OLLI 401 - Nutrition: Essential Concepts to Promote Healthful Living
Part 5 – Vitamins and Minerals

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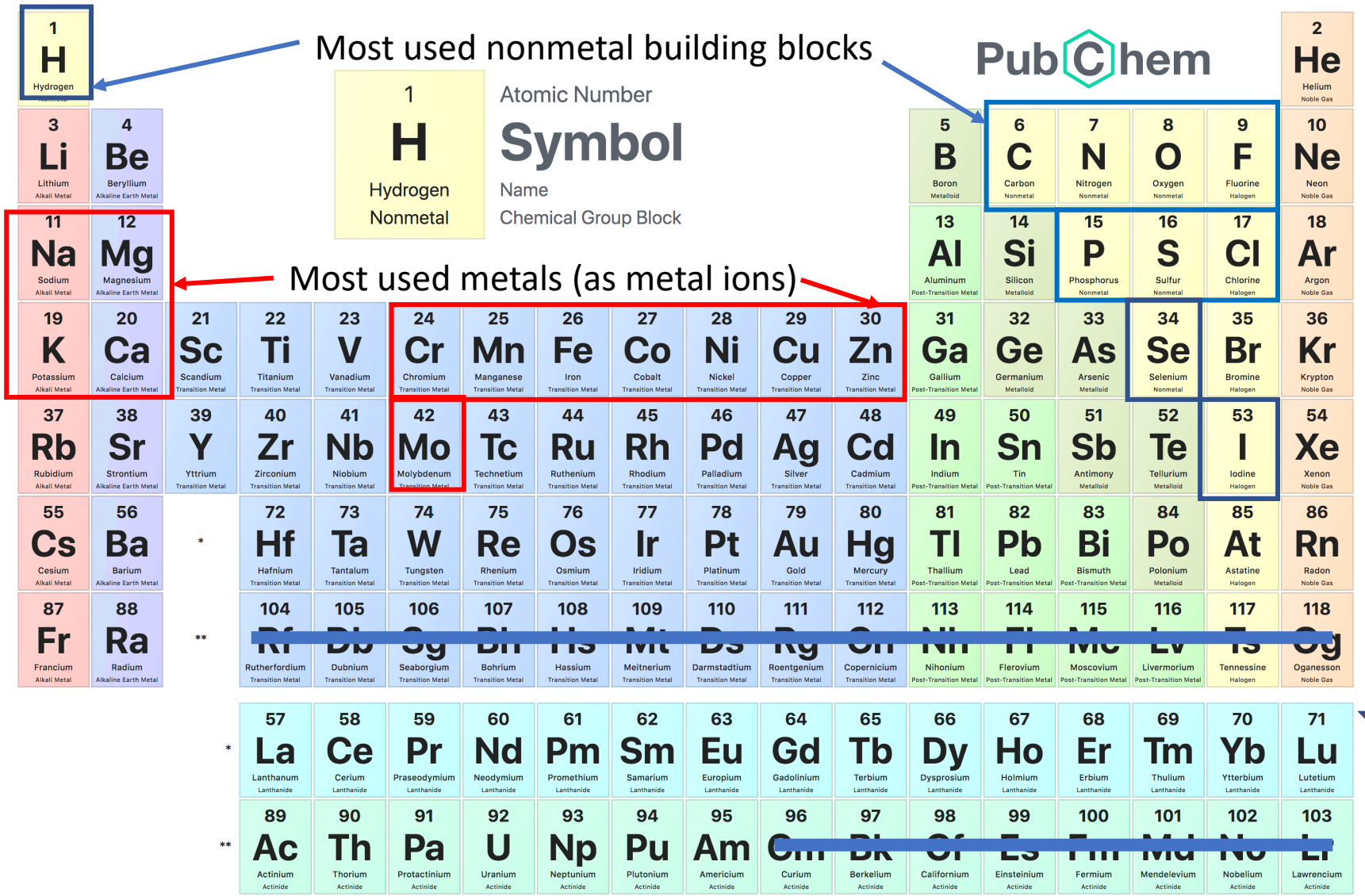
October 21, 2020

Outline of Part 5

- Elements of the periodic table; **abundance, availability and function**; life optimizes to these environmental factors
- Concepts of **deficiency, adequacy, excess and toxicity**
- **Vitamins and minerals** – **cofactors** to proteins and enzymes; structural and regulatory roles; operational niches/functions
- Given the large number of vitamins and minerals, see the textbook for specific requirements, deficiency symptoms and individual best sources; our **focus** will be on **functions** and **special situations** that might lead to **deficiency or toxicity**

PERIODIC TABLE OF ELEMENTS



https://pubchem.ncbi.nlm.nih.gov/periodic-table/

Abundance

More

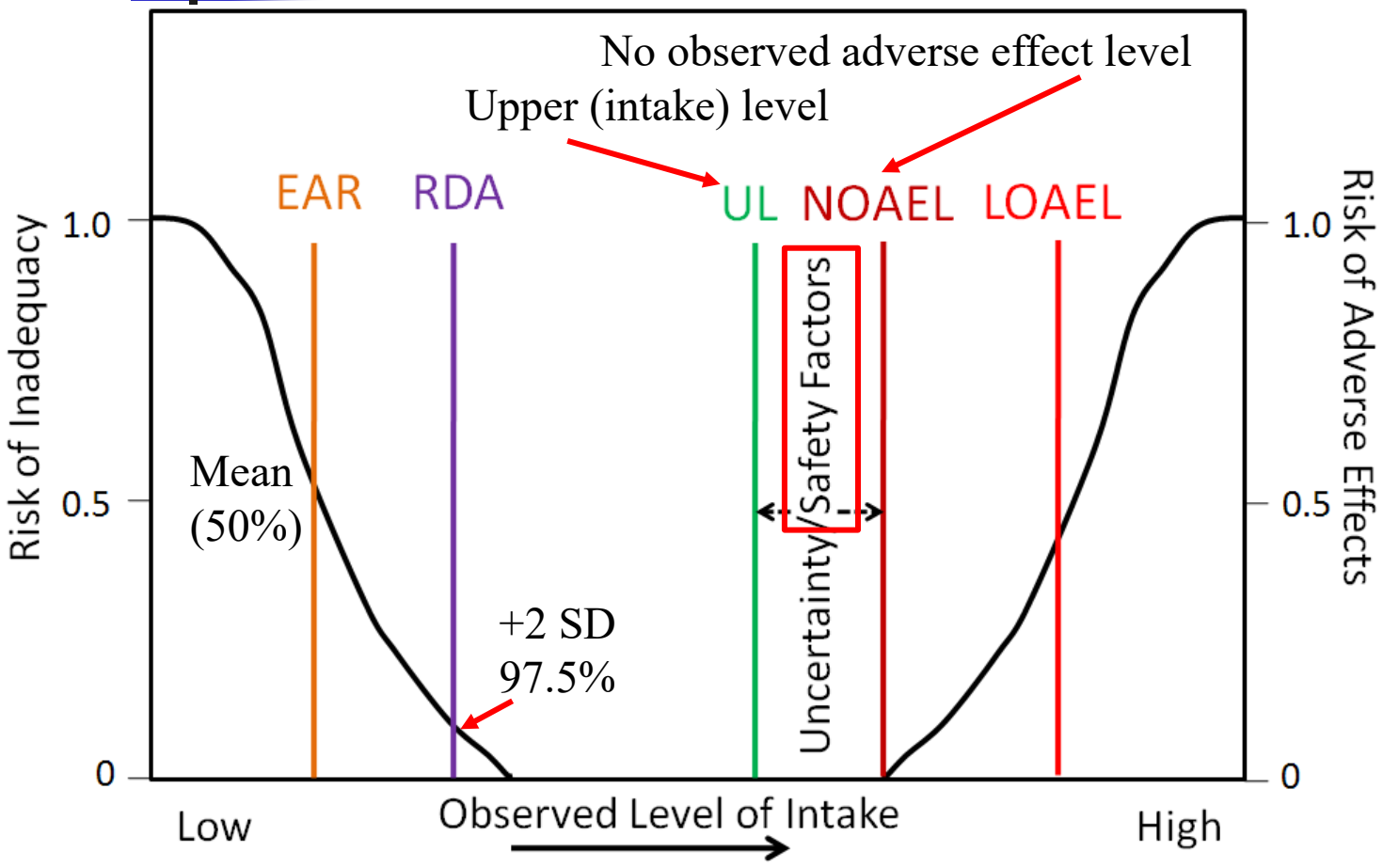
Availability - Aluminum and titanium oxides are very insoluble, so not available

Function – iron oxide very insoluble, but iron is very useful, so we use it, but may encounter shortages

Less

Life based on gold would constantly starve

Nutritional Adequacy and Homeostasis



If there are adequate or lavish dietary sources (no deficiency), the body maintains **homeostasis** (constant correct concentration) either by doing **uptake only if needed**, or by **excreting excess**, or **both**.

Toxicity results if too high a concentration builds up. **Water solubility** is an important factor for vitamins and minerals

https://courses.lumenlearning.com/suny-nutrition/chapter/8-4-dietary-reference-intakes-dris/ Figure not in Kindle edition

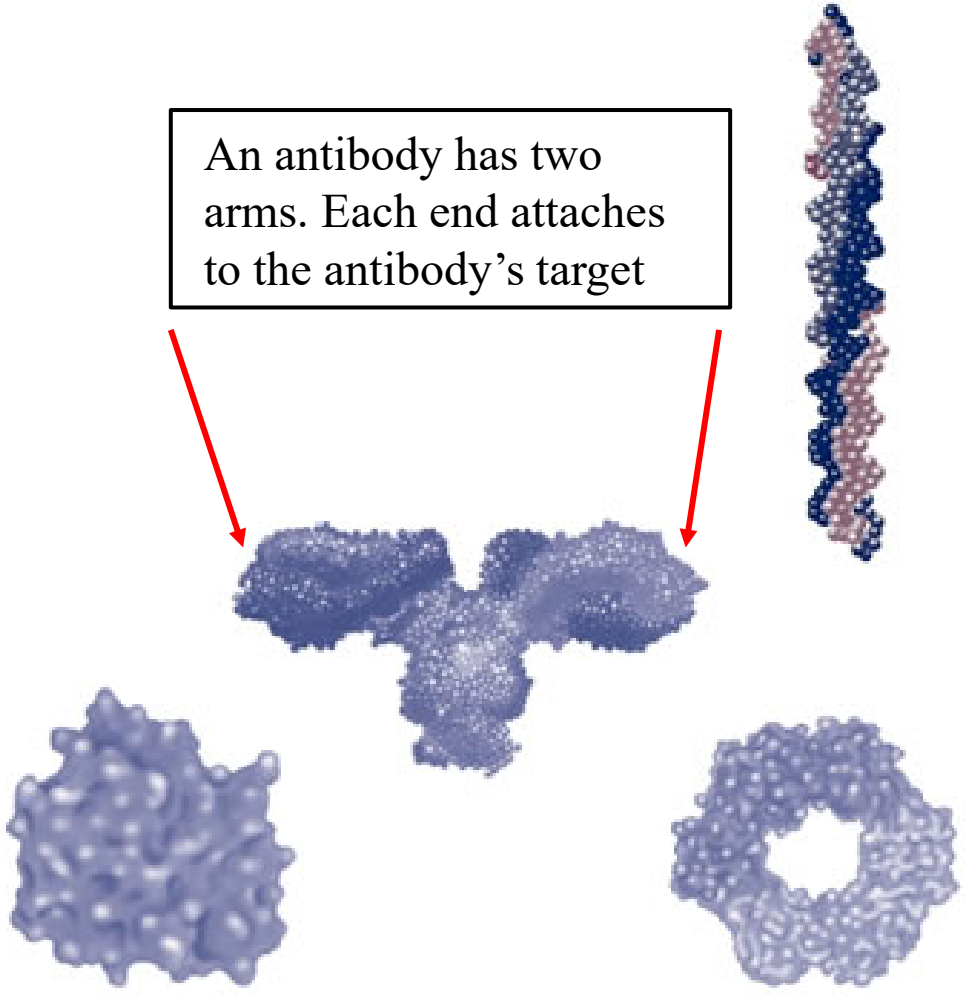
Recommended Daily Allowances to Avoid Deficiency

- **Recommended Daily Allowance** (RDA) is calculated from the Estimated Average Requirement (EAR) plus two standard deviations for a normal distribution (previous slide)
- **Adequate Intakes** (AI) are used when data are less certain, cannot do a statistically calculated RDA
- **USDA provides a calculator** that allows you to input gender, age, height and weight and activity level to get a closer list of RDAs for you:
  - https://www.nal.usda.gov/fnic/dri-calculator/

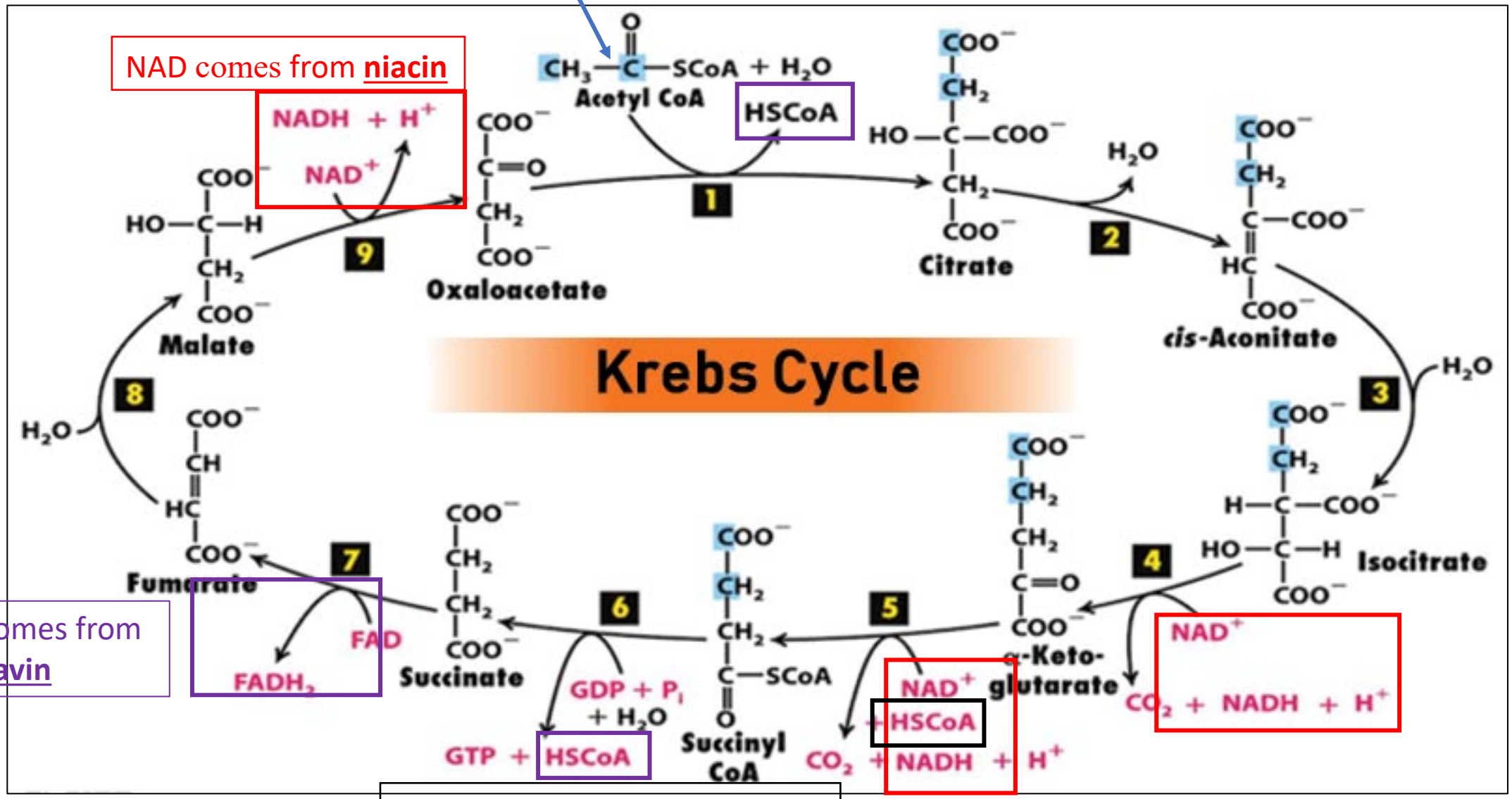
Basic Human Biochemistry

- **Water** environment
- **DNA, RNA** – information
- **Carbohydrates** – largely energy and energy storage
- **Lipids (fats)** – cell and subcellular membranes, energy and storage
- **Proteins** – structure and movement, transporters, regulators and builders; as enzymes, make chemical reactions happen
  - Constructed from 21 amino acids (includes selenocysteine), which create a wide variety of structures, but may need help to do their jobs
  - This is where vitamins and minerals come in

Structural Biology - Different Protein Shapes



Glucose is converted to **Acetyl CoA**. The last step, which yields acetyl CoA uses **thiamine** (and lipoic acid)



One illustrative metabolic pathway found on the MCAT; **enzymes** do the reactions

https://microbenotes.com/tca-cycle-citric-acid-cycle-or-krebs-cycle/

Vitamin Functions - 1

- Retinol (**A**) is also produced from beta carotene (golden rice) - vision, general wound healing, immune system function
- Thiamin (**B1**), Riboflavin (**B2**), Niacin (**B3**), Pantothenate (**B5**), and Biotin (**B7, H**) – energy generation from sugars (see previous) and fatty acids. **B3** and **B2** act as electron carriers in mitochondrial ATP production (as NAD and FAD respectively).
- Pyridoxine (**B6**) – amine metabolism, including amino acids and certain neurotransmitters (neurological health)

Vitamin Functions - 2

- Cobalamin (**B12**) and folate (**B9**, which incorporates p-aminobenzoic acid, PABA) – methyl transfer reactions, blood cell formation and neurological health
- Ascorbate **(C)** – collagen maintenance (scurvy), antioxidant, immune response. Pauling – hominid ancestors ate lots of fruit
- **D** complex – calcium homeostasis with phosphate, bone health. Related to sunlight level; skin color, deficiency today?
- Tocopherol **(E)** – antioxidant
- **K** – coagulation; need healthy microbiome

Need for Vitamin and Mineral Supplements

- **Michael Pollan – Eat food, not too much, mostly plants**.
- **Avoid too many highly refined foods**; fruits and vegetables are good and may be sufficient. Note genomics says we adapted to meat; B12 deficiency in vegans
- Focus on special deficiency cases for individual vitamins and minerals. **Foodstuff supplementation** indicates commonly recognized shortages – refined **wheat flour** is enriched with thiamine, riboflavin, niacin, reduced iron (Fe+2) and after 1998, folate (spina bifida); **milk** with vitamin D

Macroelement Functions

Mostly Metallic Elements in the Periodic Table; Act as Ions

- **Sodium** (Na+), **Potassium** (K+) and **Chloride** (Cl-) – electrolyte balance and neural transmission, blood pressure
- **Calcium** (Ca+2) + **Phosphate** ($H_{1,2}PO_4$ –1 or -2) as crystalline hydroxyapatite – bone, teeth, **note osteoporosis**; Ca (+2) also involved in metabolic control – calcium channels, calmodulin
- **Magnesium** (Mg+2) – chemically similar to calcium; cellular metabolic function, associated with proteins, DNA and RNA
- C, H, O, N and S are found combined with other elements, not independently, so are not covered here

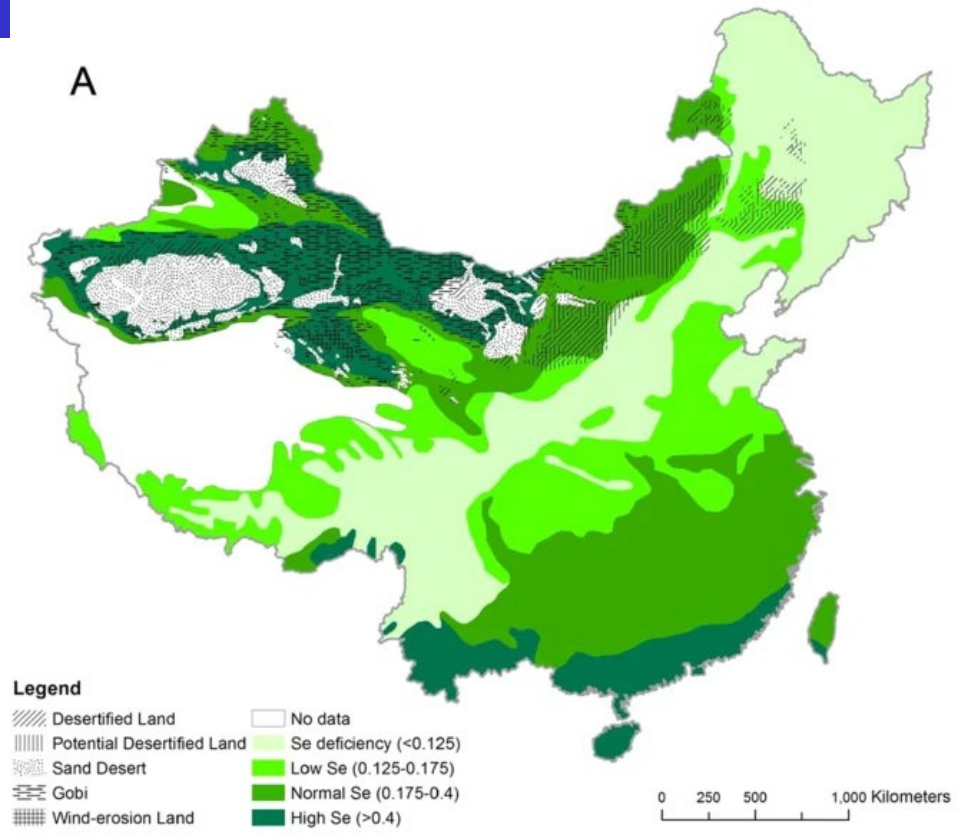
Micro-(trace)element Functions
First Transition Metal Row from Cr to Zn

- **Chromium** (Cr+3) – glucose tolerance, diabetes prevention
- **Manganese** (Mn+2) – enzyme cofactor, including SOD
- **Iron** (Fe+2/+3) – oxygen and electron transport, enzyme cofactor where oxidation-reduction occurs
- (Cobalt (Co+2) – found in vitamin B12, not independently)
- (Nickel (Ni+2) – oddity, essential or not? Cancer, dermatitis)
- **Copper** (Cu+2 and +1) enzyme cofactor; antioxidant SOD
- **Zinc** (Zn+2) – enzyme cofactor, especially DNA, RNA

Other Trace Elements

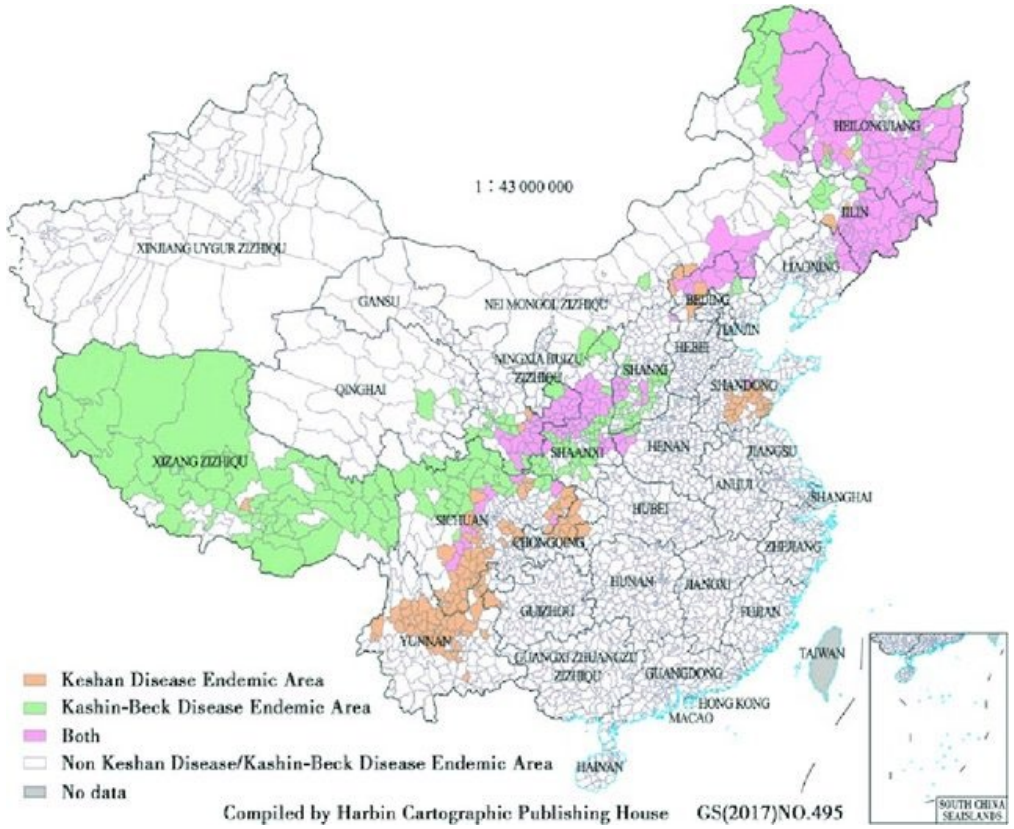
- **Fluoride** (F-) – deficiency associated with tooth decay; excess with fluorosis, mottled teeth, brittle bones
- **Selenium** (selenocysteine, the 21st amino acid); anti-lipid peroxidation; Keshan disease – cardiomyopathy and congestive heart failure in China
- **Molybdenum** (Mo+6) – xanthine oxidase, purine, uric acid metabolism; also aldehyde oxidase (blocked by Antabuse)
- **Iodine** (I-) – exception to rule of essential elements are at the top of periodic table, thyroid function and goiter

Keshan Disease China (Selenium Deficiency)



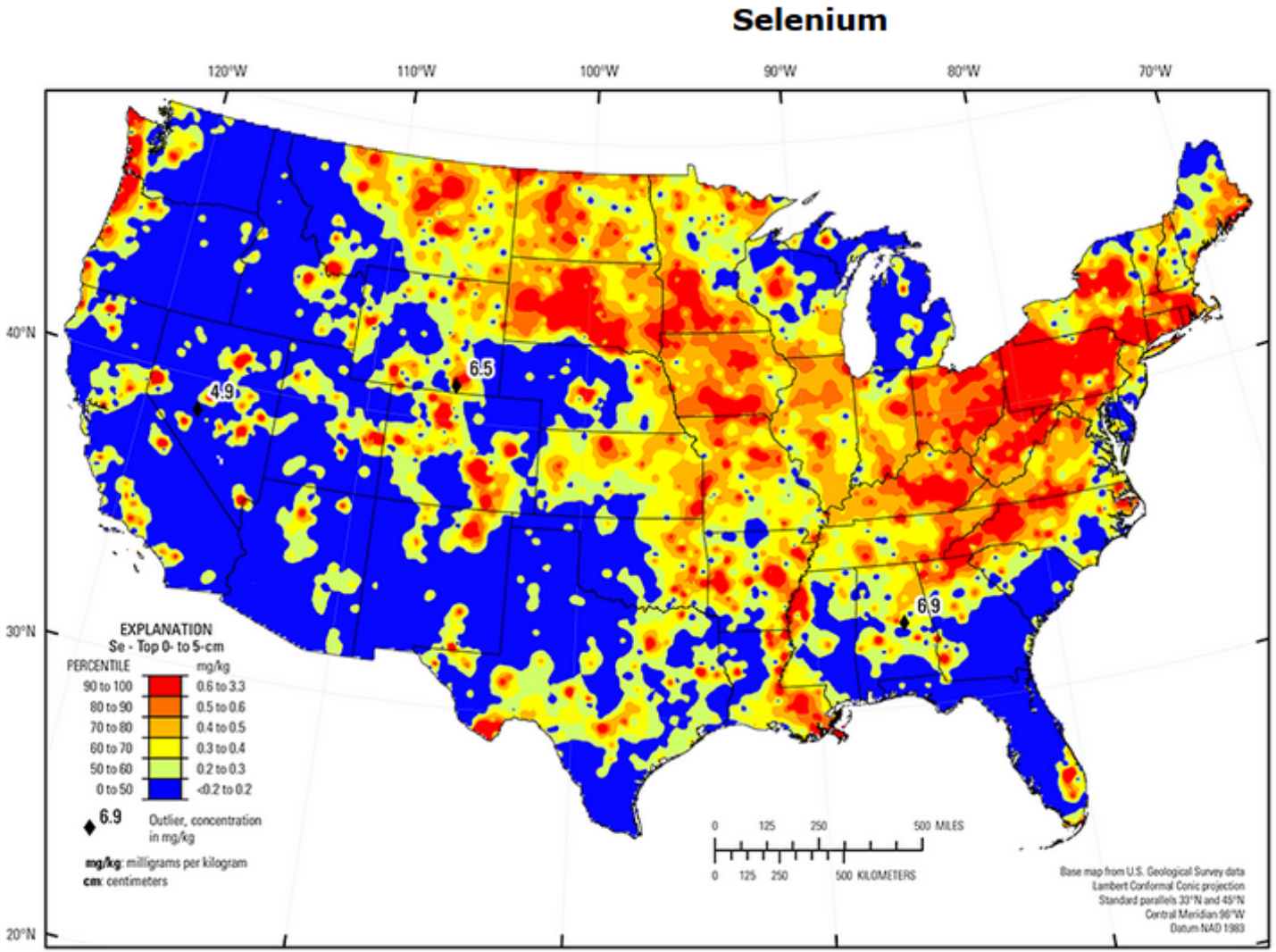
Soil selenium levels; pale green = deficiency

https://www.nature.com/articles/srep20953



Keshan disease regions (purple)

https://www.researchgate.net/publication/339031516_Endemic_Disease_in_China/figures?lo=1



https://pubs.usgs.gov/sir/2017/5118/sir20175118_element.php?el=34

Climate change expected to aggravate selenium deficiency in soils:

http://food-form-minerals.cypressingredients.com/blog/selenium-deficiency-predicted-from-climate-change

Trace Element Deficiencies and Ways to Counter Them

- **Nutrient deficiencies common with old age**: calcium (women especially, but also men), vitamin D, and to a lesser extent, magnesium, B12 and folate, potassium, zinc
- Avoid diets low in concentration
- Find foods high in concentration
- Consider supplements – chemical form – solubility, chelation
- (Soil deficiencies)

Toxic Elements

- **Iron** (hemochromatosis) and **Copper** (Wilson's disease) with two oxidation states can produce oxygen radicals, so are kept under tight control; **avoid excess intake**
- Elements toward the bottom of the periodic table are rare; don't see much, may not take much to be too much; Paracelsus
- **Lead** (Pb+2) and **Mercury** (Hg+2 and methylmercury) are neurotoxic; **Cadmium** (Cd+2 mimics Zn+2) and **Arsenic** (As as arsenate, AsO_4 mimics phosphate, PO_4) are carcinogenic and generally toxic; **Thallium** (Tl) is a general poison; Be