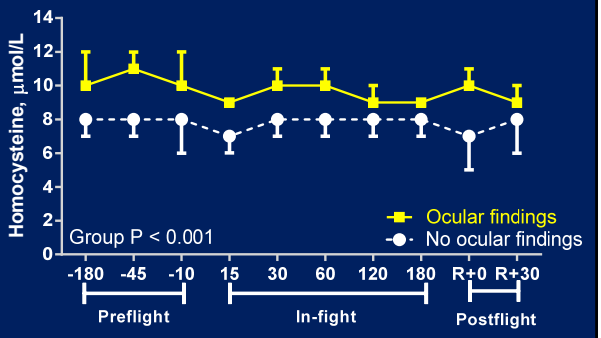

Forward Work: Optimize Nutrition
Fruit/Vegetables
Omega-3s
• Vegetable Protein
• Phytochemicals
• Flavonoids
• Lycopene
• Etc.
SPACE FOOD
SYSTEMS LABORATORY
NASA-JSC
Sodium
Iron
HYGIENE MODULE


Integrated Life Support
System Test Facility


One-Carbon Metabolism
Methylated Acceptor
SAH
Acceptor
SAM
HCY
CBS
B6
CYS
B6
α-KBT
AA, FA
PRP-CoA
2MCA
MTRR
B12
5-MTHF
MS
Methionine
Biotin
MTHFR
Dietary Protein Muscle Catabolism
THF
D-MM-CoA
MMA
Serine
SHMT
Dietary Folate
Glycine
5, 10-MTHF
L-MM-CoA
B12
SUC-CoA

Homocysteine

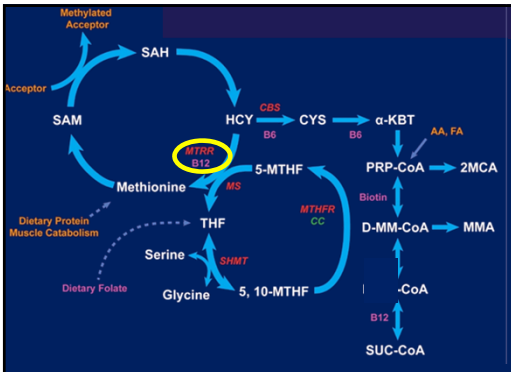


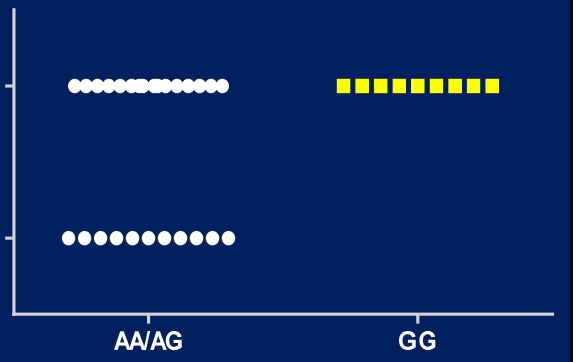


Astronauts with vision issues had higher serum homocysteine concentration than astronauts without vision issues. *Before* flight.

Zwart et al., J Nutr, 2012

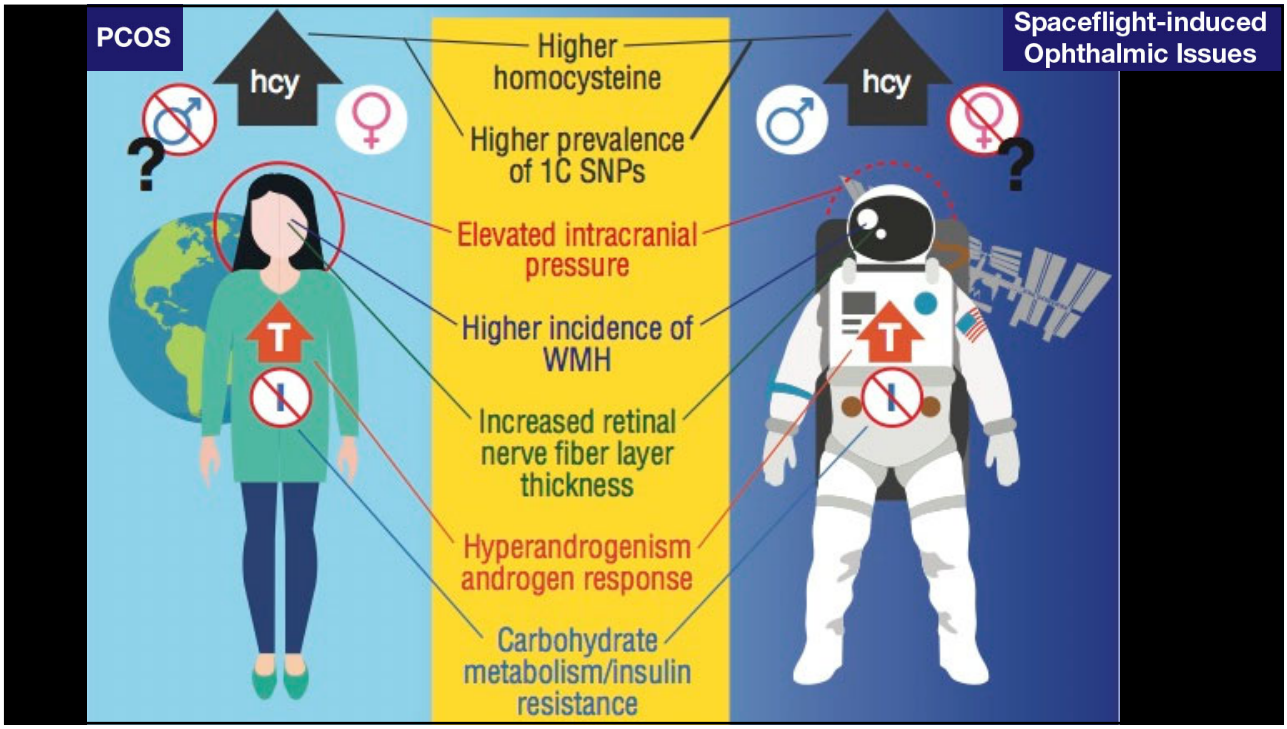
MTRR A66G



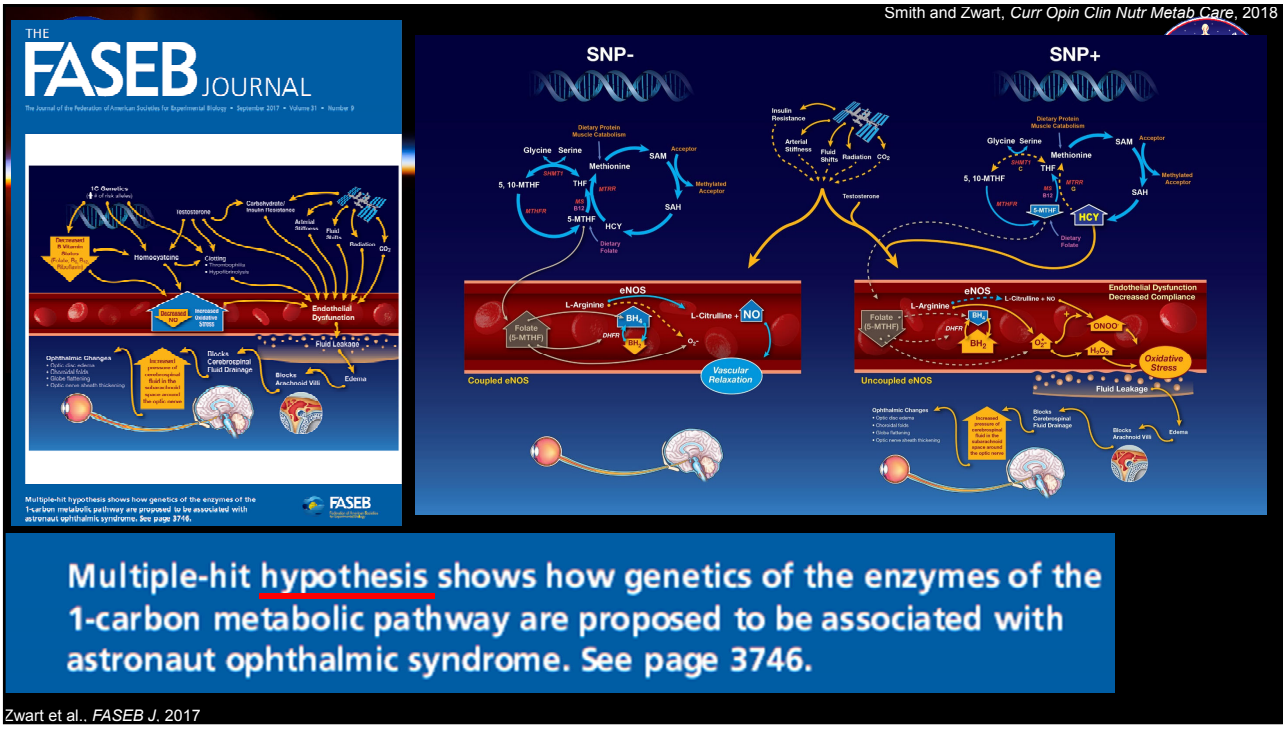


- Every astronaut with the minor form of the MTRR SNP developed some ocular issue.
- But not every astronaut with some ocular issue had this form of the SNP.

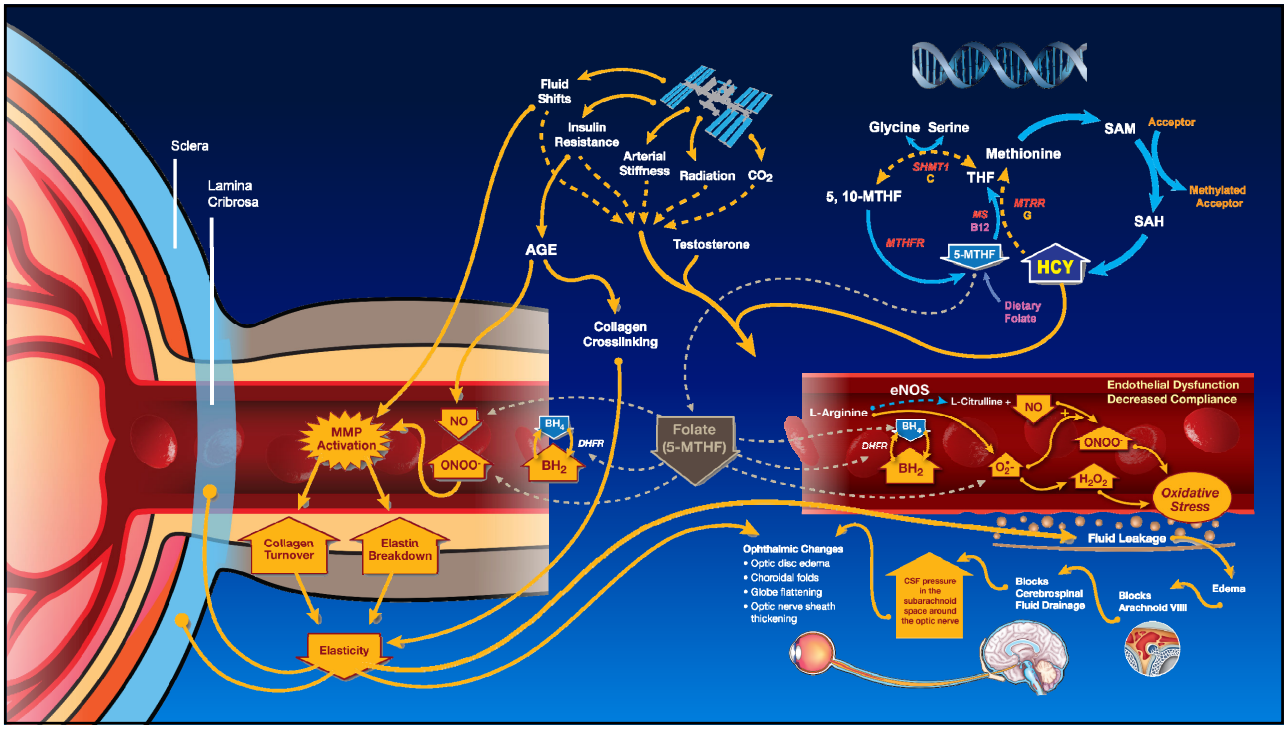
SNP = Single Nucleotide Polymorphism
MTRR = Methionine Synthase Reductase

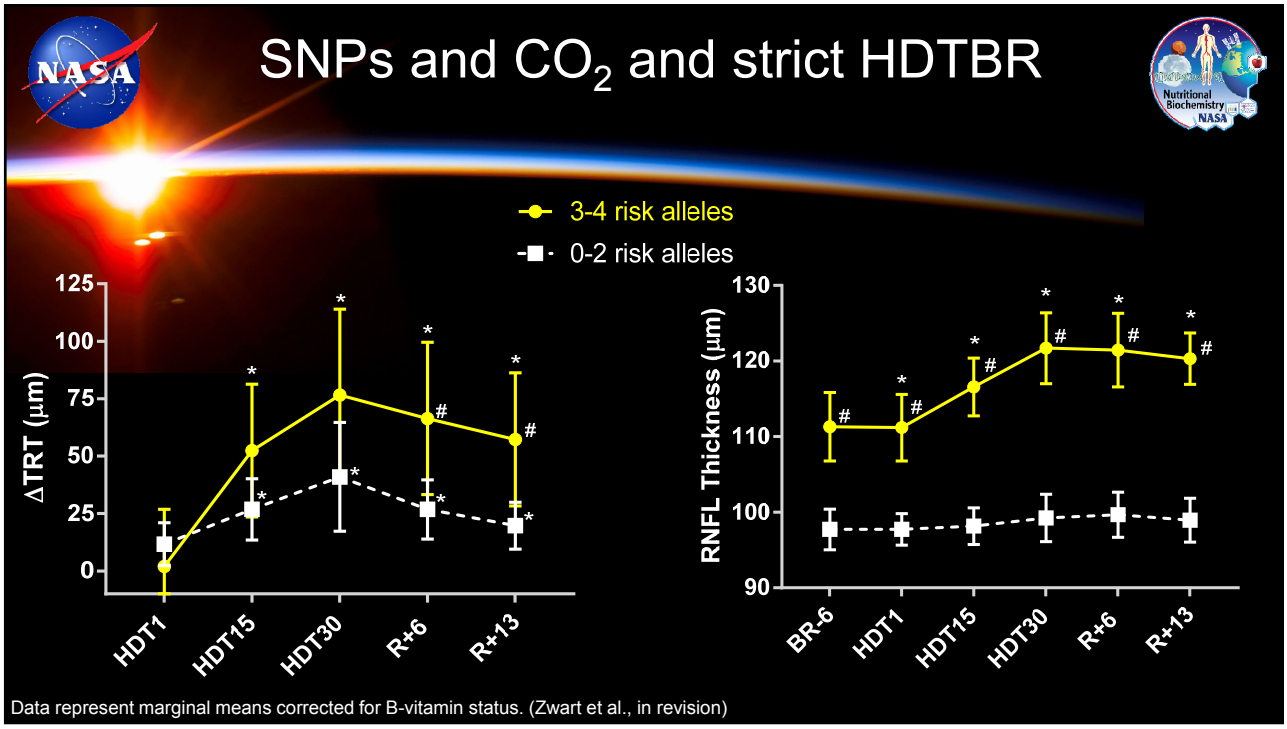


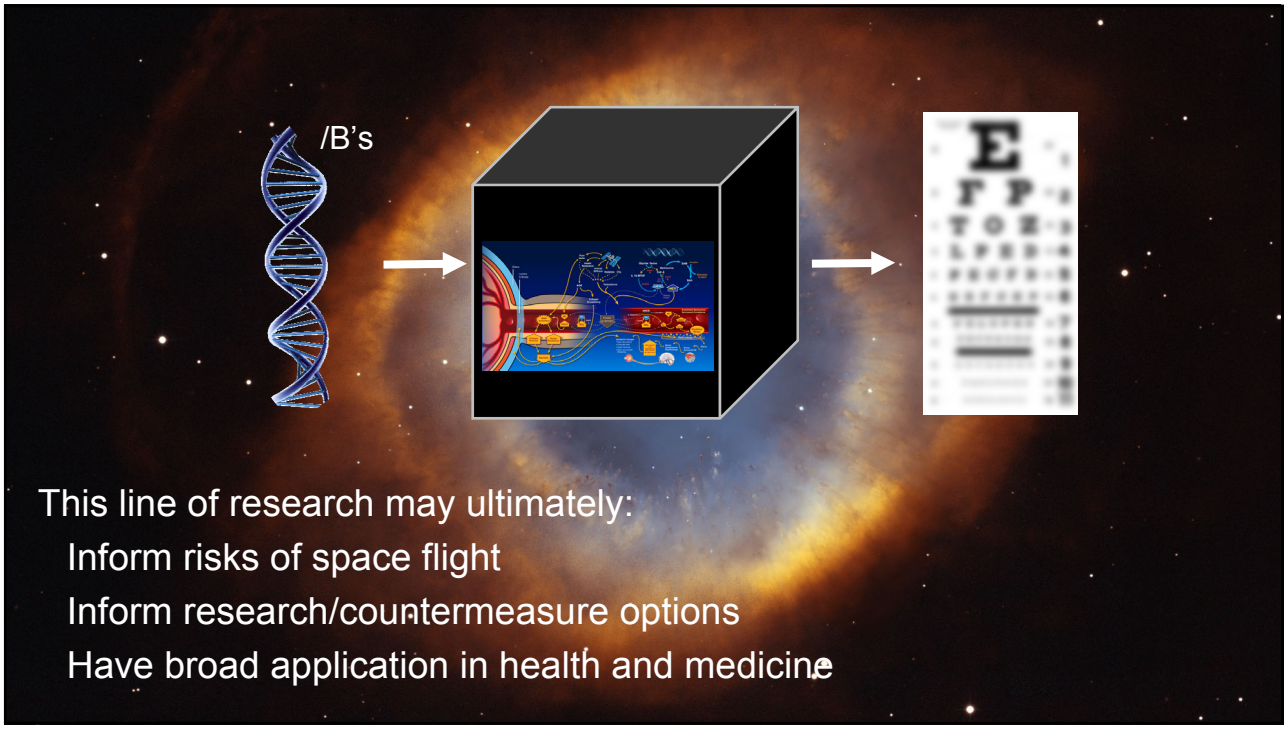
Smith and Zwart, *Curr Opin Clin Nutr Metab Care*, 2018



Zwart et al., *FASEB J.* 2017

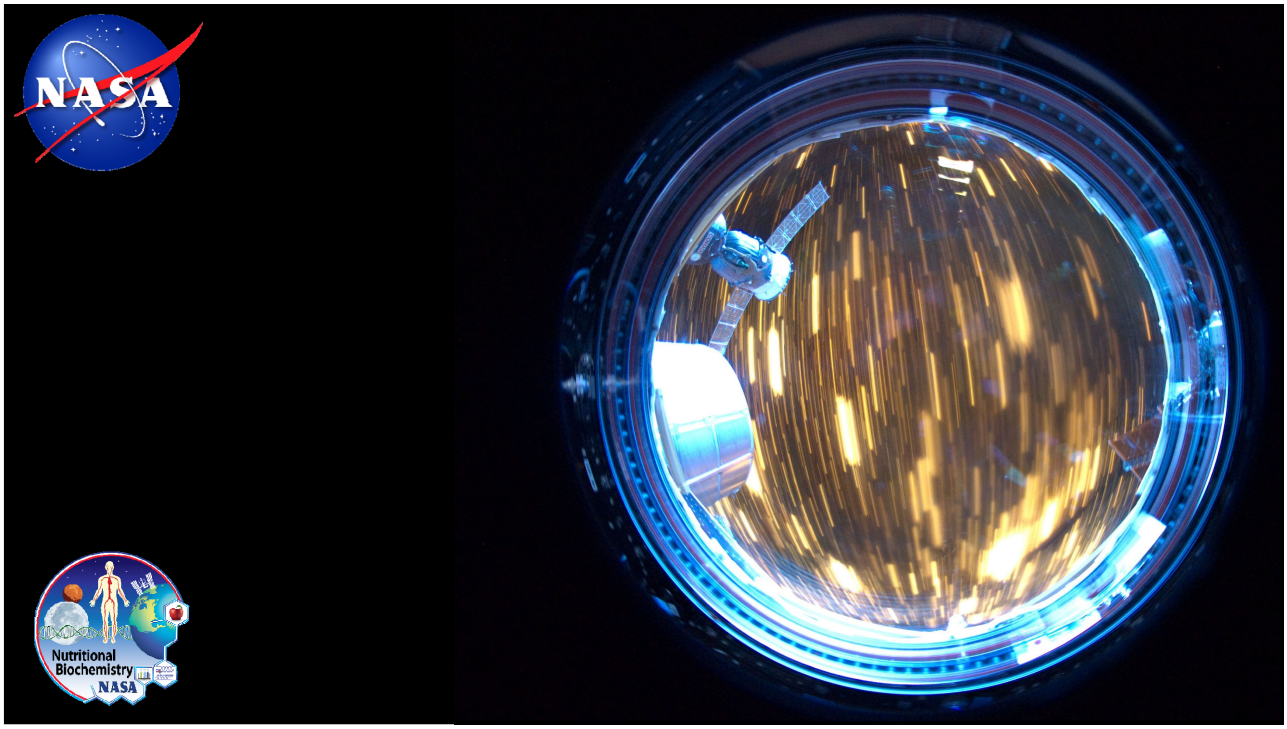

Sclera
Lamina Cribrosa
Fluid Shifts
Insulin Resistance
Arterial Stiffness
Radiation
CO_2
AGE
Testosterone
Collagen Crosslinking
Glycine
Serine
Methionine
SAM
Acceptor
Methylated Acceptor
SAH
THF
5, 10-MTHF
5-MTHF
HCY
Dietary Folate
MMP Activation
NO
ONOO⁻
BH_4
BH_2
DHFR
Folate (5-MTHF)
Collagen Turnover
Elastin Breakdown
Elasticity
eNOS
L-Arginine
L-Citrulline +
O_2^-
H_2O_2
Oxidative Stress
Endothelial Dysfunction
Decreased Compliance
Fluid Leakage
Ophthalmic Changes
• Optic disc edema
• Choroidal folds
• Globe flattening
• Optic nerve sheath thickening
CSF pressure in the subarachnoid space around the optic nerve
Blocks Cerebrospinal Fluid Drainage
Blocks Arachnoid VIII
Edema


SNPs and CO_2 and strict HDTBR
Nutritional Biochemistry
NASA
3-4 risk alleles
0-2 risk alleles
ΔTRT (μm)
125
100
75
50
25
0
HDT1
HDT15
HDT30
R+6
R+13
RNFL Thickness (μm)
130
120
110
100
90
BR-6
HDT1
HDT15
HDT30
R+6
R+13
Data represent marginal means corrected for B-vitamin status. (Zwart et al., in revision)



This line of research may ultimately:

- Inform risks of space flight
- Inform research/countermeasure options
- Have broad application in health and medicine


NASA
Nutritional Biochemistry
NASA