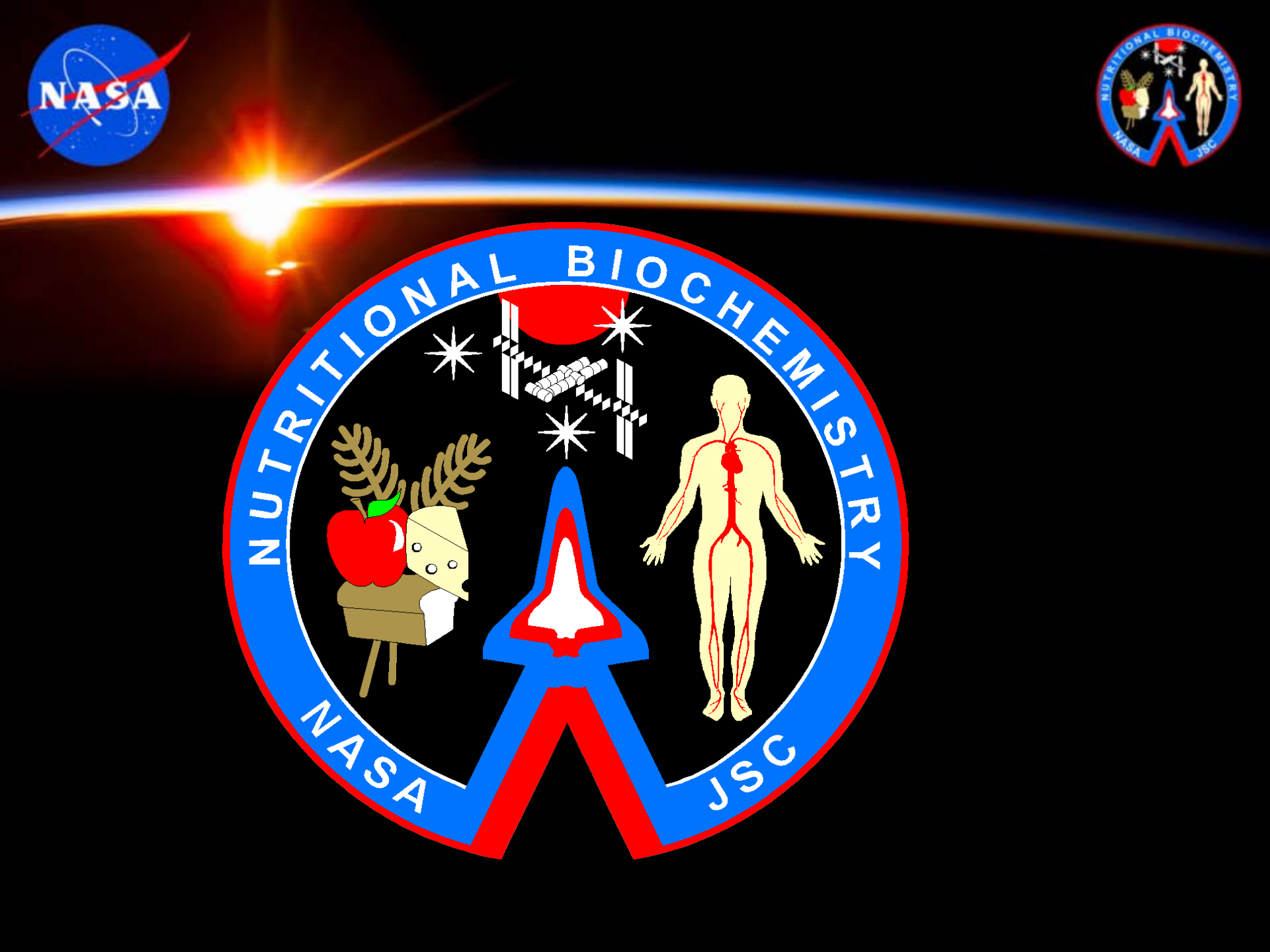
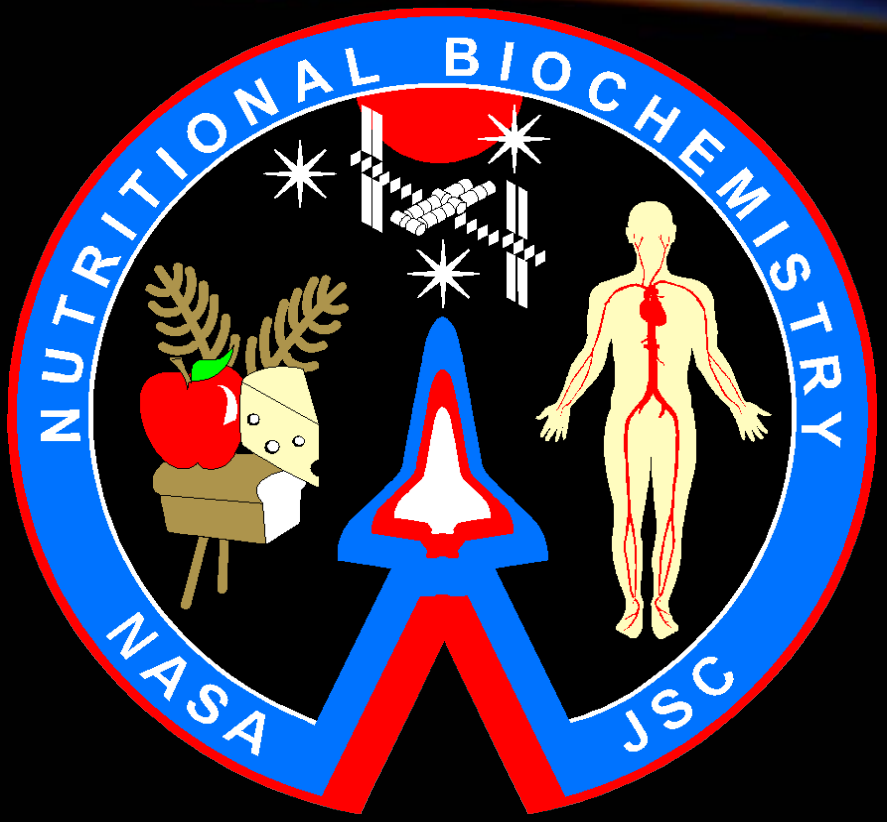

NUTRITIONAL BIOCHEMISTRY
NASA
JSC

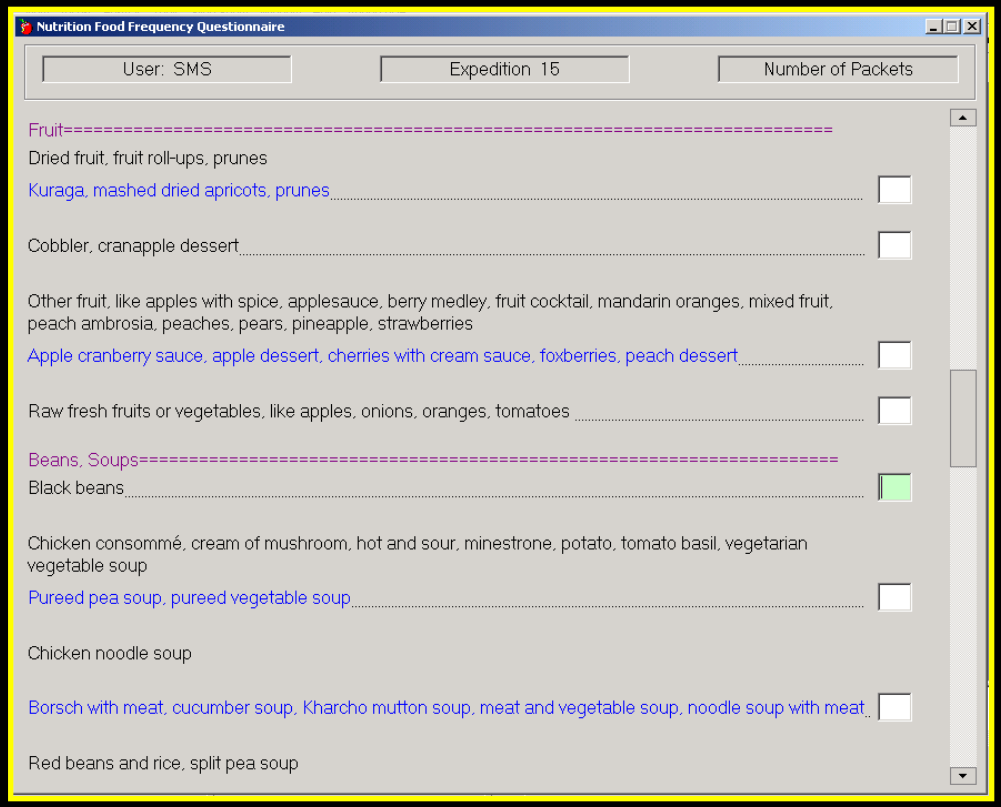
Operations
Research
- Flight
- Ground

Service
Education/Outreach



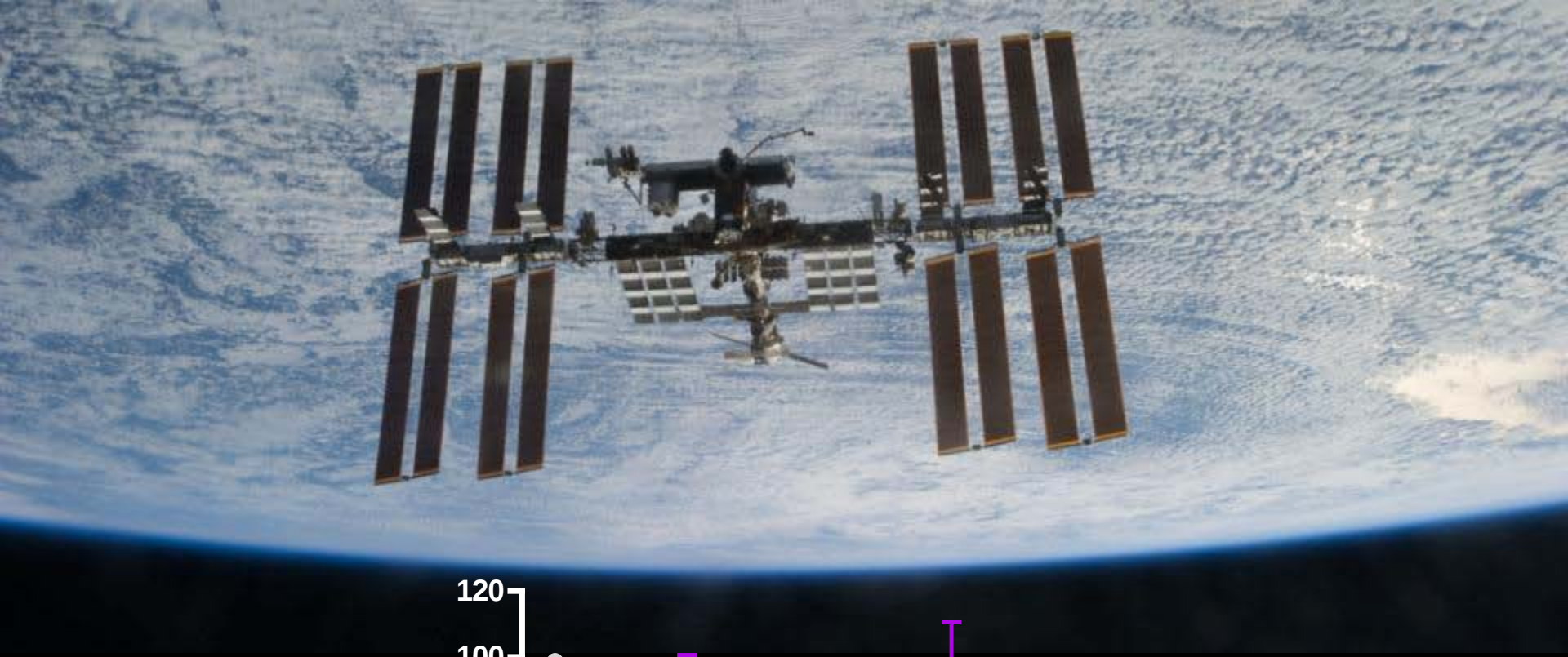
Clinical Nutritional Assessment (MedB8.1)

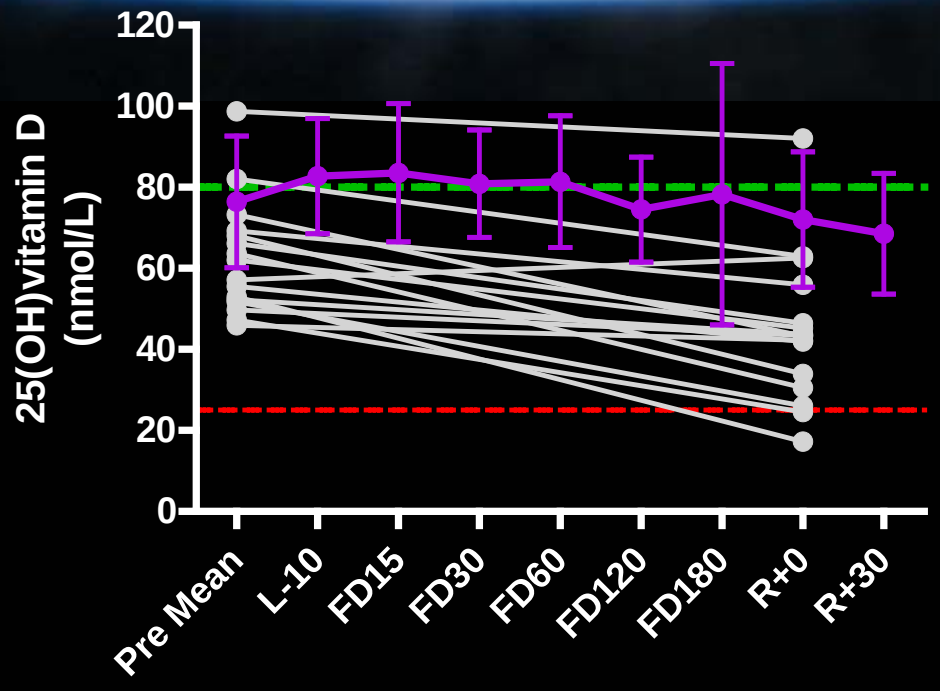
Preflight
Inflight
Postflight



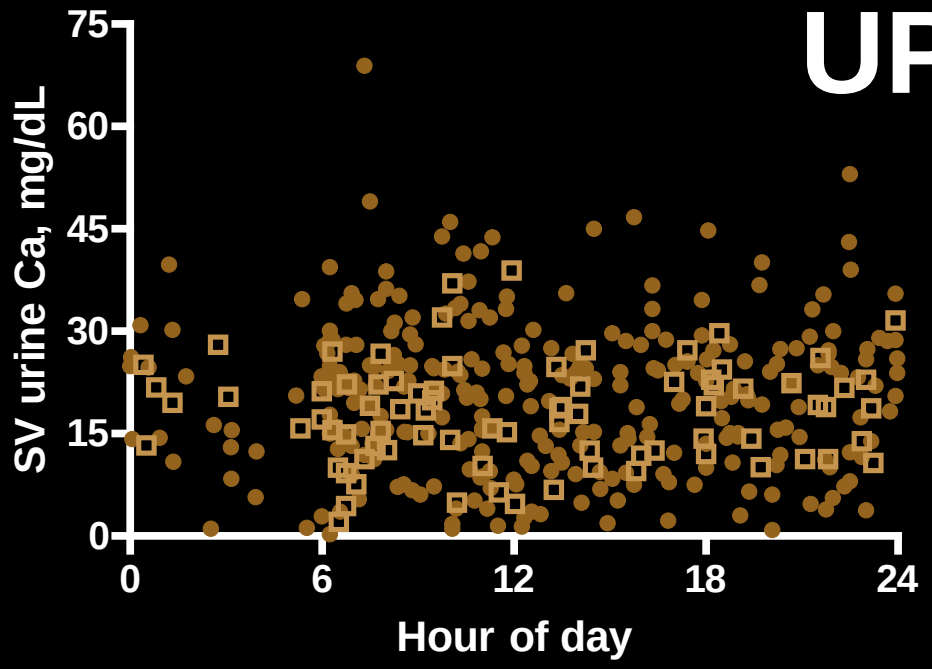
Nutrition SMO

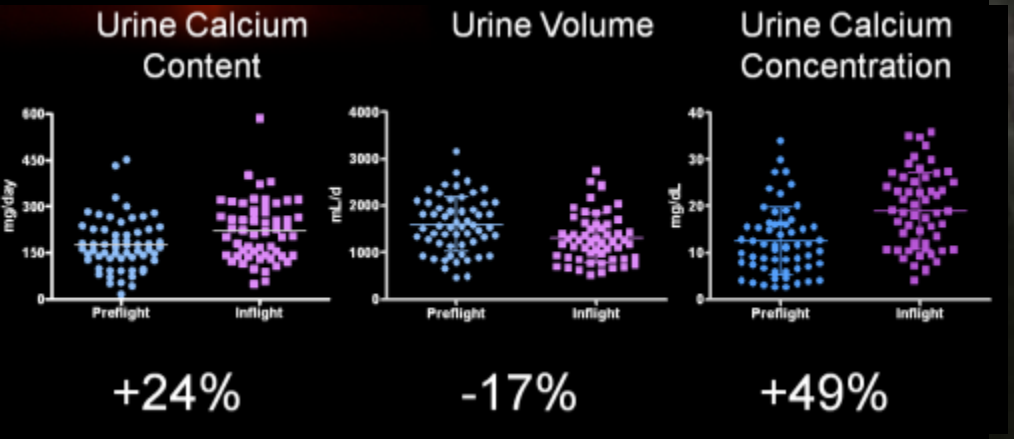
Extend MedB 8.1
Inflight Collections
CM evaluation



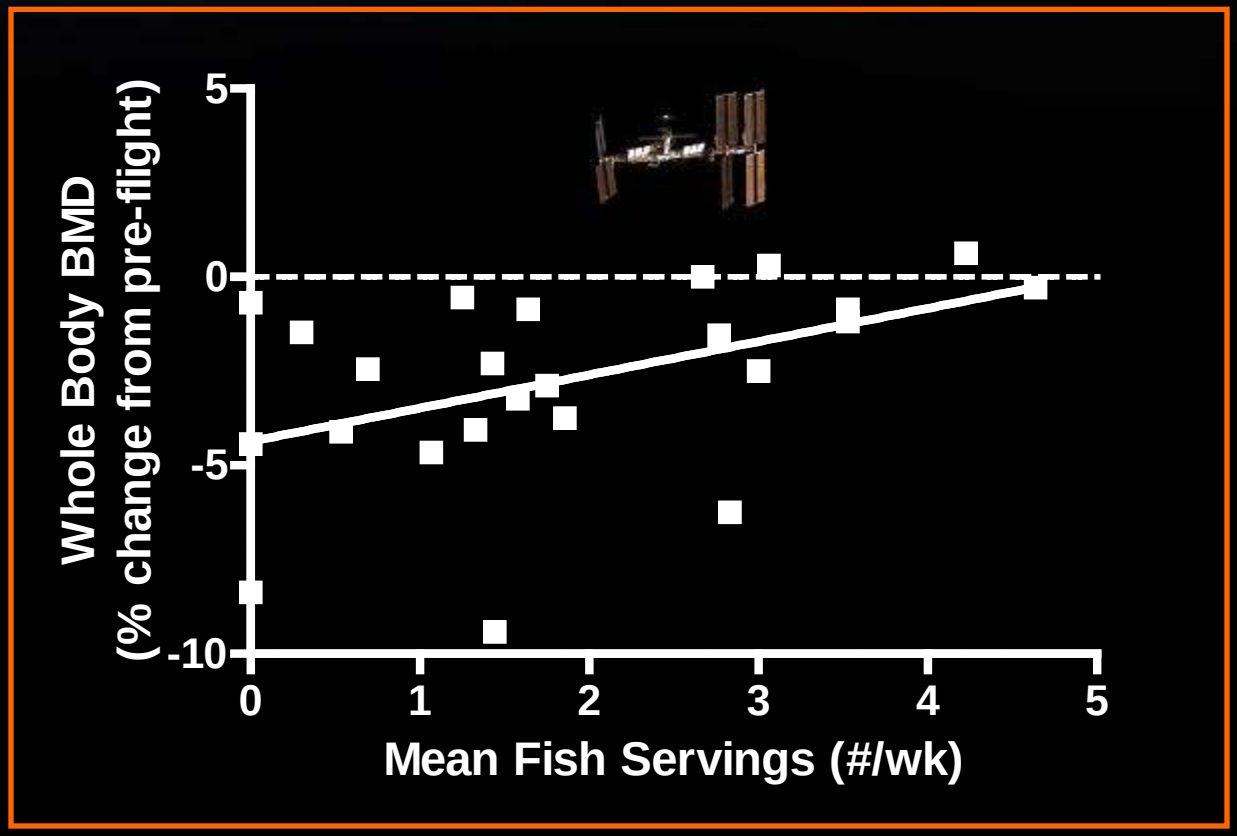

25(OH)vitamin D
(nmol/L)
120
100
80
60
40
20
0
Pre Mean
L-10
FD15
FD30
FD60
FD120
FD180
R+0
R+30

UPA


SV urine Ca, mg/dL
75
60
45
30
15
0
0
6
12
18
24
Hour of day


Urine Calcium Content
Urine Volume
Urine Calcium Concentration
mg/day
mL/d
mg/dL
Preflight
Inflight
Preflight
Inflight
Preflight
Inflight
+24%
-17%
+49%

Omega-3 Fatty Acids

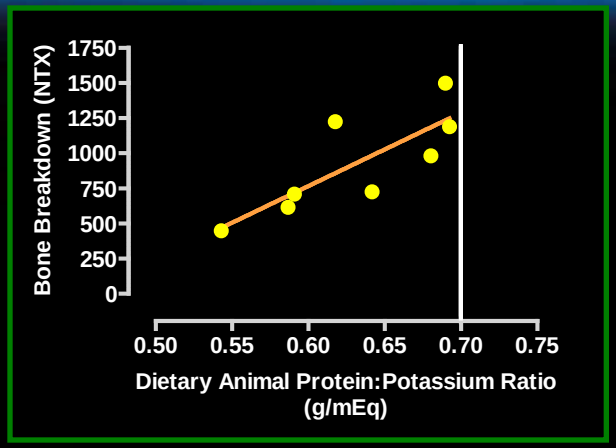


Fish intake may mitigate bone and muscle loss, cardiovascular, and cancer risks.

Vitamin K

Vitamin K status does not appear affected by spaceflight (or bed rest).

Pro K



Preflight

Inflight

L-180	L-45	FD15	FD30	FD60	FD120	FD180
4-d High APro:K	4-d Low APro:K	4-d Low APro:K	4-d Monitored	4-d Low APro:K	4-d High APro:K	4-d High APro:K

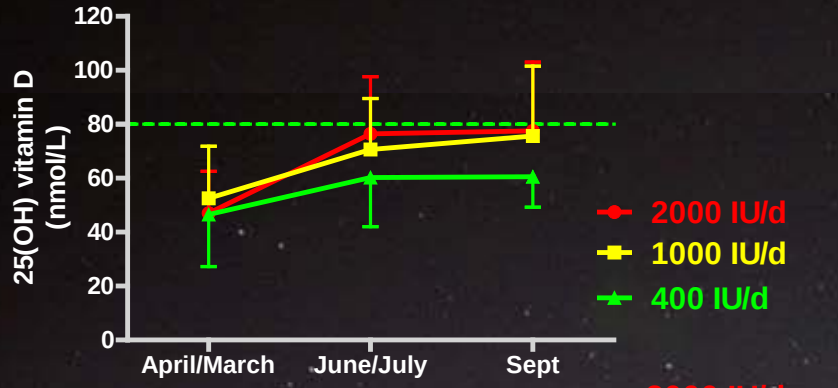
Postflight

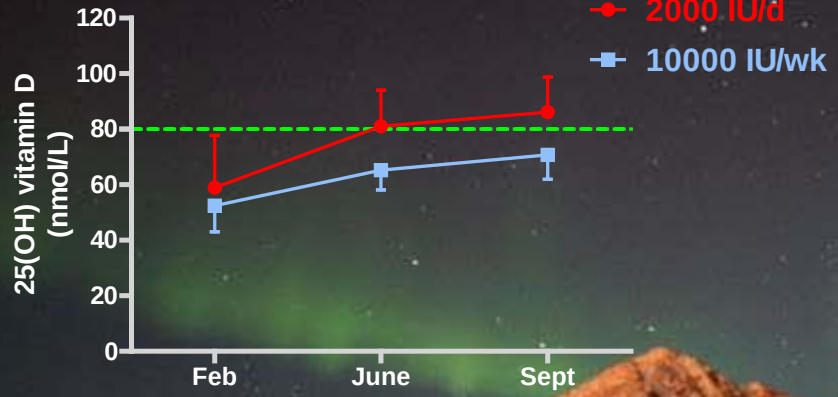
R+30	R+180	R+365
4-d Monitored	4-d Monitored	4-d Monitored

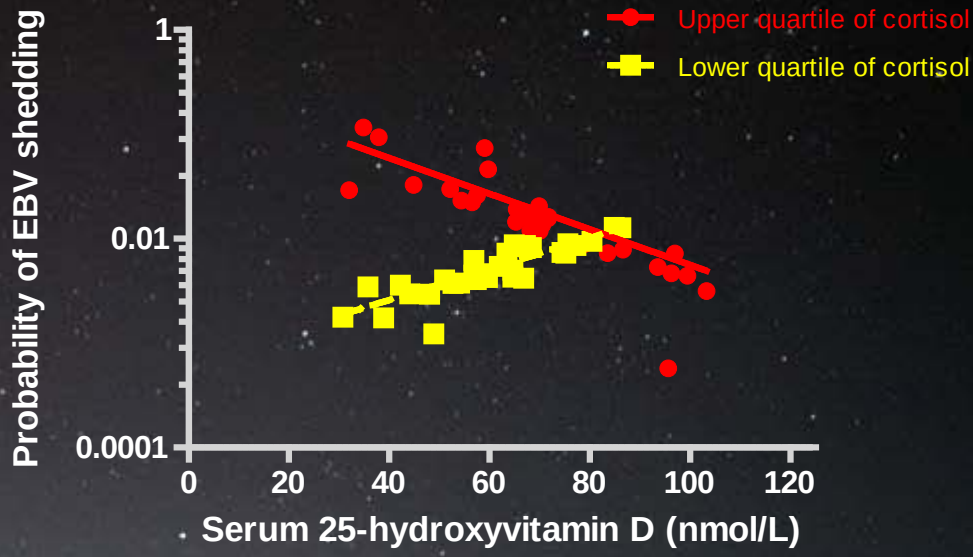
NOTE: the low ratio diet is **NOT** low protein, and **NOT** vegetarian

Diets are designed to maintain: energy, protein, calcium, sodium

Vitamin D



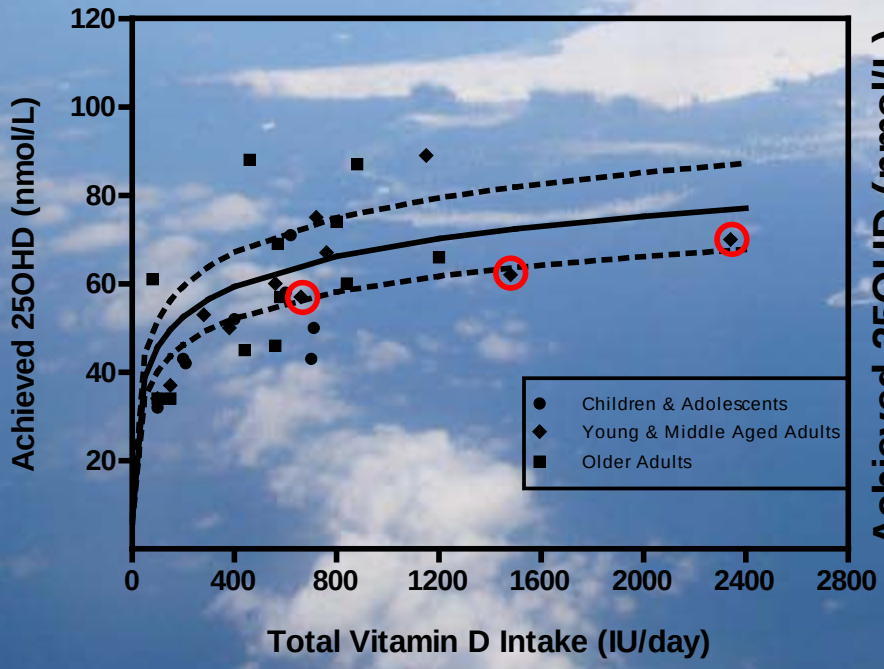


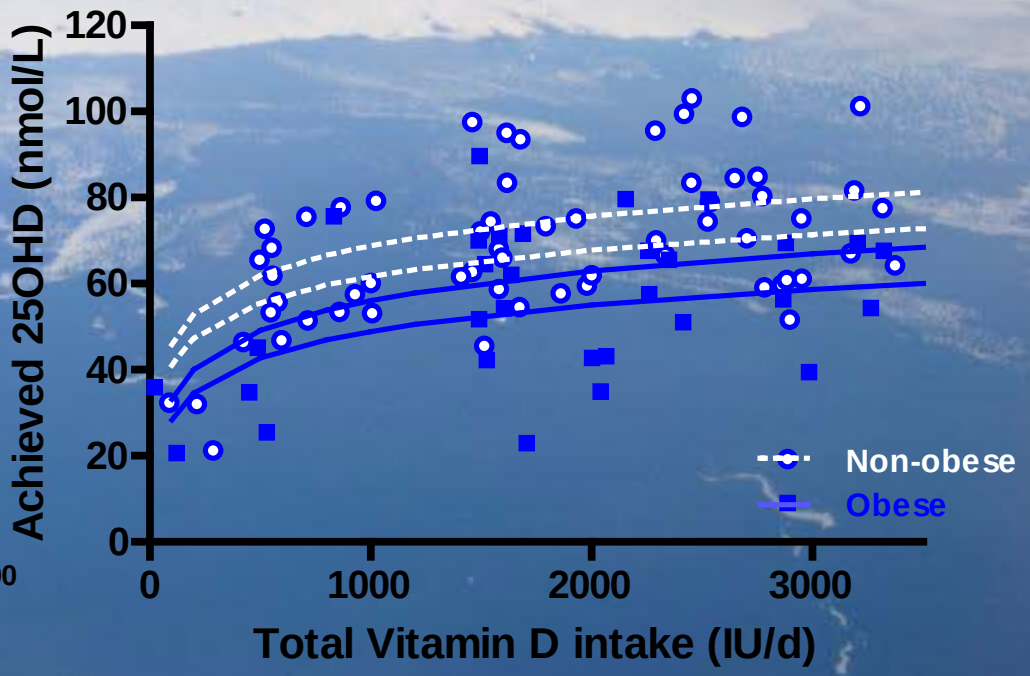


800 IU Vitamin D/day maintains vitamin D status during flight.
In Antarctic analog: Vitamin D, stress, and viral reactivation are interrelated.

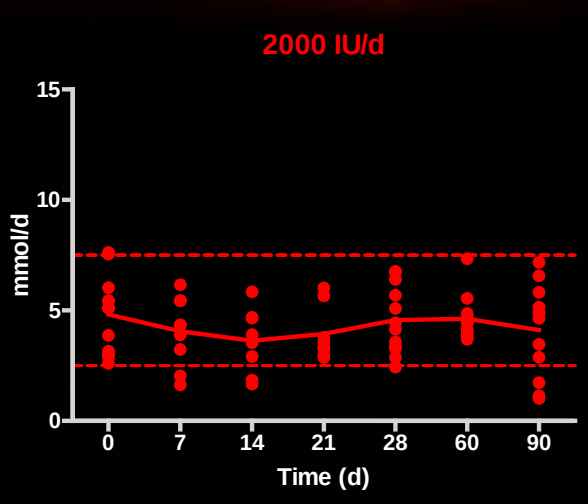
Vitamin D

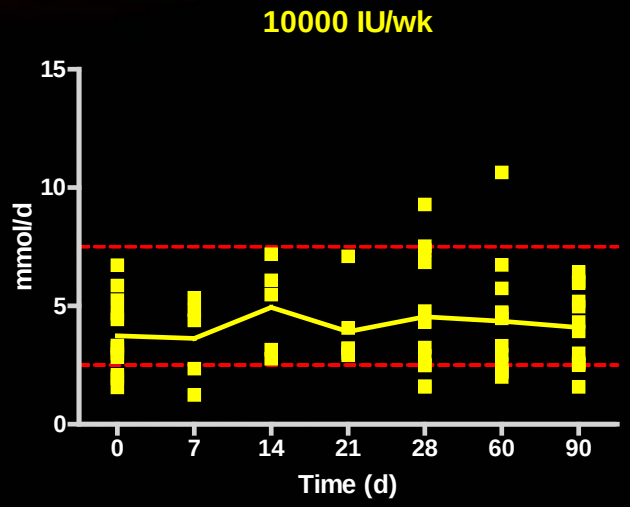
2011 Dietary Reference Intakes

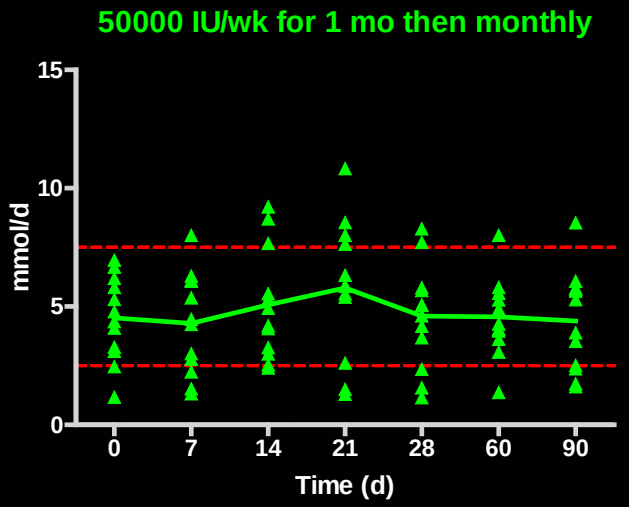




Vitamin D Dosing Study



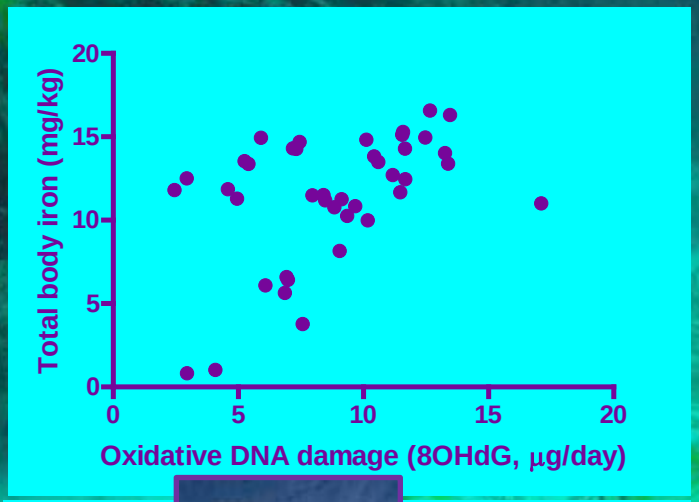


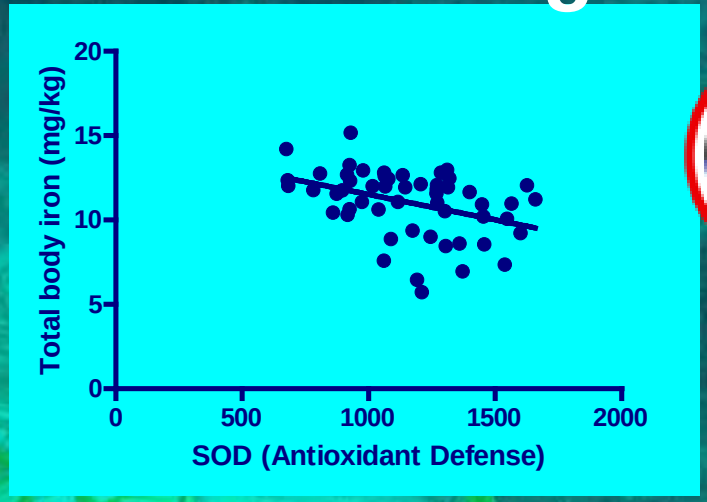


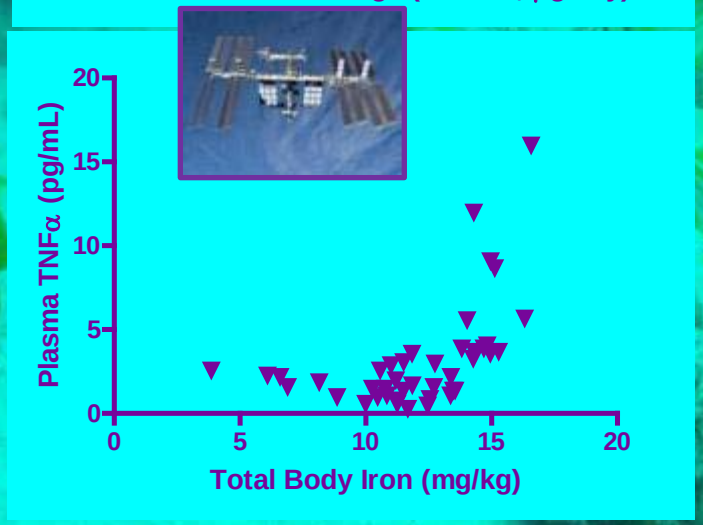
Increased urinary calcium is more often observed at higher vitamin D doses.

Iron

Inflammation/Oxidative Damage

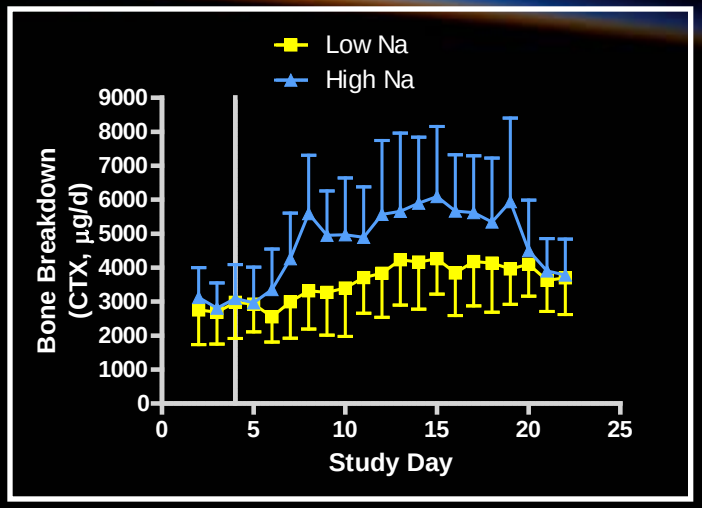


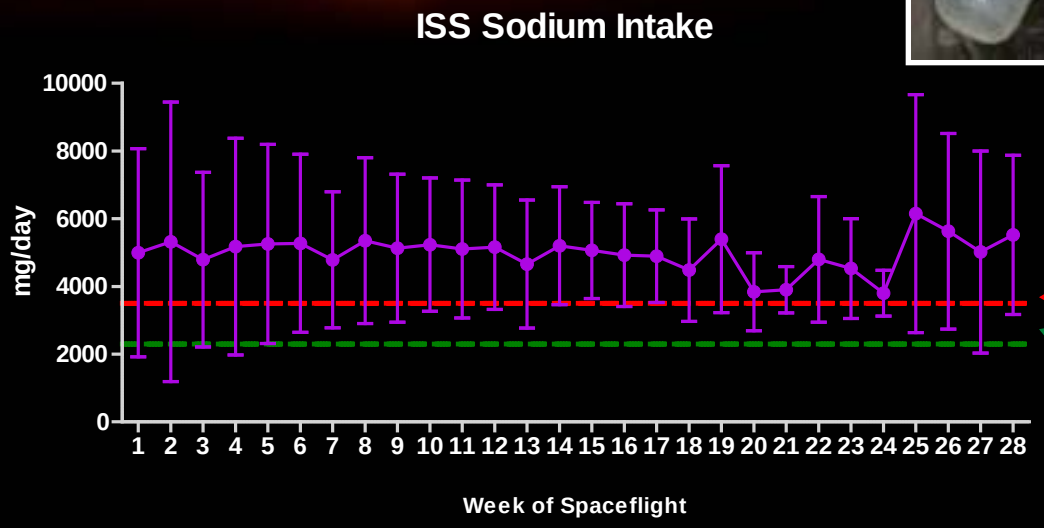




Gaps remain in our understanding the interrelationships of iron, oxidative damage, immune function, and radiation.

Sodium

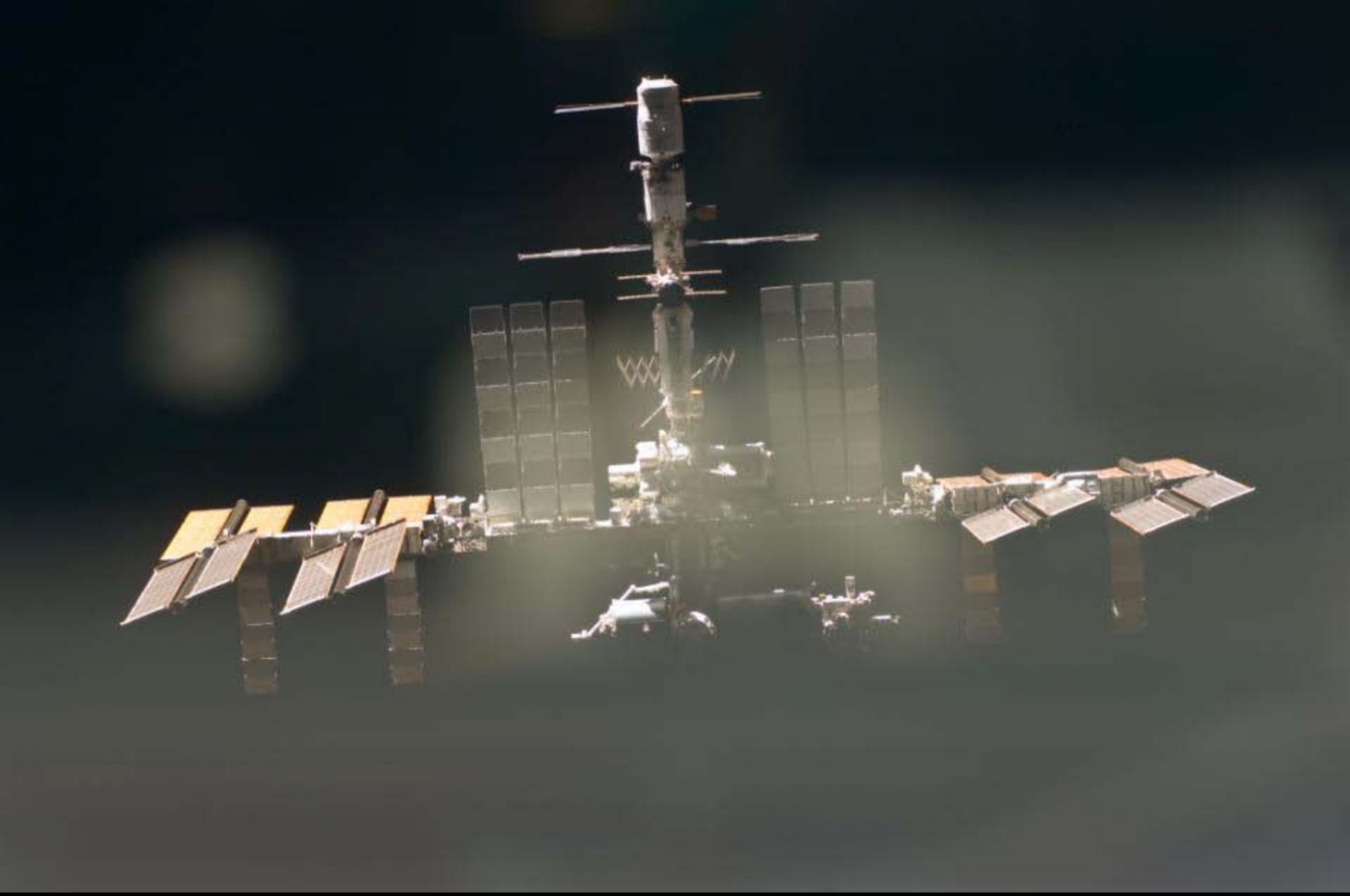




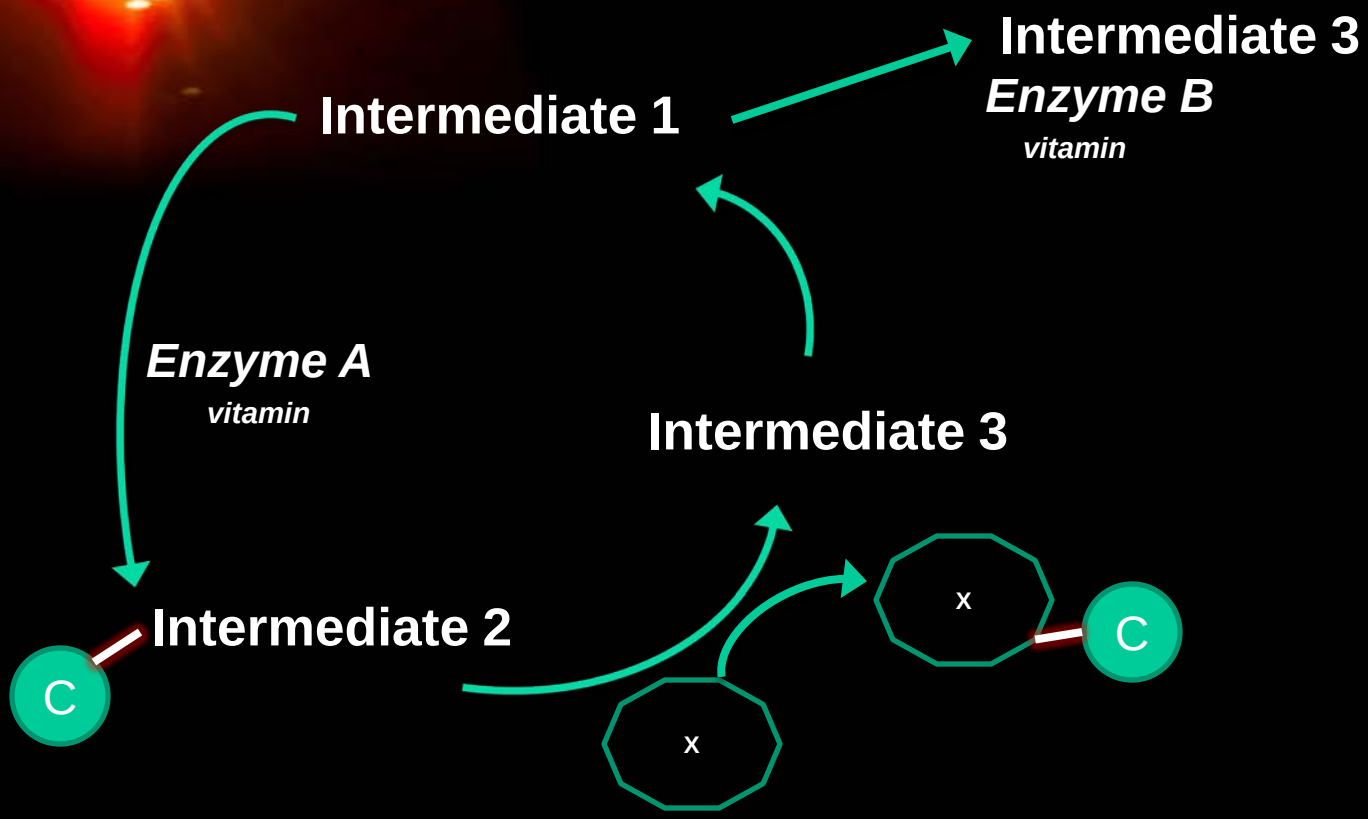
3500 mg/d = ISS requirement (JSC-28038); and the "old" RDA)
2300 mg/d = US Dietary Reference Intake Tolerable Upper Intake Level (UL)**, and NASA exploration requirement (JSC-63555)

In 2005-2006, the average US intake of Na was estimated at 3,436 mg Na/d*
In 1990-1999, the average US intake of Na was estimated at: 3,377 mg for 31-50 yo M**
3,539 mg for 31-50 yo F

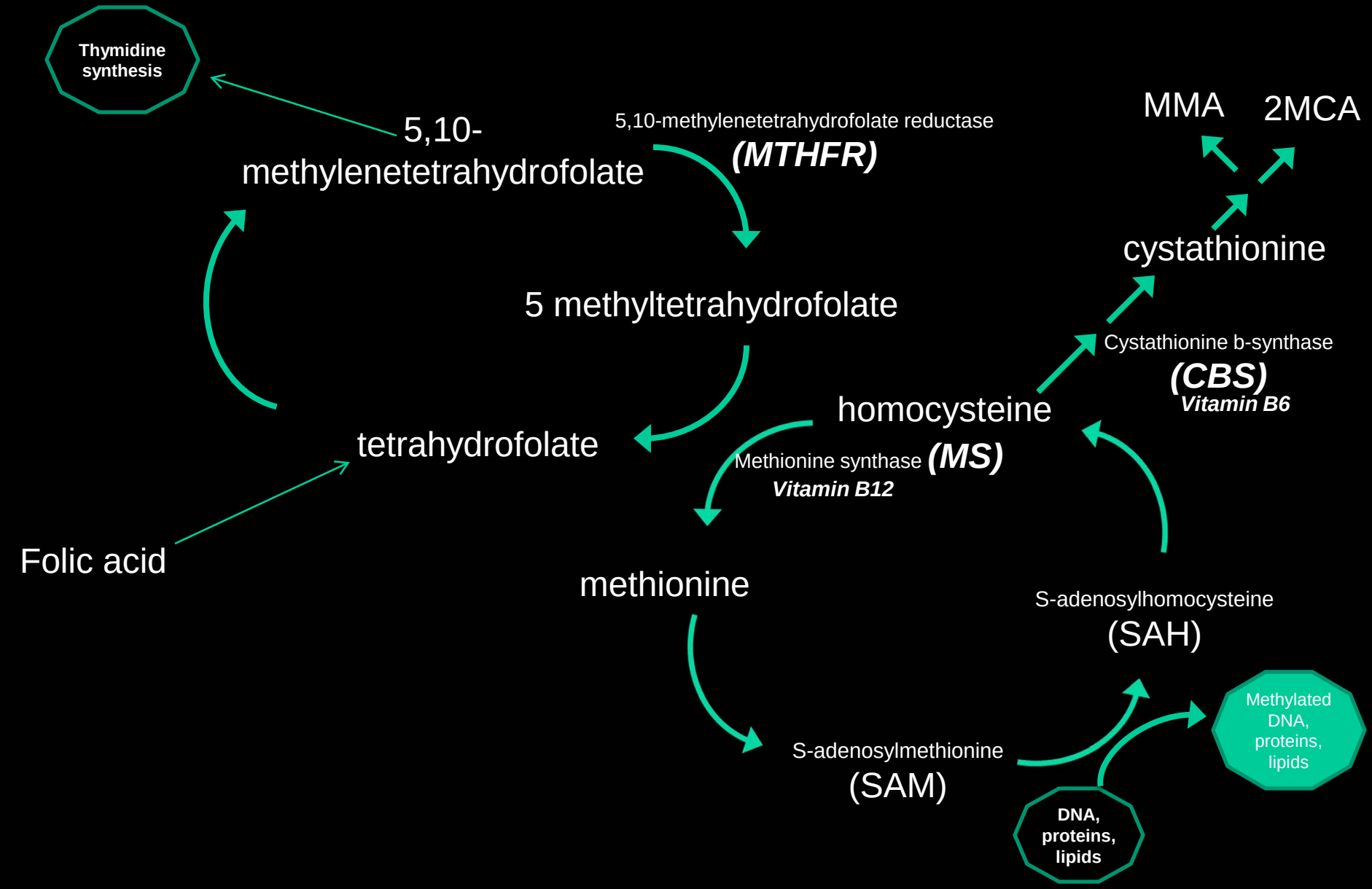
*** http://www.cdc.gov/media/pressrel/2009/r090326.htm**
**** IOM, Dietary Reference Intakes, 2004**



Biochemistry



One Carbon Transfer

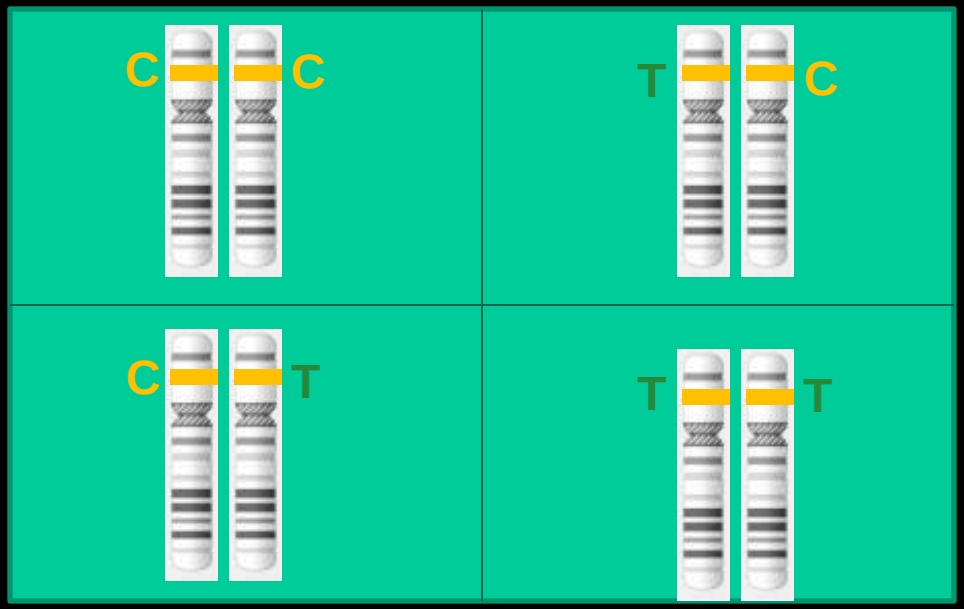


Enzymes/Polymorphisms

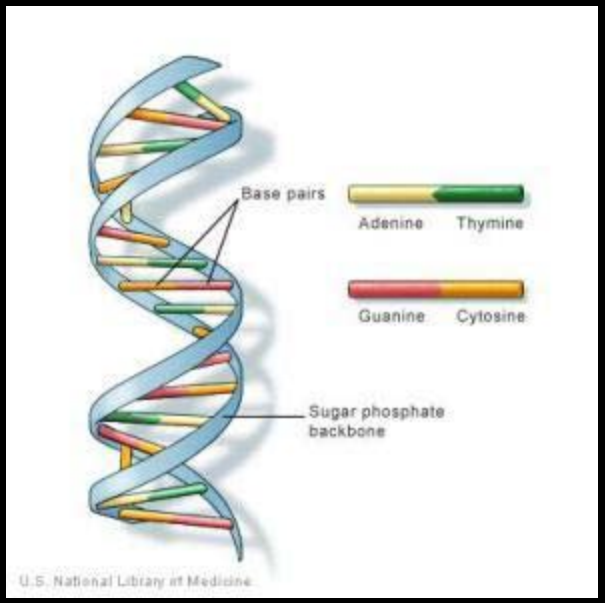
- Proteins
  - Assembled based on “blueprints”
- For many (all?) enzymes, there are small differences in blueprints across the population
  - These are known as “polymorphisms”
    - –poly = multiple, “morph” = forms
  - Example: blood types

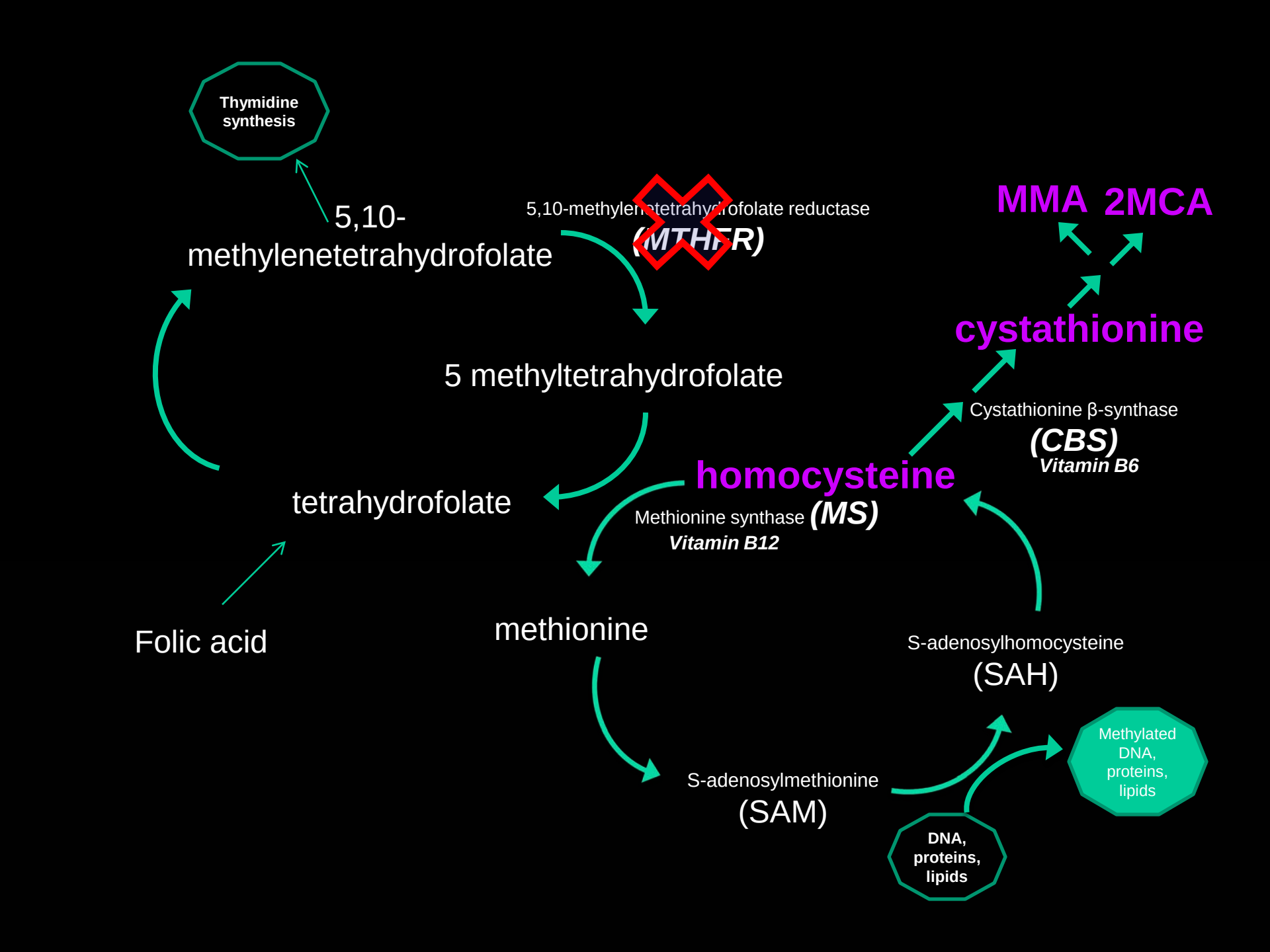
Enzymes/Polymorphisms

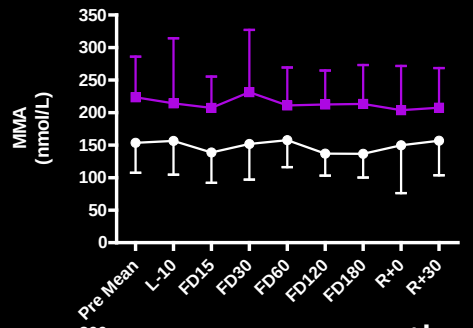
- Everybody has 2 copies (one from mom and one from dad), resulting in four possibilities of this MTHFR polymorphism:

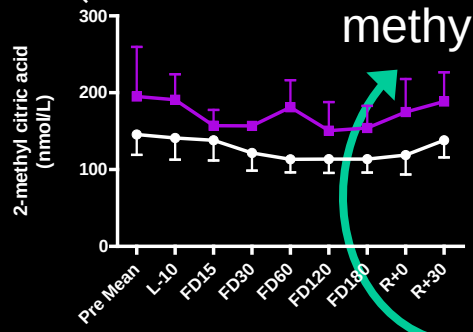


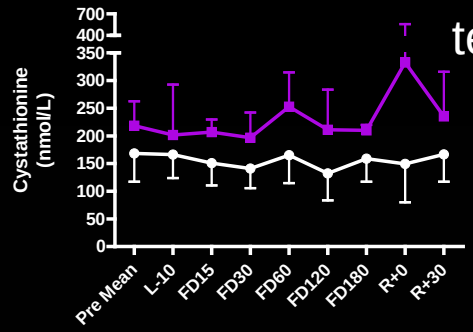
C/C (~35% of the population)
C/T (or **T/C**)(~50% of the population)
T/T (~15% of the population)

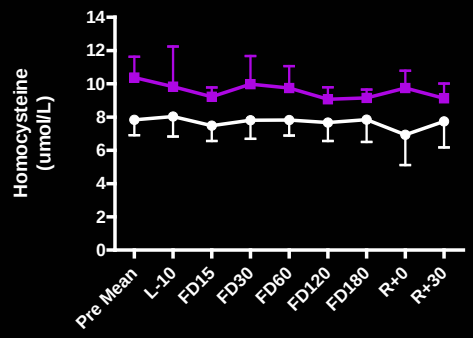



Thymidine synthesis
5,10-methylenetetrahydrofolate
5,10-methylenetetrahydrofolate reductase
(MTHFR)
MMA
2MCA
cystathionine
5 methyltetrahydrofolate
Cystathionine β-synthase
(CBS)
Vitamin B6
homocysteine
Methionine synthase (MS)
Vitamin B12
tetrahydrofolate
Folic acid
methionine
S-adenosylhomocysteine
(SAH)
S-adenosylmethionine
(SAM)
Methylated DNA, proteins, lipids
DNA, proteins, lipids









5,10-methylenetetrahydrofolate

5,10-methylenetetrahydrofolate reductase ***(MTHFR)***

MMA 2MCA

5 methyltetrahydrofolate

cystathionine

Cystathionine β-synthase ***(CBS)***

Vitamin B6

tetrahydrofolate

homocysteine

Methionine synthase ***(MS)***

Vitamin B12

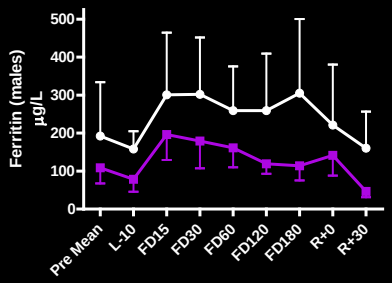
methionine

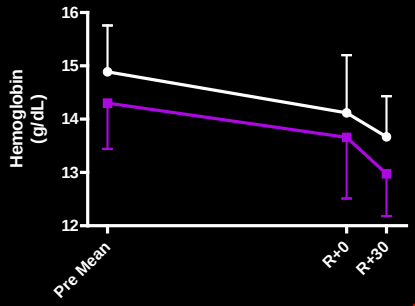
S-adenosylhomocysteine (SAH)

S-adenosylmethionine (SAM)

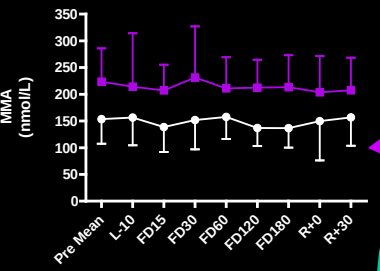
DNA, proteins, lipids

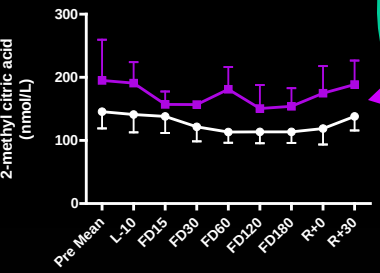
Methylated DNA, proteins, lipids

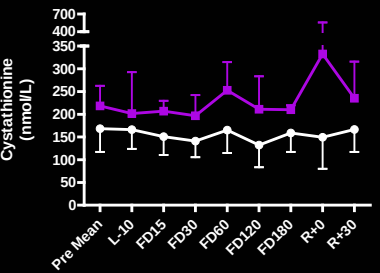


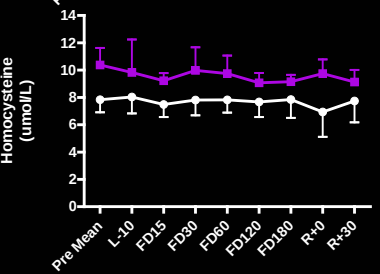


Homocysteine misincorporation into proteins









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5 methyltetrahydrofolate

tetrahydrofolate

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cystathionine

Cystathionine β-synthase ***(CBS)*** ***Vitamin B6***

homocysteine

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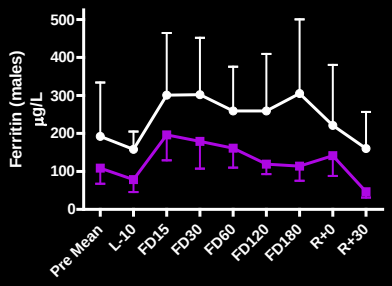
methionine

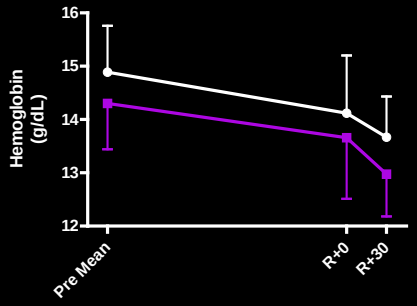
S-adenosylhomocysteine (SAH)

S-adenosylmethionine (SAM)

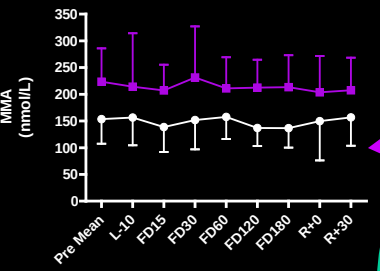
DNA, proteins, lipids

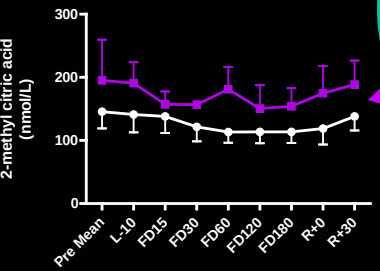
Methylated DNA, proteins, lipids

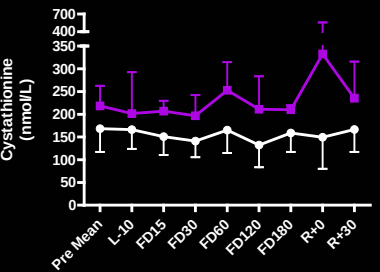


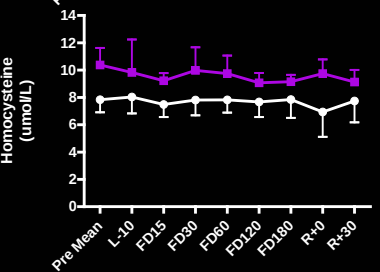


Homocysteine misincorporation into proteins









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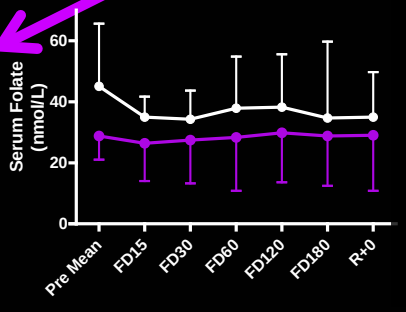
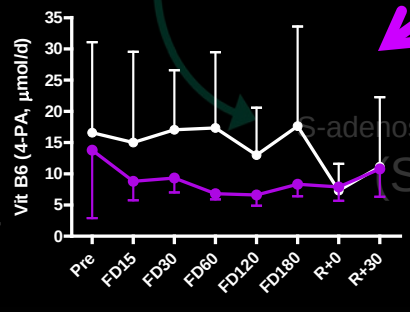
S-adenosylhomocysteine (SAH)

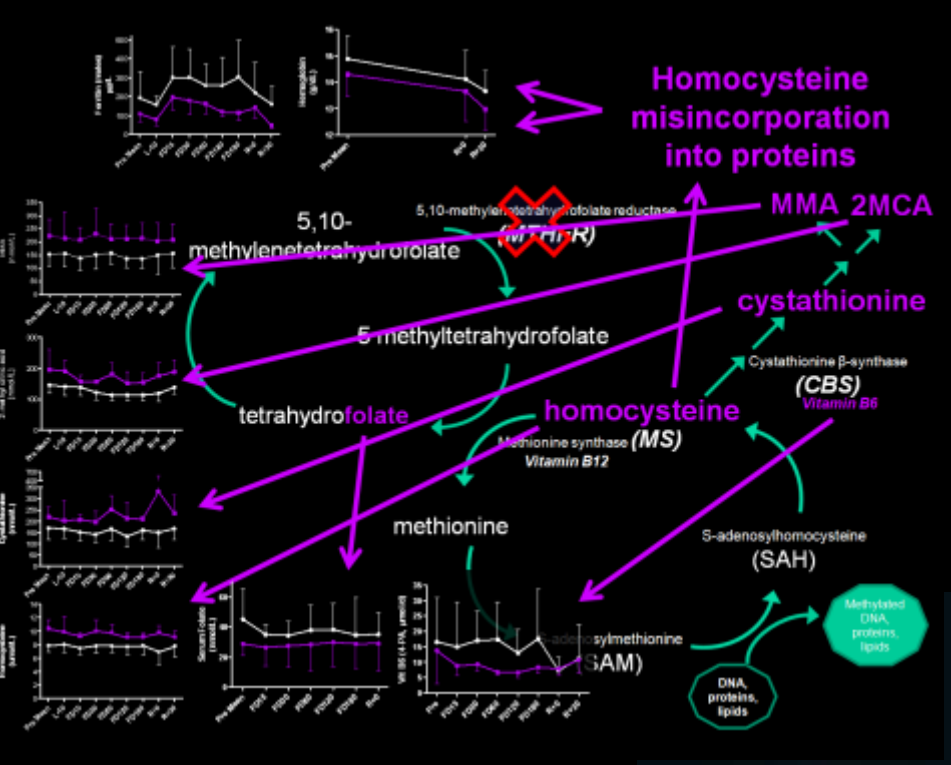




S-adenosylmethionine (SAM)

Methylated DNA, proteins, lipids

DNA, proteins, lipids


Homocysteine misincorporation into proteins
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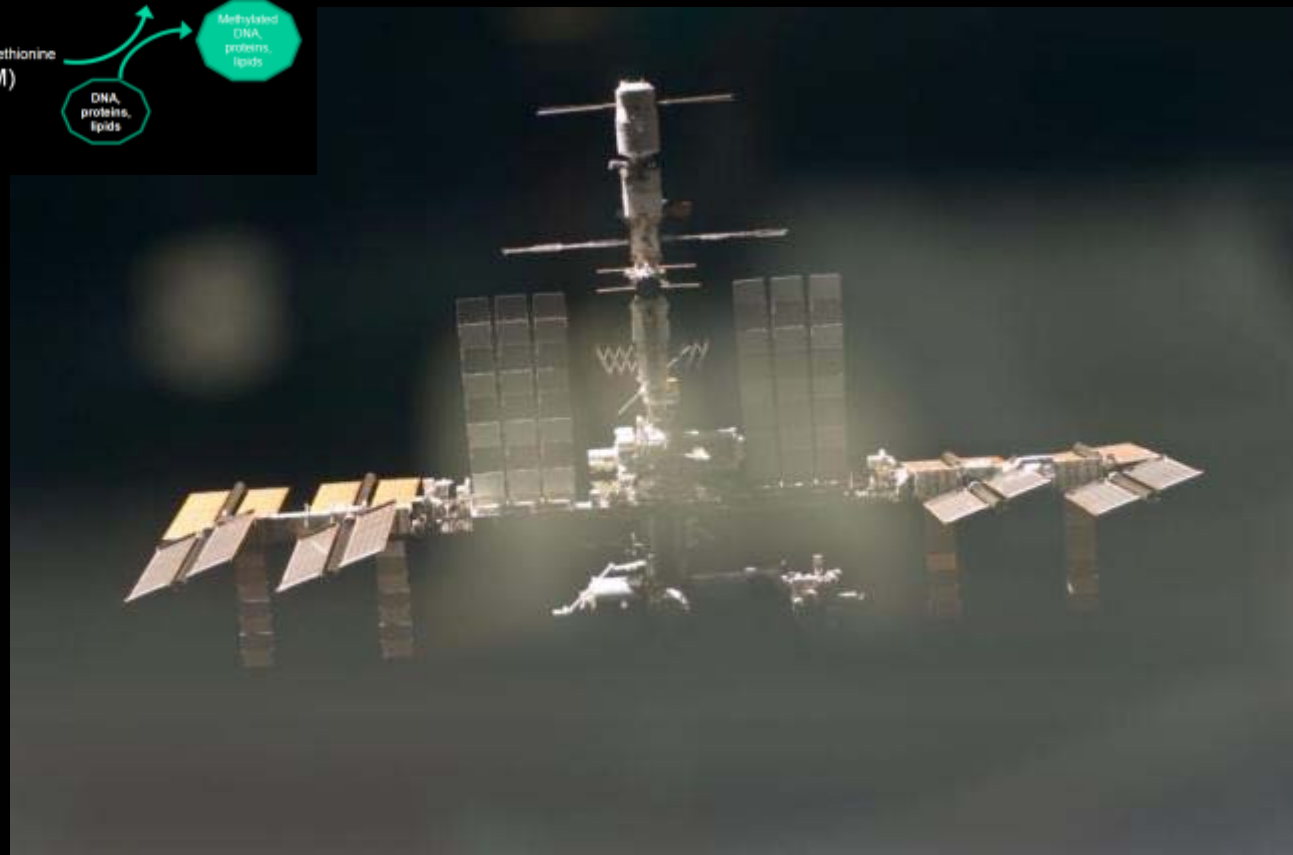
5-methyltetrahydrofolate
cystathionine
Cystathionine β-synthase (CBS)
Vitamin B6
tetrahydrofolate
homocysteine
Methionine synthase (MS)
Vitamin B12
methionine
S-adenosylhomocysteine (SAH)
S-adenosylmethionine (SAM)
Methylated DNA, proteins, lipids
DNA, proteins, lipids



Polymorphism/Associated Risks

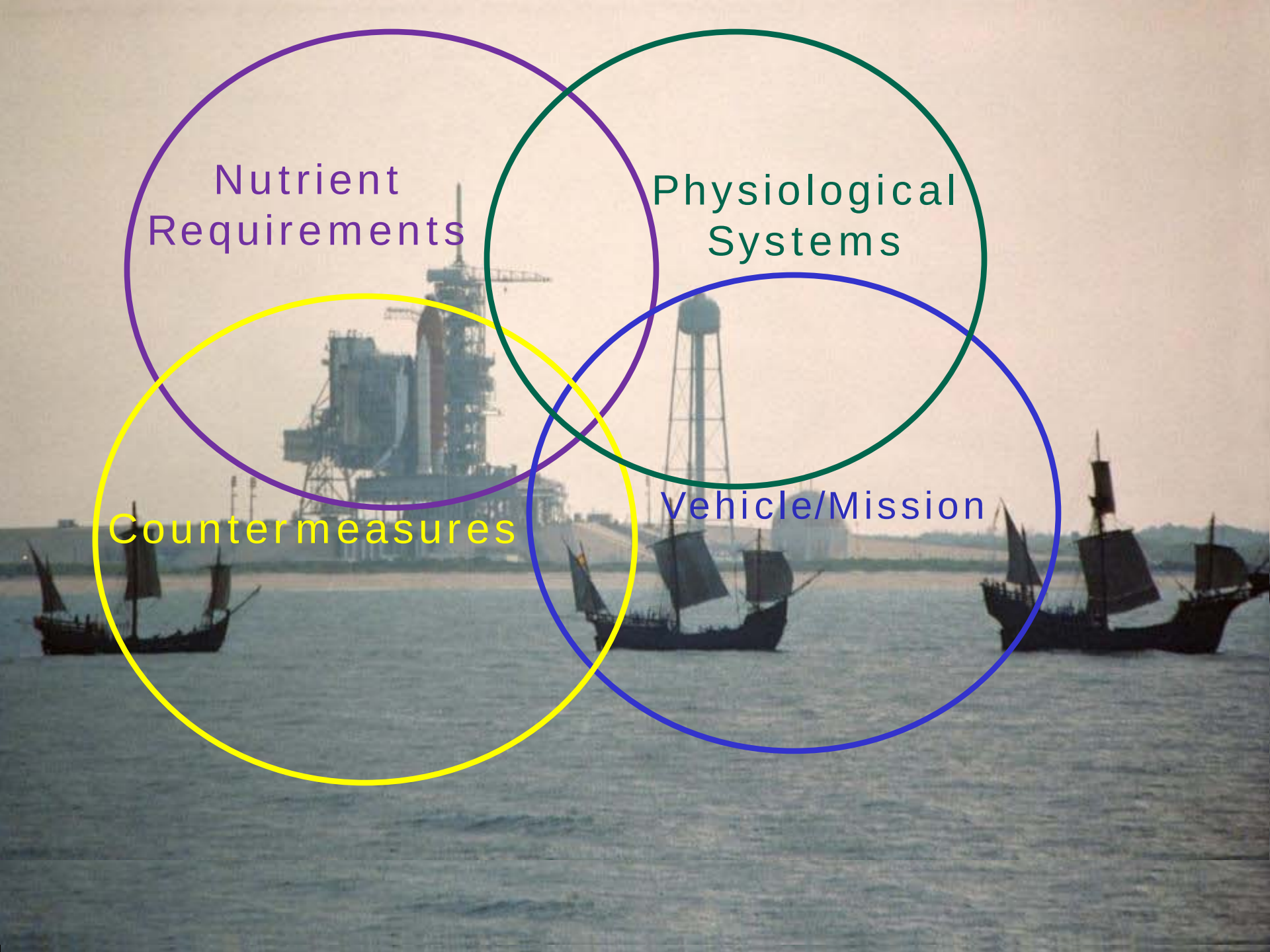
- MTHFR polymorphisms associated with:
  - Increased risk of ischemic and hemorrhagic stroke
  - Increased risk of migraine
- Increased homocysteine associated with:
  - Increased risk of vascular events
  - Increased risk of stroke
  - Risk factor for retinal venous occlusive disease
  - Risk factor for narrower retinal vasculature in men
- Case study(ies?) exists relating folic acid deficiency and optic neuropathy

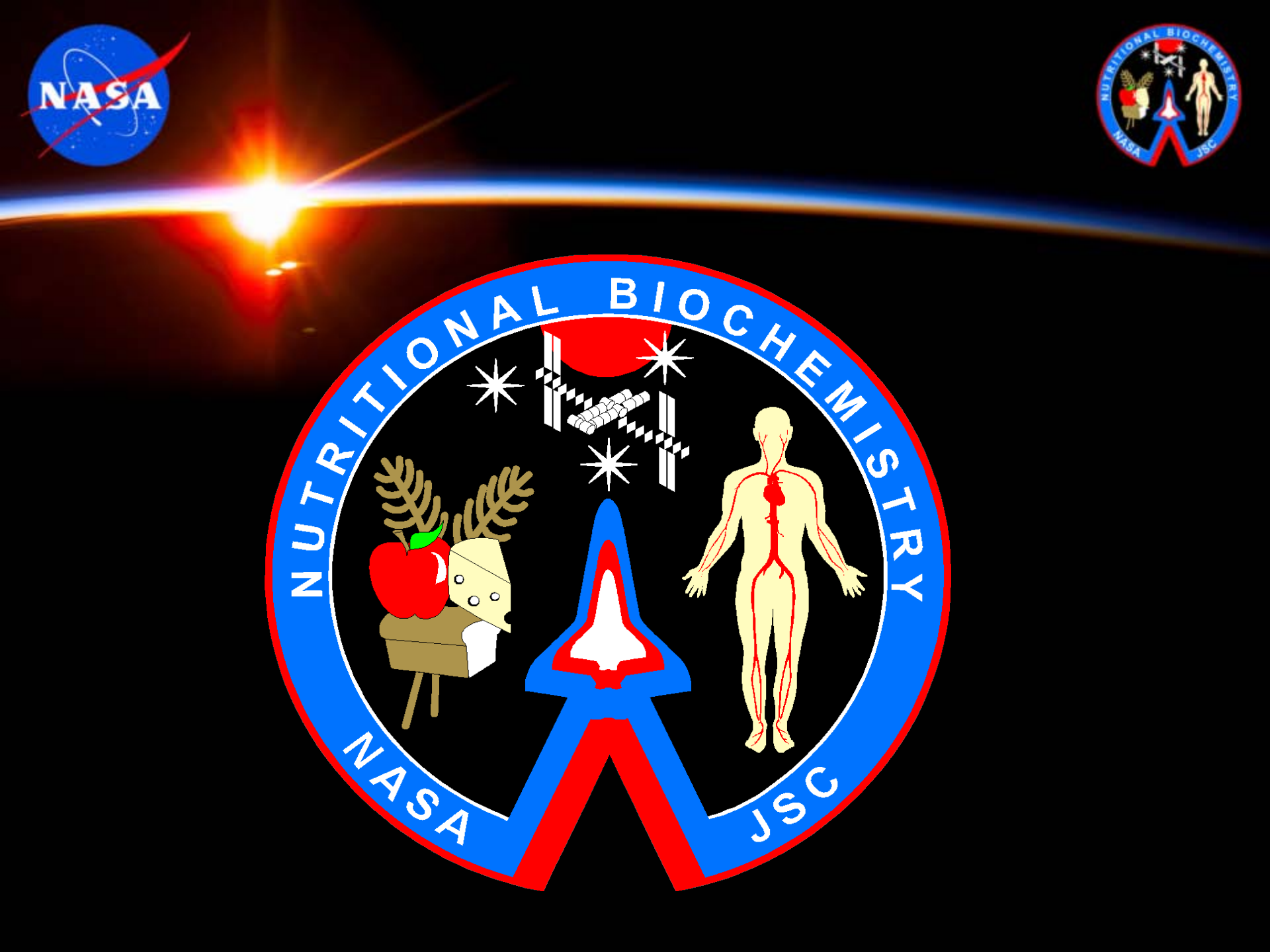
Brain Res Bull 71:45-50, 2006; Annals Neurology 59(2): 372-375; Ophthal 109(2):287-290; Am J Ophthalmol. 2009; 148(6):902-909; J Med Case Reports 2:299, 2008.

1C/VIIP

- We’ve documented 4 intermediates strongly suggesting the existence of polymorphism(s) in the 1-carbon metabolism pathway.
- Additional evidence: folate/B6; ferritin, hemoglobin

- Follow-on proposal submitted to HHC/VIIP
  - Expected results:
    - Inform risks
    - Inform therapeutic options
    - Inform VIIP research


Nutrient Requirements
Physiological Systems
Countermeasures
Vehicle/Mission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