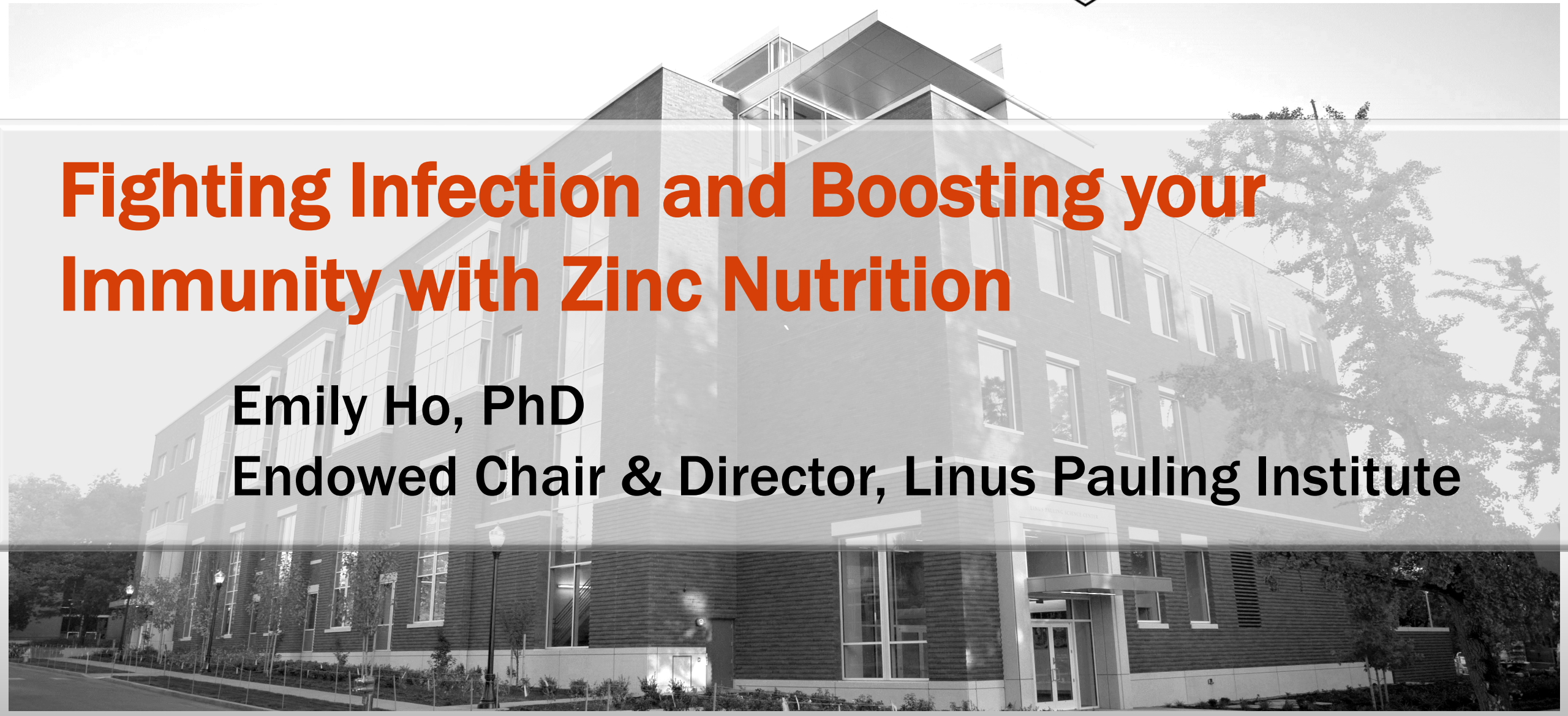
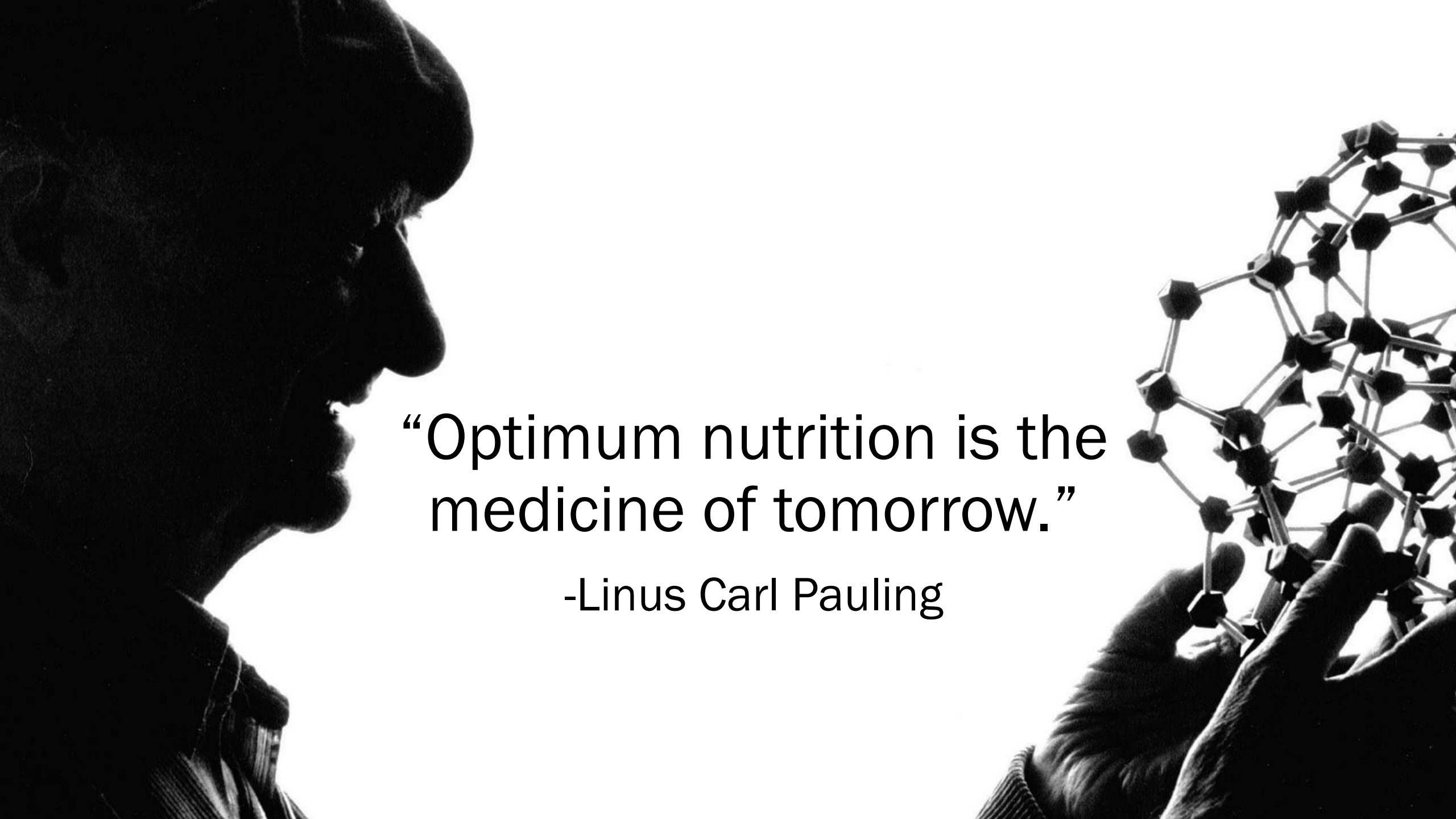
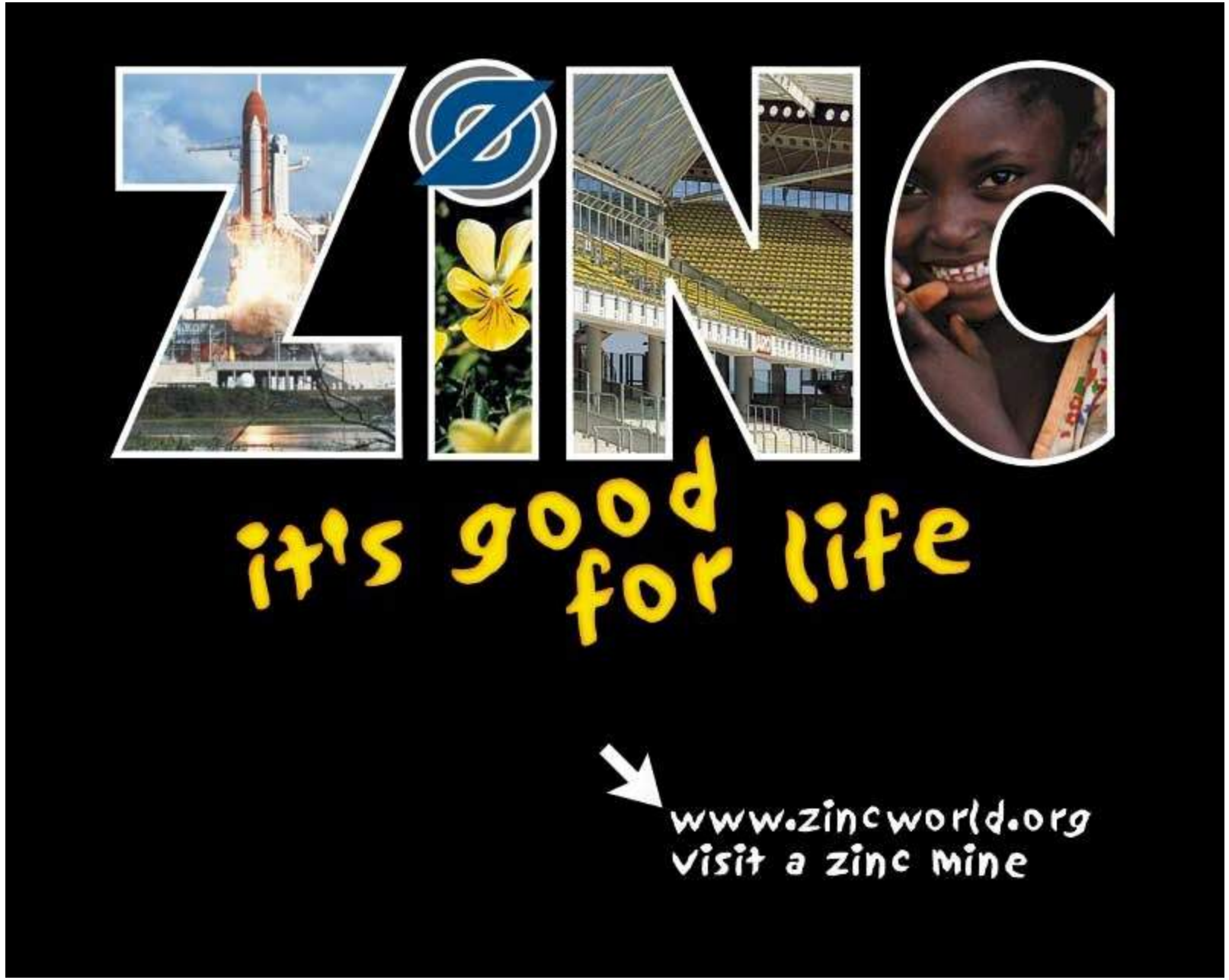


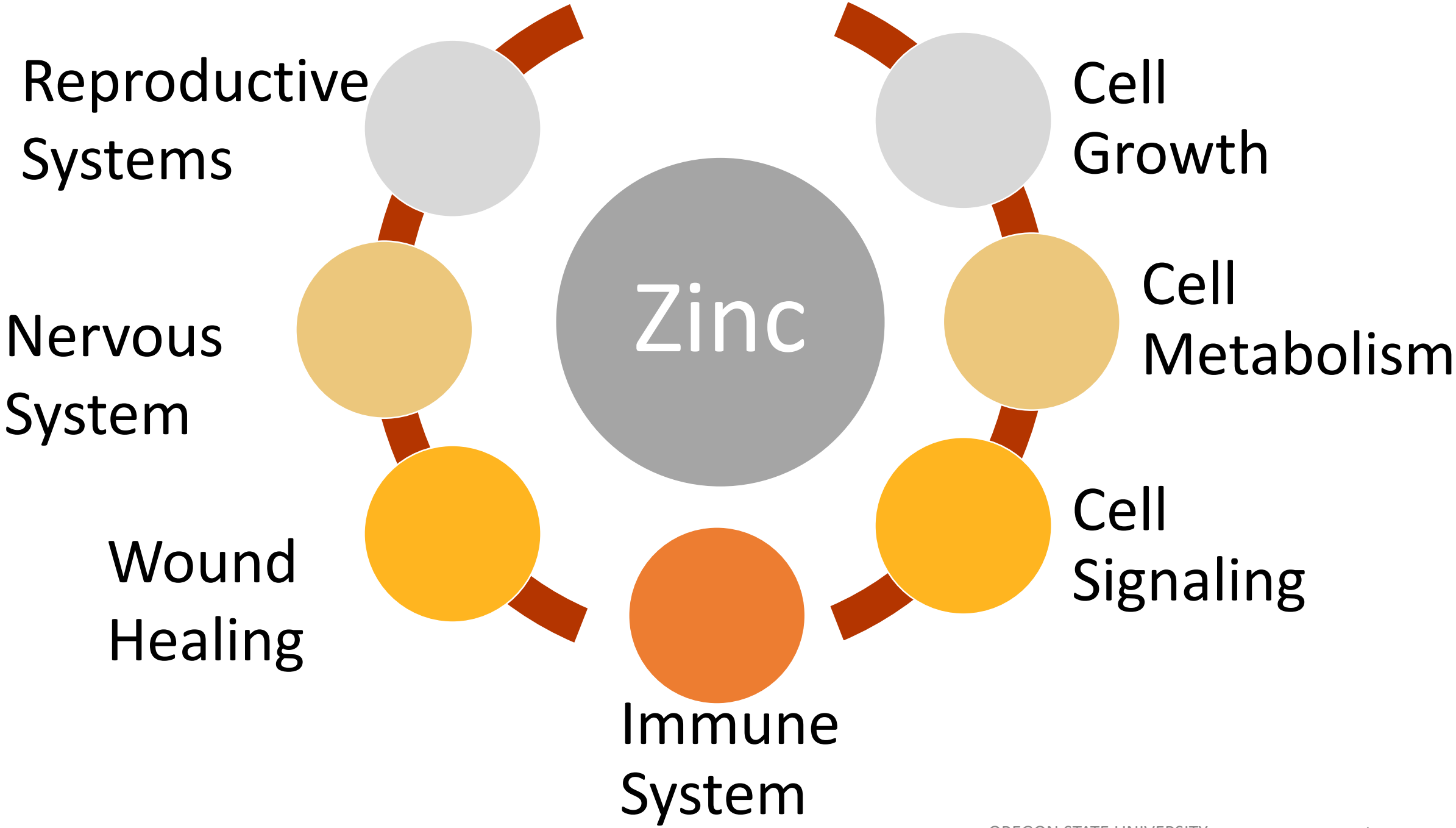
Oregon State University
Linus Pauling Institute

Fighting Infection and Boosting your Immunity with Zinc Nutrition

Emily Ho, PhD
Endowed Chair & Director, Linus Pauling Institute

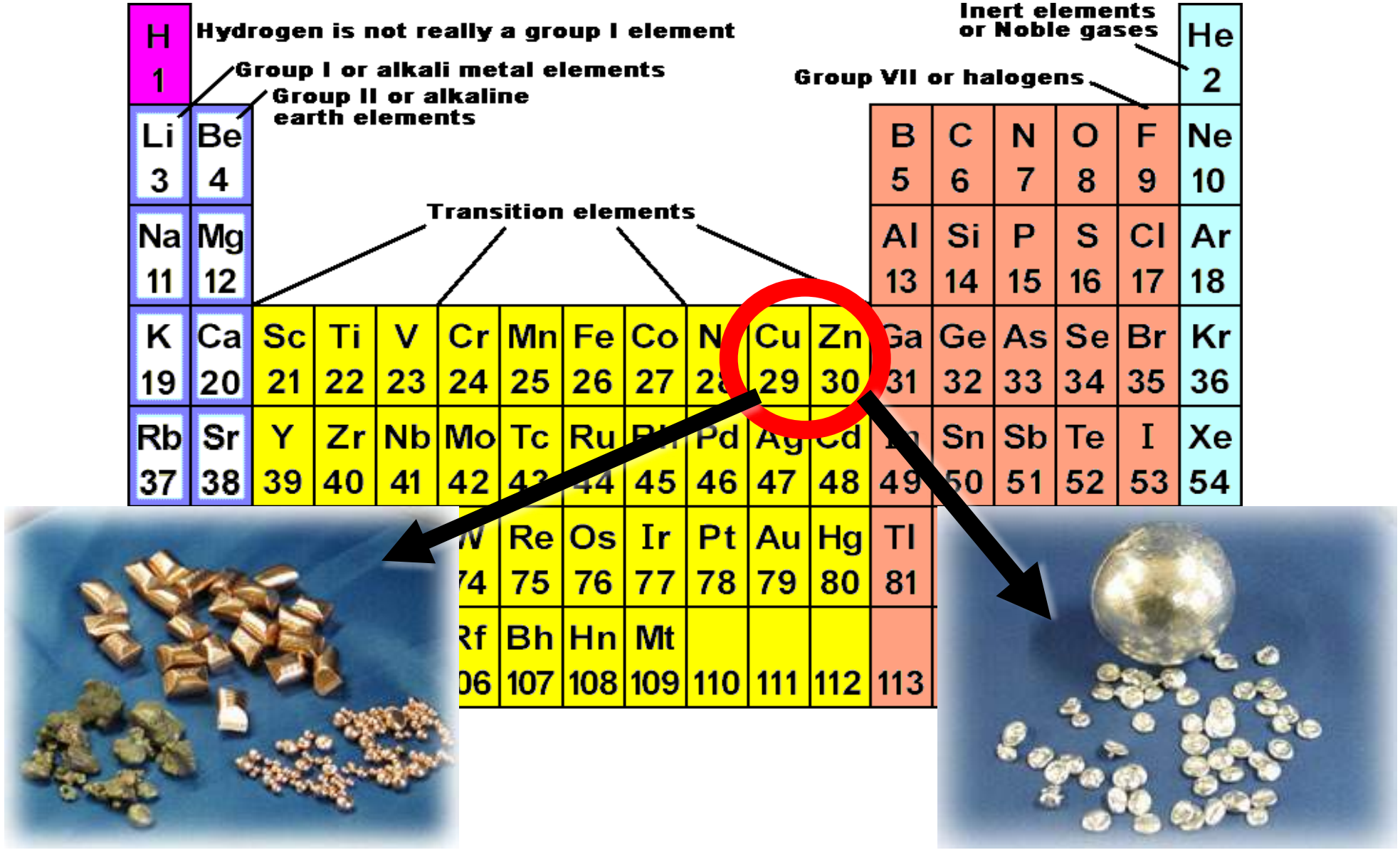

“Optimum nutrition is the medicine of tomorrow.”
-Linus Carl Pauling


ZINC
it's good for life
www.zincworld.org
visit a zinc mine


Reproductive Systems
Cell Growth
Nervous System
Zinc
Cell Metabolism
Wound Healing
Cell Signaling
Immune System

ZINC

- Zinc is a IIB element, but does not exhibit redox chemistry
- Readily complexes with proteins, peptides, amino acids and nucleotides
- Over 300 catalytically active zinc metalloprotein and more than 2000 zinc dependent transcription factors involved in gene expression have been recognized.


H 1
Hydrogen is not really a group I element
Group I or alkali metal elements
Group II or alkaline earth elements
Inert elements or Noble gases
Group VII or halogens
He 2
Li 3
Be 4
B 5
C 6
N 7
O 8
F 9
Ne 10
Transition elements
Na 11
Mg 12
Al 13
Si 14
P 15
S 16
Cl 17
Ar 18
K 19
Ca 20
Sc 21
Ti 22
V 23
Cr 24
Mn 25
Fe 26
Co 27
Cu 29
Zn 30
Ga 31
Ge 32
As 33
Se 34
Br 35
Kr 36
Rb 37
Sr 38
Y 39
Zr 40
Nb 41
Mo 42
Pd 46
Ag 47
Cd 48
Sn 50
Sb 51
Te 52
I 53
Xe 54
Re 75
Os 76
Ir 77
Pt 78
Au 79
Hg 80
Tl 81
Bh 107
Hn 108
Mt 109
111
112
113

Zinc is a strong antioxidant

Role of zinc in immune function

- **Zinc is an essential micronutrient**
  - Key component of metalloenzymes and transcription factors
  - Required for many biological processes, including the normal development and function of the immune system
  - Intracellular zinc homeostasis is critically involved in the signaling events in immune cells

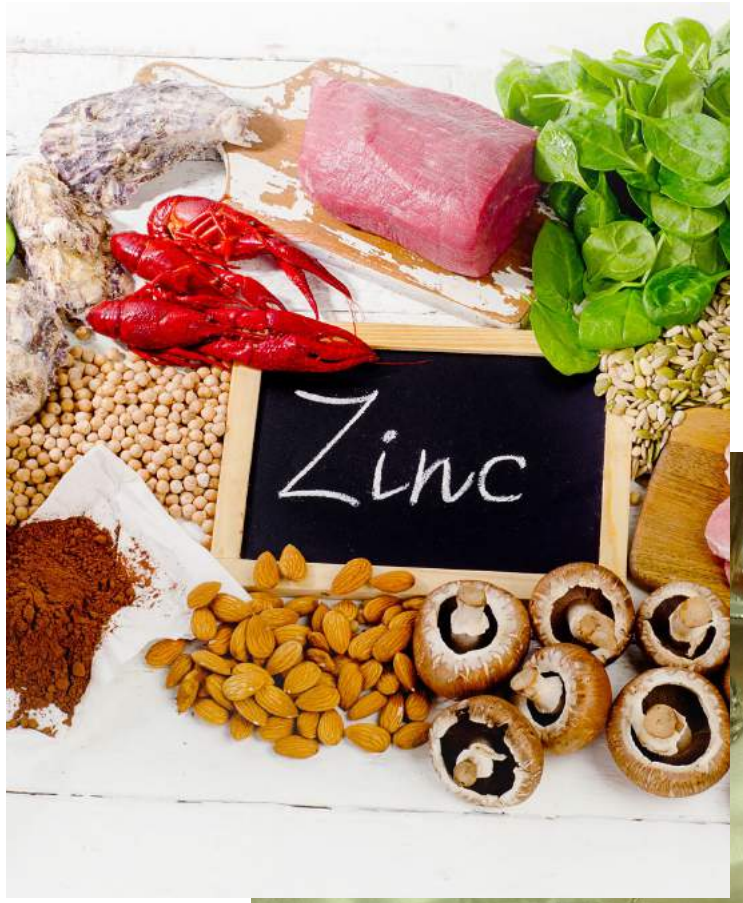
Zinc Requirements

Males: 11 mg/day

Females: 8 mg/day

Good sources of zinc:

- ✓lean meats
- ✓seafood
- ✓nuts & legumes
- ✓whole grains and cereals



Sources of zinc

Food	Zinc Content (mg)
Oysters, cooked (6 medium)	43.4
Crab meat (3 oz)	4.6
Beef (3 oz)	5.8
Pork (3 oz)	2.2
Chicken (dark meat, 3 oz)	2.4
Yogurt, fruit (1 cup)	1.8
Almonds (1 oz)	0.9
Beans, baked (1/2 cup)	1.8
Chick peas (½ cup)	1.3

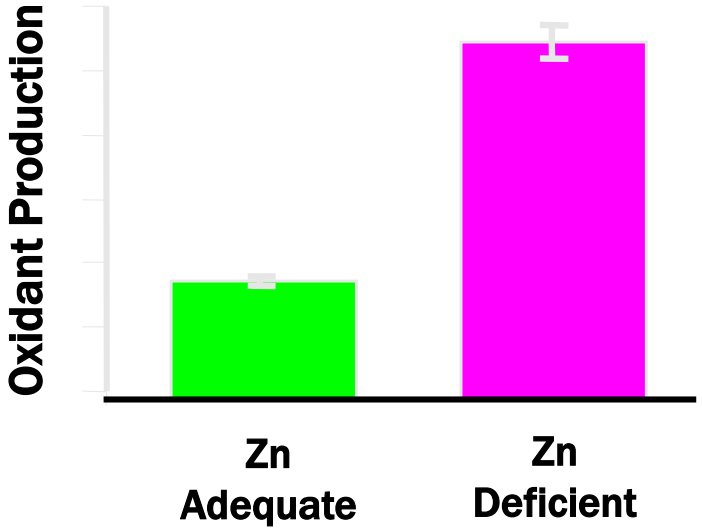
How prevalent is zinc deficiency?

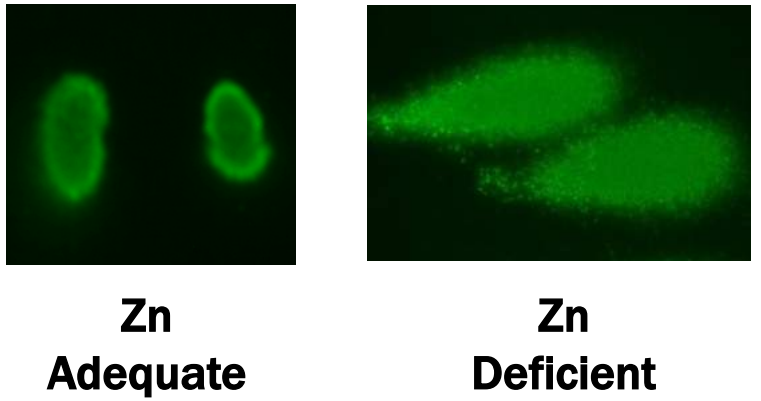
- Large problem worldwide
- In developing countries, millions of children die each year because of poor zinc status
- In the US approximately many population do not meet the current recommended intake for zinc

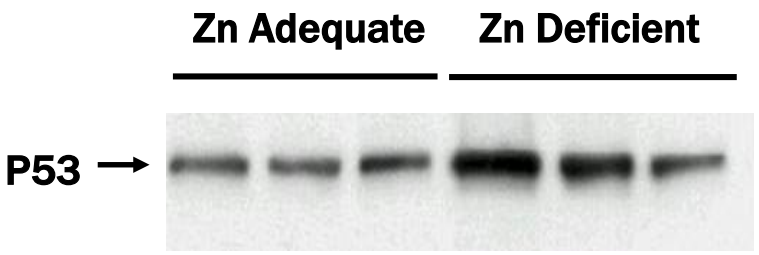
- However, there are no biomarkers for identifying individuals at risk for zinc deficiency.

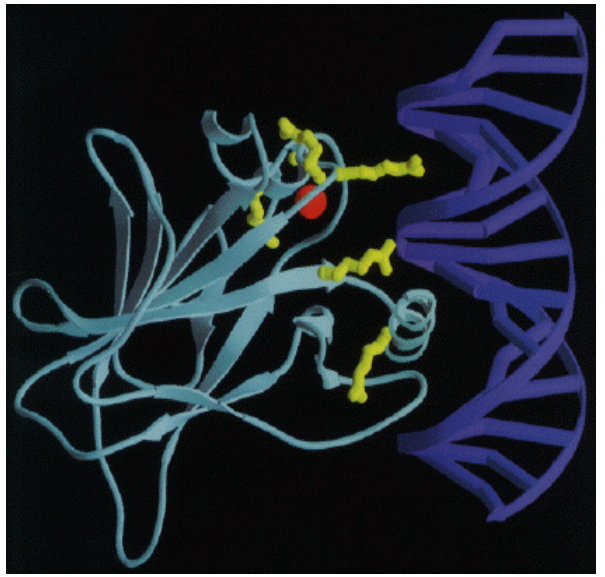
- Protein rich diets tend to be rich in zinc
- Americans get 70% of their dietary zinc from animal sources.
- Whole grain cereal products and plant proteins contain zinc in a less bioavailable form
  - Phytic acid decreases absorption
  - Calcium may decrease absorption

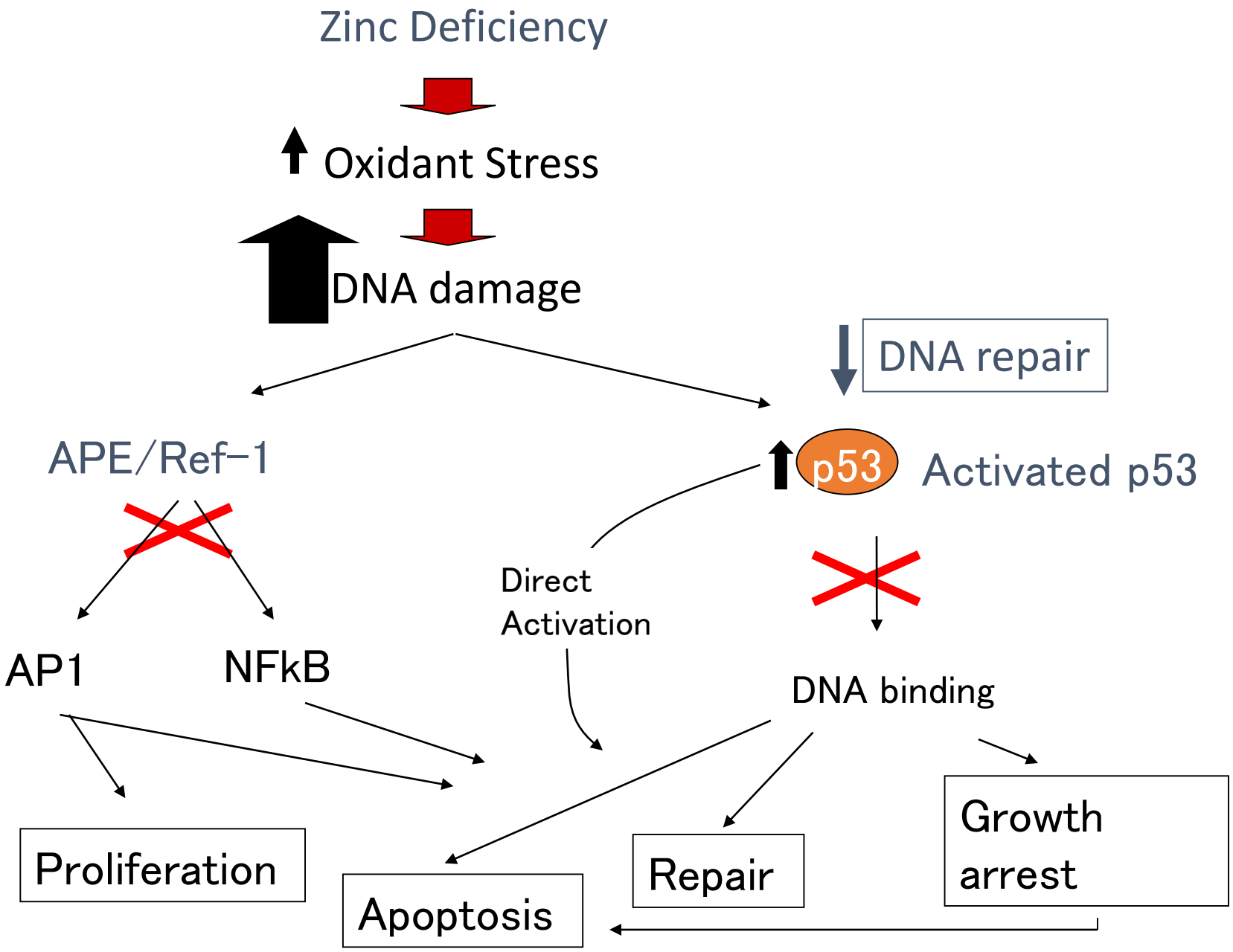
Zinc Deficiency Induces Oxidative Stress and DNA damage





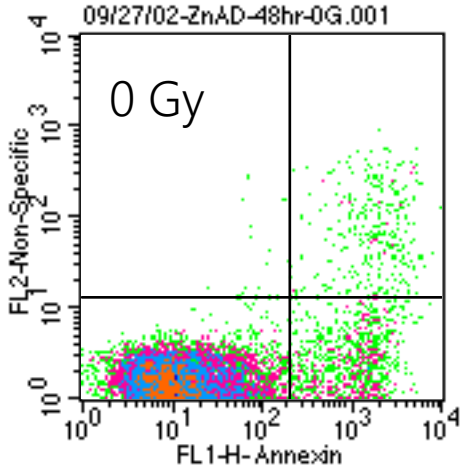


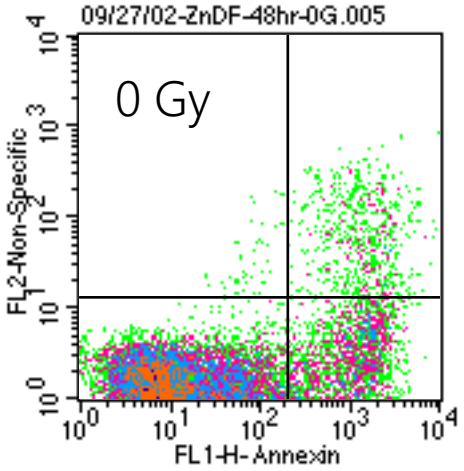


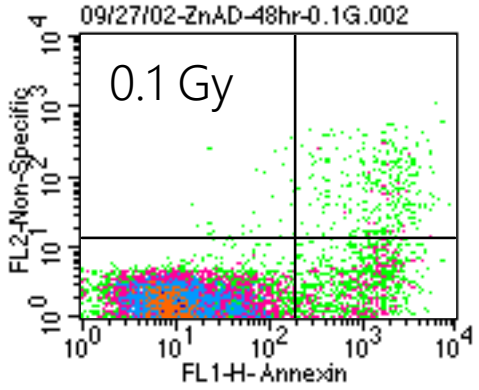

Zinc Deficiency
Oxidant Stress
DNA damage
DNA repair
APE/Ref-1
p53
Activated p53
Direct
Activation
AP1
NFkB
DNA binding
Proliferation
Apoptosis
Repair
Growth
arrest

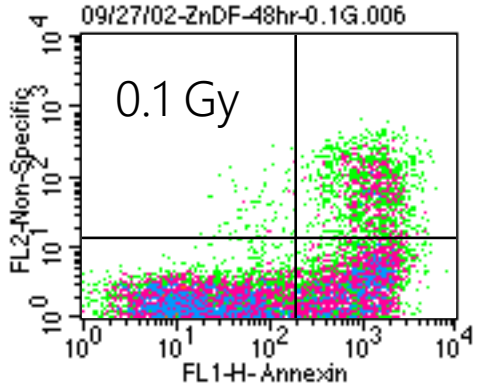
Zinc adequate

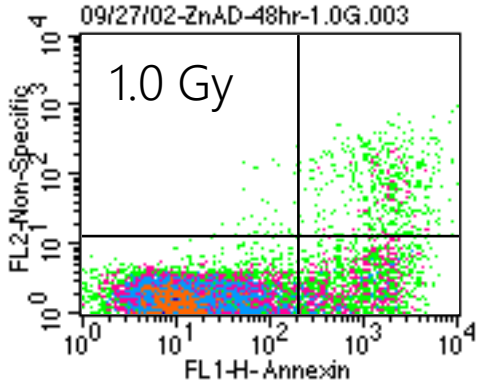
Zinc deficient

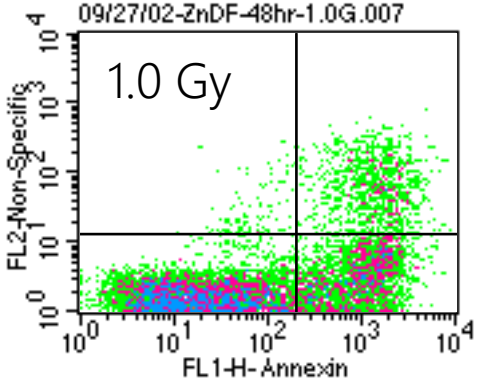










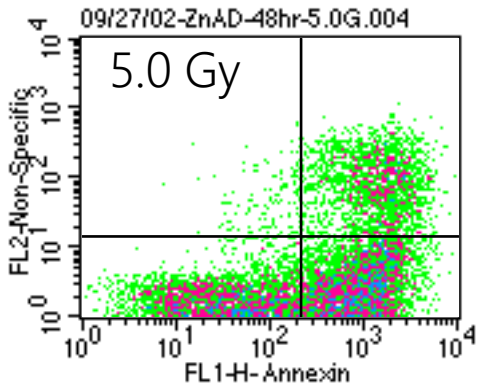


Propidium iodide

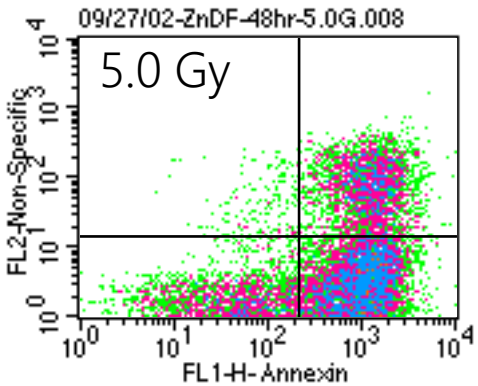
Annexin-FITC

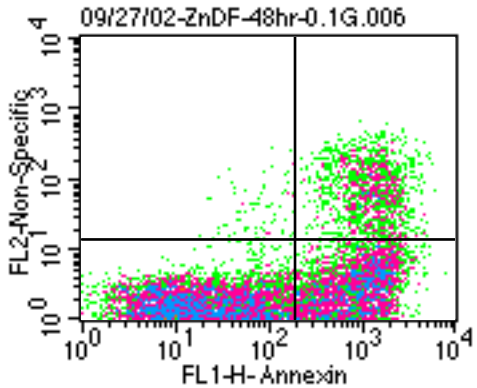
Annexin-FITC

Zinc adequate



Zinc deficient

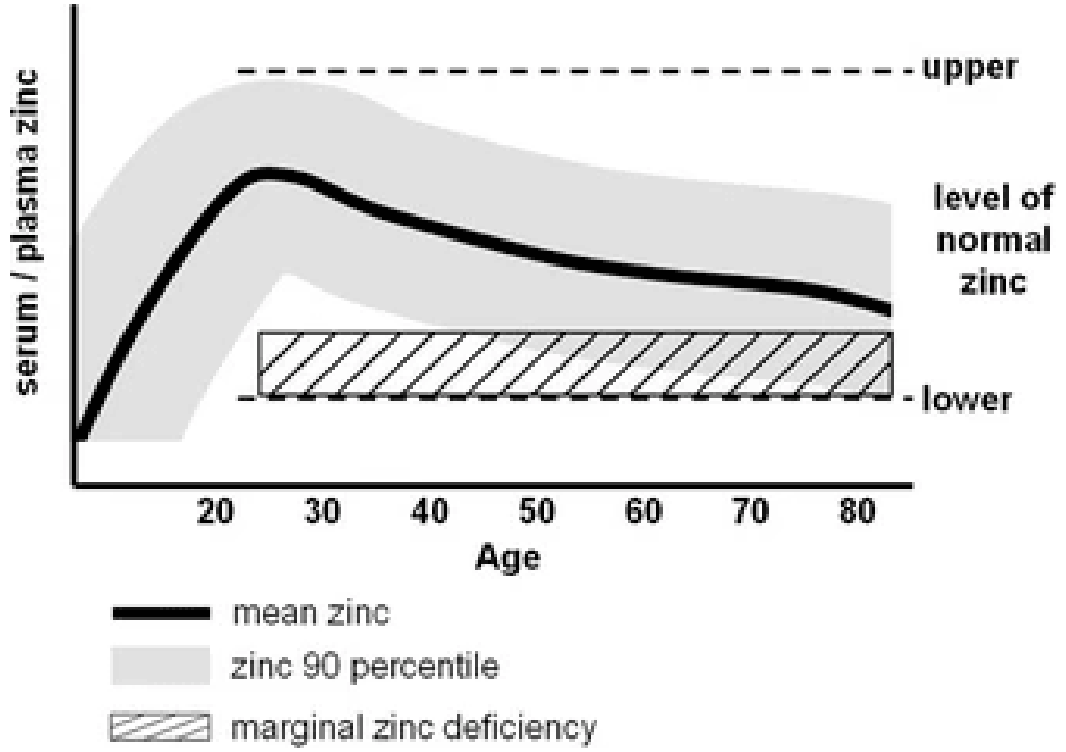




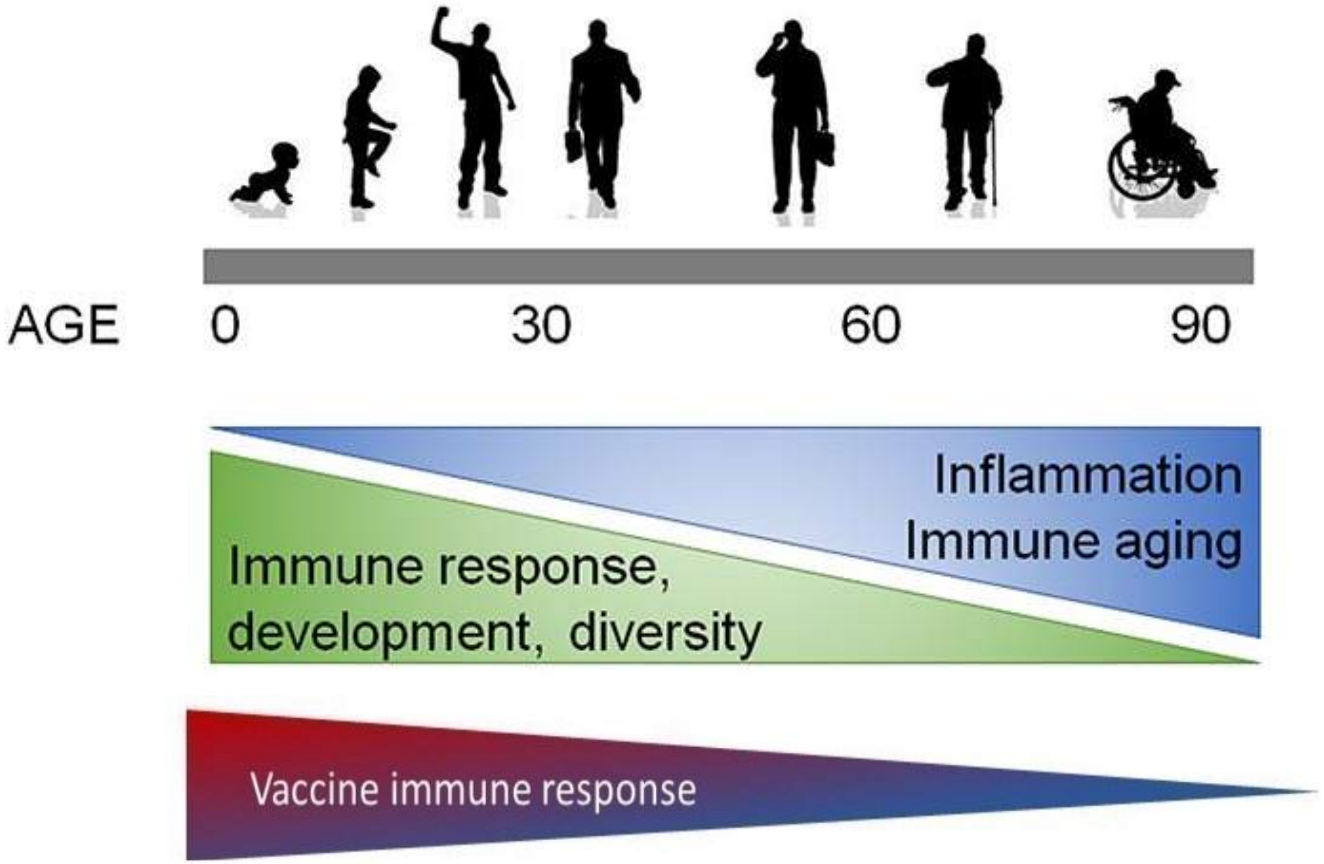
Zinc deficient- 0.1 Gy

Aging is associated with reduced zinc status

- Prevalence of inadequate zinc intake is higher in older adults
- Possible age-related changes in absorption and/or retention



Aging is associated with compromised immune system



- Increased susceptibility to infectious diseases
- Reduced vaccine efficacy
- Increased chronic inflammation

https://atlasofscience.org/the-aged-immune-system-in-multiple-sclerosis-focus-on-b-cells/

The immune system provides three levels of defense against disease-causing organisms:

1 BARRIERS
Prevent entry

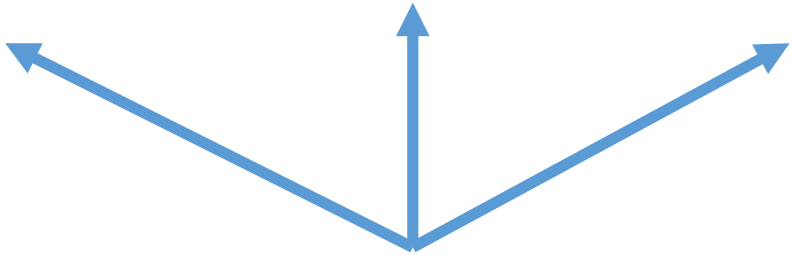
- Skin and mucus membranes
- Stomach acid and digestive enzymes
- Beneficial bacteria that live in the colon (the gut microbiota)

2 INNATE IMMUNITY
General defense

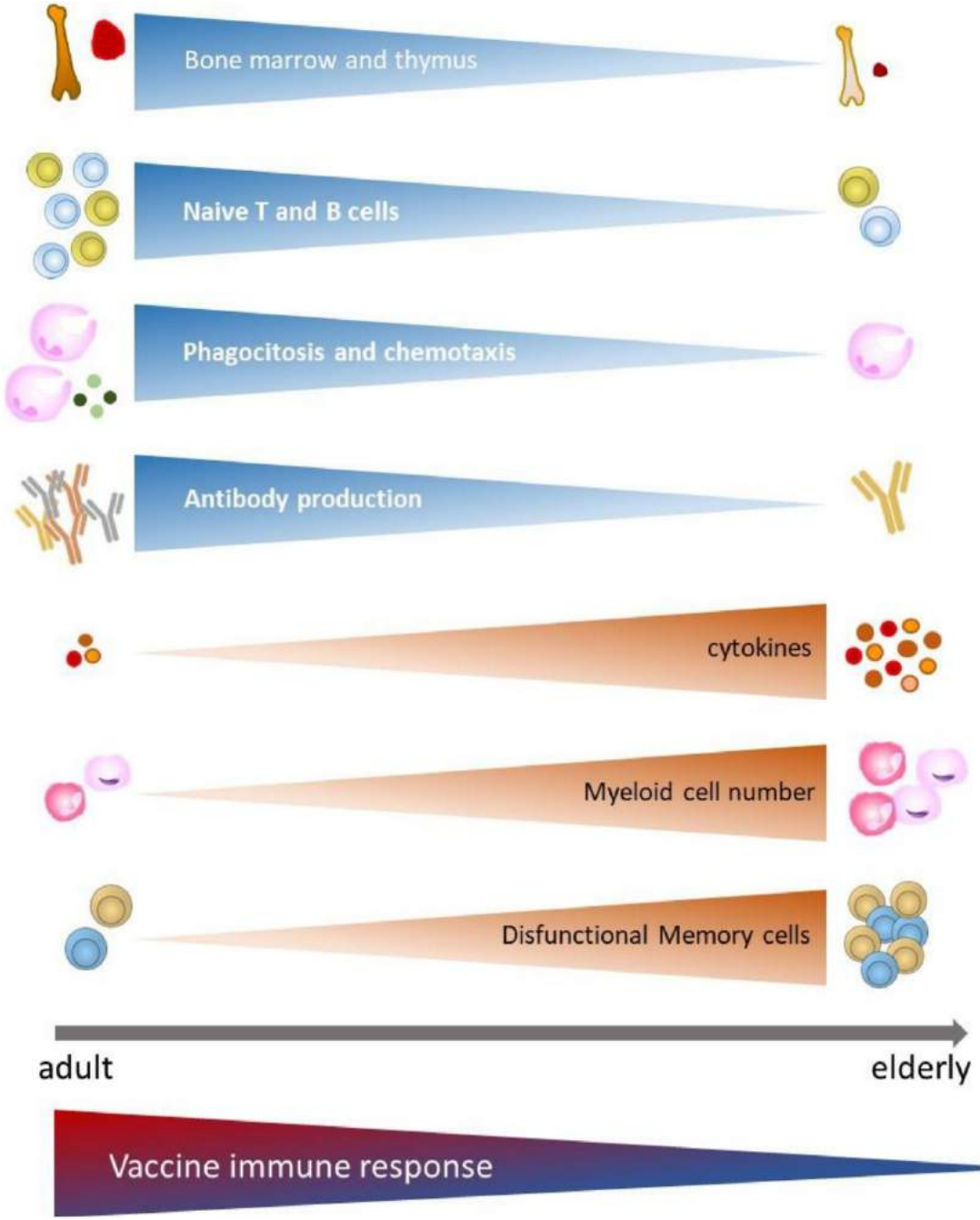
WBCs called neutrophils and macrophages engulf and destroy foreign invaders and damaged cells

3 ACQUIRED IMMUNITY
Specific defense

- WBCs called T lymphocytes (T cells) target and destroy infected or cancerous cells
- WBCs called B lymphocytes (B cells) and plasma cells produce antibodies that target and destroy infected or cancerous cells



ZINC is critical for each of these functions!

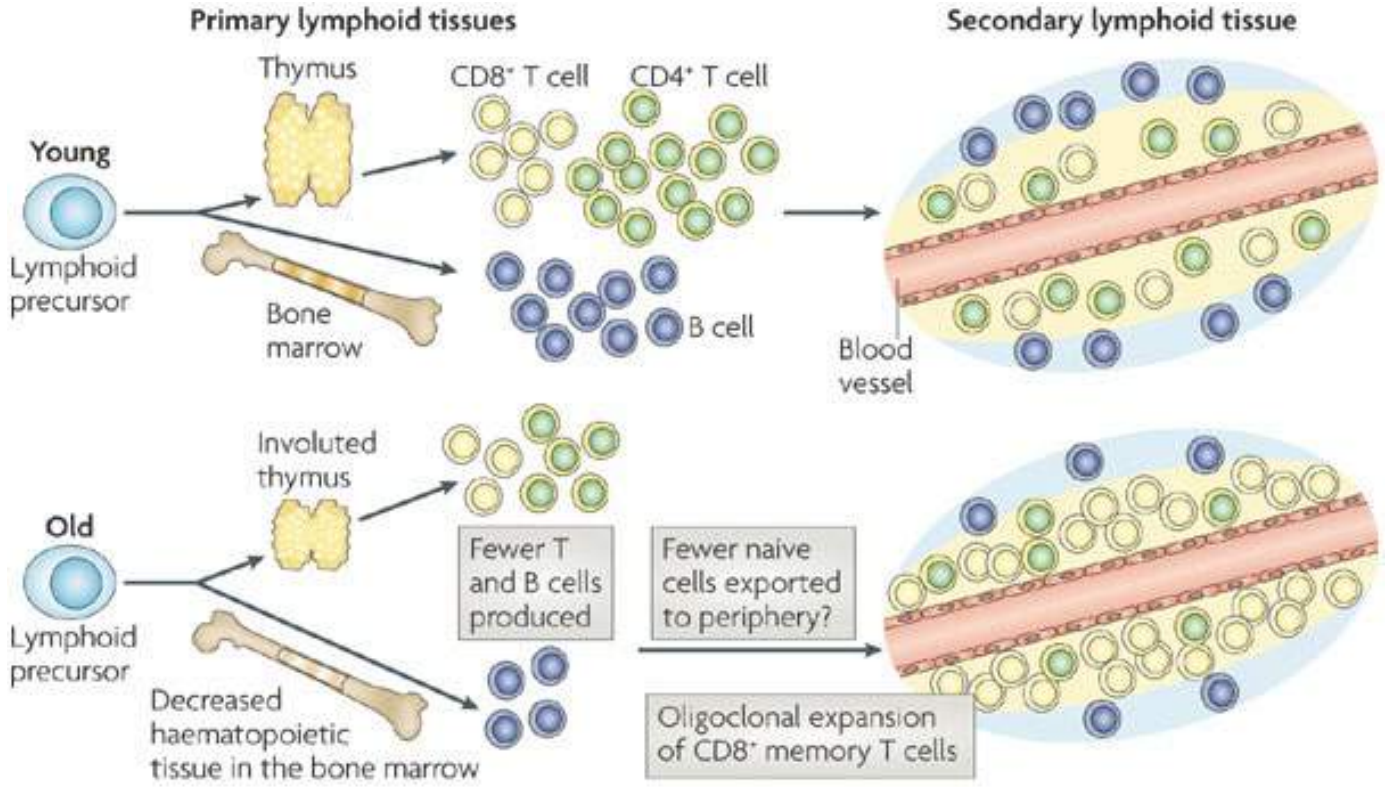


Aging is associated with progressive dysregulation of immune functions:

- Increased susceptibility to infectious diseases
- Reduced vaccine efficacy
- Increased chronic inflammation

https://www.sciencedirect.com/science/article/pii/S1044532318300678

Aging is associated with a progressive dysregulation of immune functions



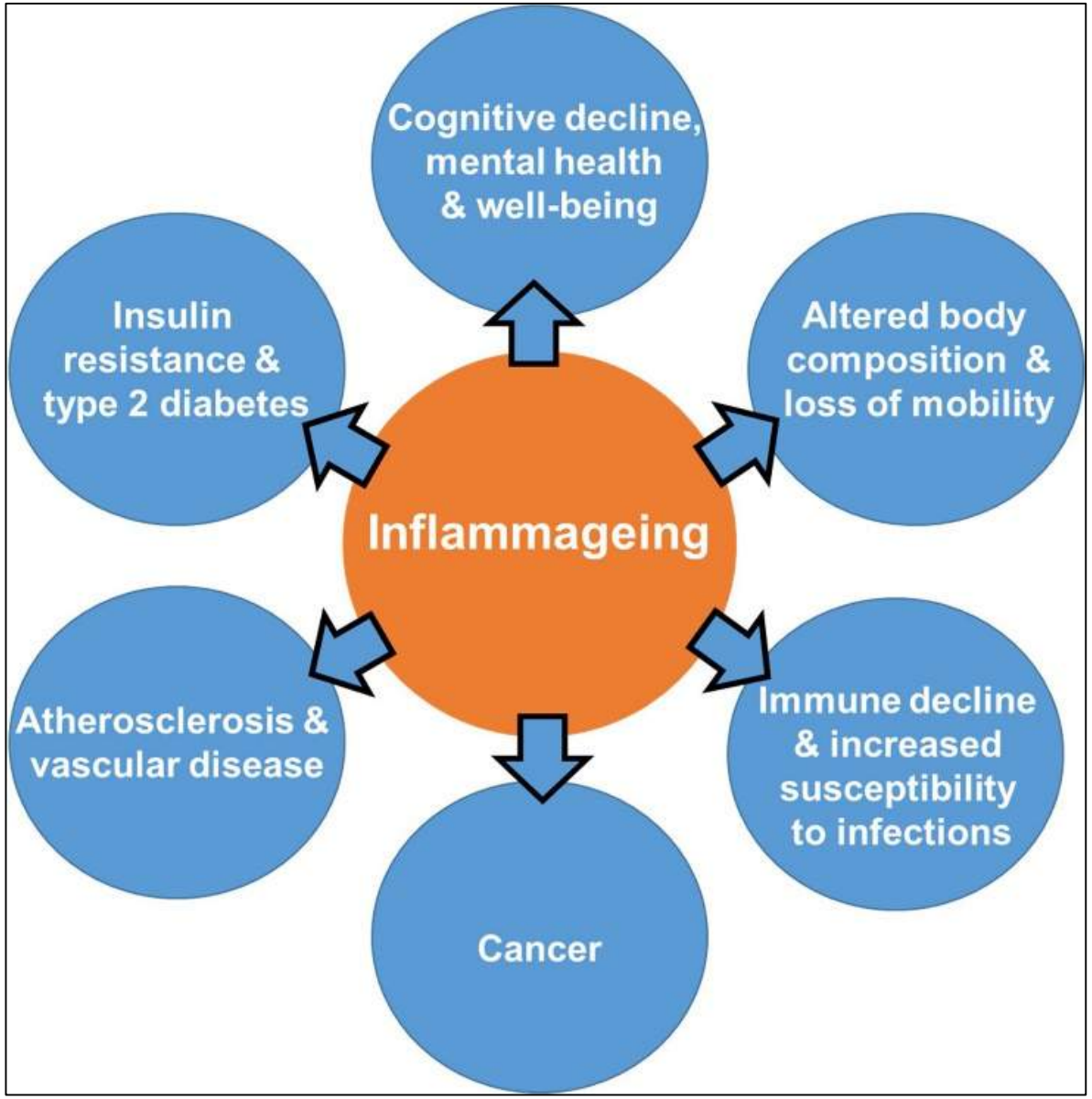
Thymic atrophy
Reduced hematopoietic tissues in bone marrow

→

Reduced number of naïve T and B cells in the periphery

→

Increased susceptibility to infectious diseases
Reduced vaccine efficacy


Cognitive decline, mental health & well-being
Insulin resistance & type 2 diabetes
Altered body composition & loss of mobility
Inflammageing
Atherosclerosis & vascular disease
Immune decline & increased susceptibility to infections
Cancer

Effects of severe zinc deficiency are similar to effects of aging on immune functions

- Reduced thymic output, lymphopenia, depressed adaptive immunity
- Impaired host defense, increased risk to opportunistic infections
- Increases in inflammatory cytokines
- Increases oxidative stress and DNA damage that promotes inflammation

➢ Does low zinc status contribute to age-related chronic inflammation in the elderly?

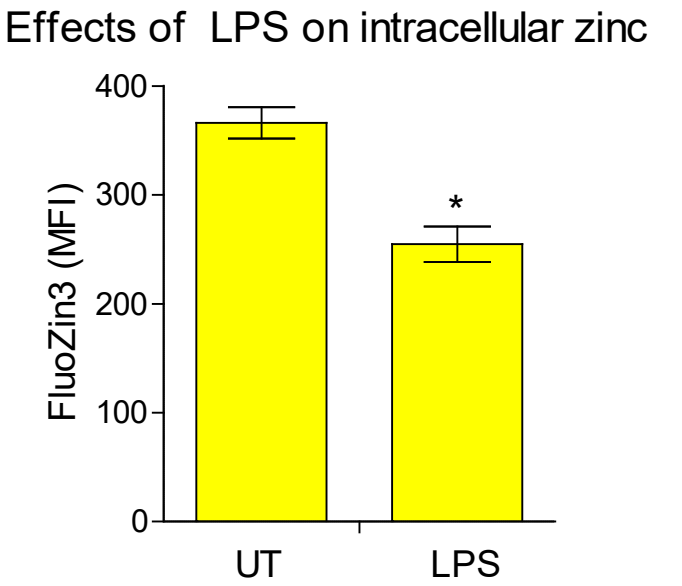
Reduced zinc status with age

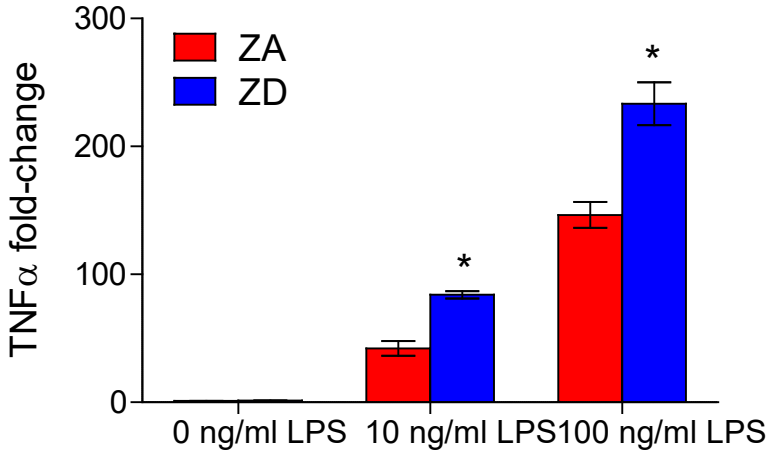
- In US, marginal zinc deficiency is a potentially widespread problem
  - 12% of the US population does not consume the estimated average requirement (EAR) for zinc
  - Prevalence of inadequate zinc intake is even higher among individuals above 50 years of age (40% of men and 45% of women consume less than the EAR)

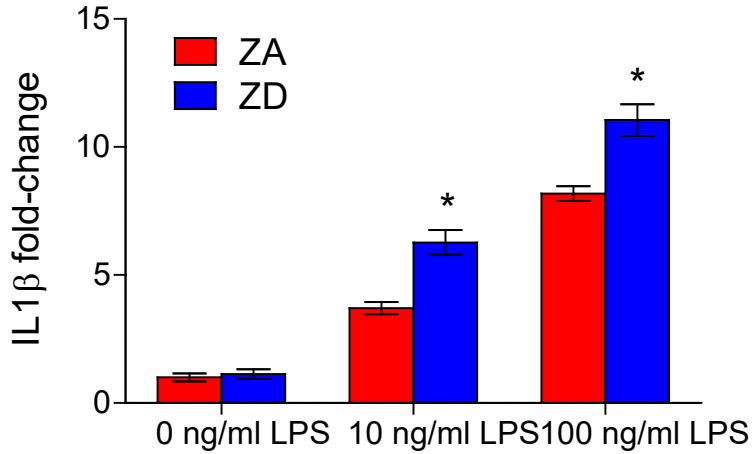
- In the elderly, insufficient nutrition, alteration to absorption, and/or retention of zinc can lead to elevated risk for marginal zinc deficiency that affects immunity

- Precise mechanisms linking zinc loss, age, and inflammation are unclear

Proinflammatory response is associated with reduced intracellular zinc and is enhanced by zinc deficiency

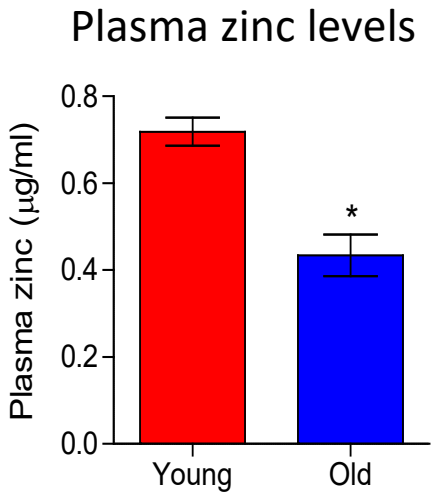


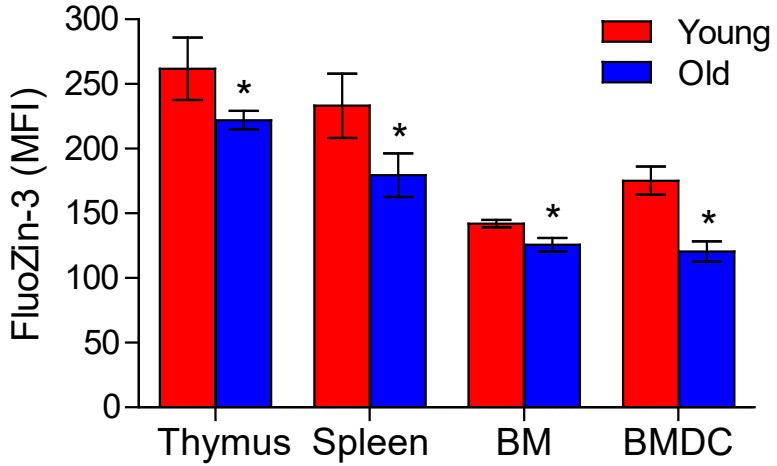




Wong et.al, JNutrBiochem 24:353-359, 2013

Aged mice have reduced intracellular zinc in immune cells

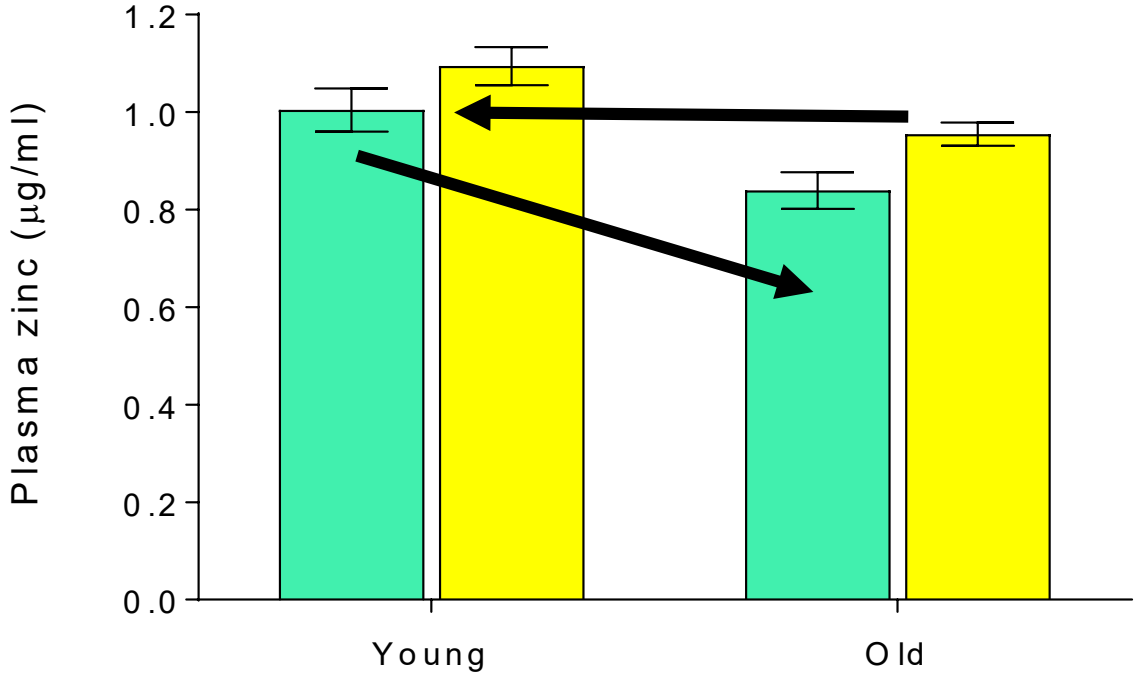


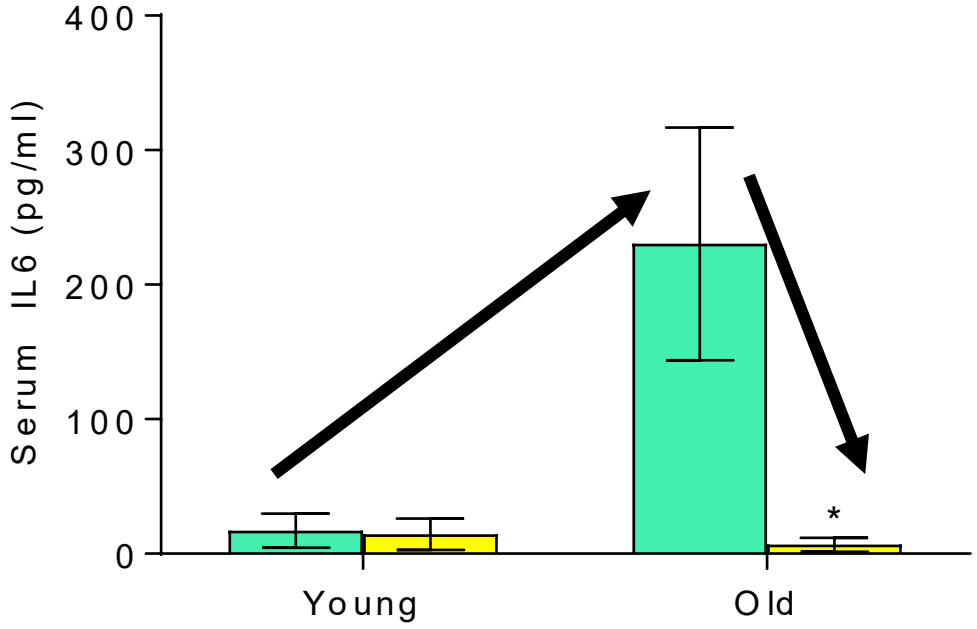


- Dendritic cells (DC) are professional antigen presenting cells that process and present antigens to T cells for immune activation
- Upon encounter with inflammatory stimuli (e.g. LPS), DC mature and activates and elicits a potent inflammatory response
- Bone marrow-derived dendritic cells (BMDC) differentiated from aged mice (7 days in zinc adequate DC-differentiating media) had reduced cellular zinc compared to young

Wong et.al, JNutrBiochem 24:353-359, 2013

Dietary zinc supplementation reduces age-associated inflammation





Zinc

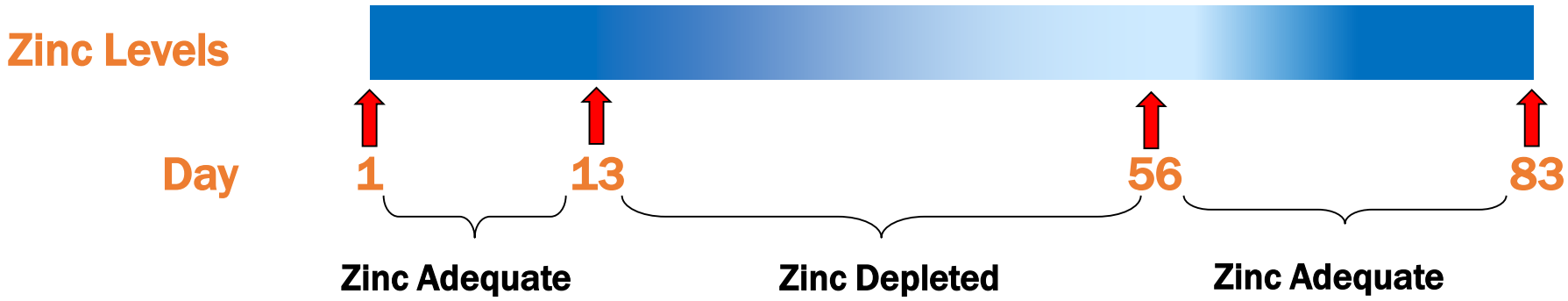
Zn
up to **40 mg per day**

Immune functions:
Zinc is required for the growth and development of immune cells. Zinc is a structural component of proteins critical for normal immune function. It is also important for the synthesis of antibodies.

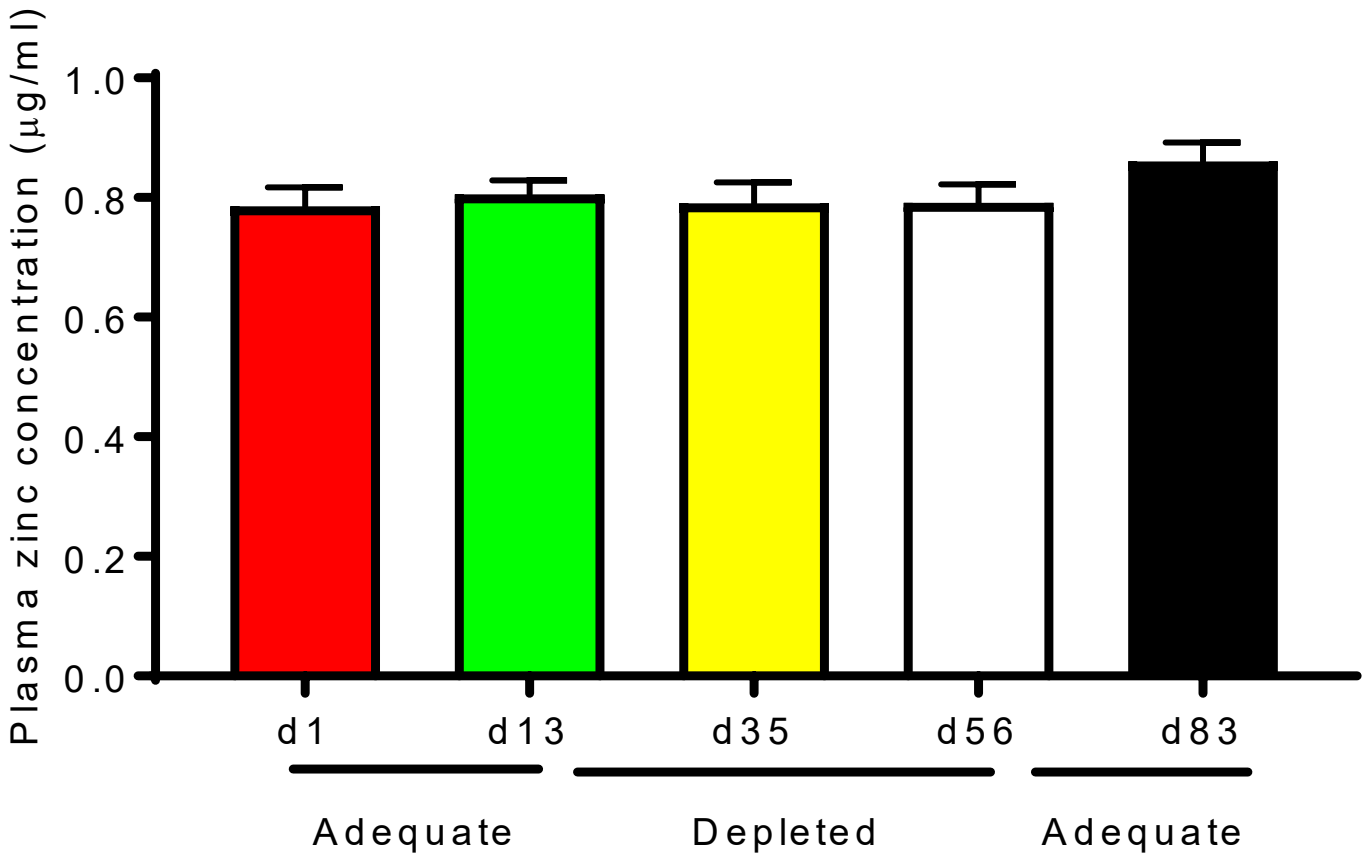
Why take a supplement?
Extra zinc might help if you feel a cold coming on. Older adults are more susceptible to zinc deficiency.

Caution:
Try not to exceed 40 mg of zinc a day from a combination of diet and supplements.

Finding markers of human zinc deficiency

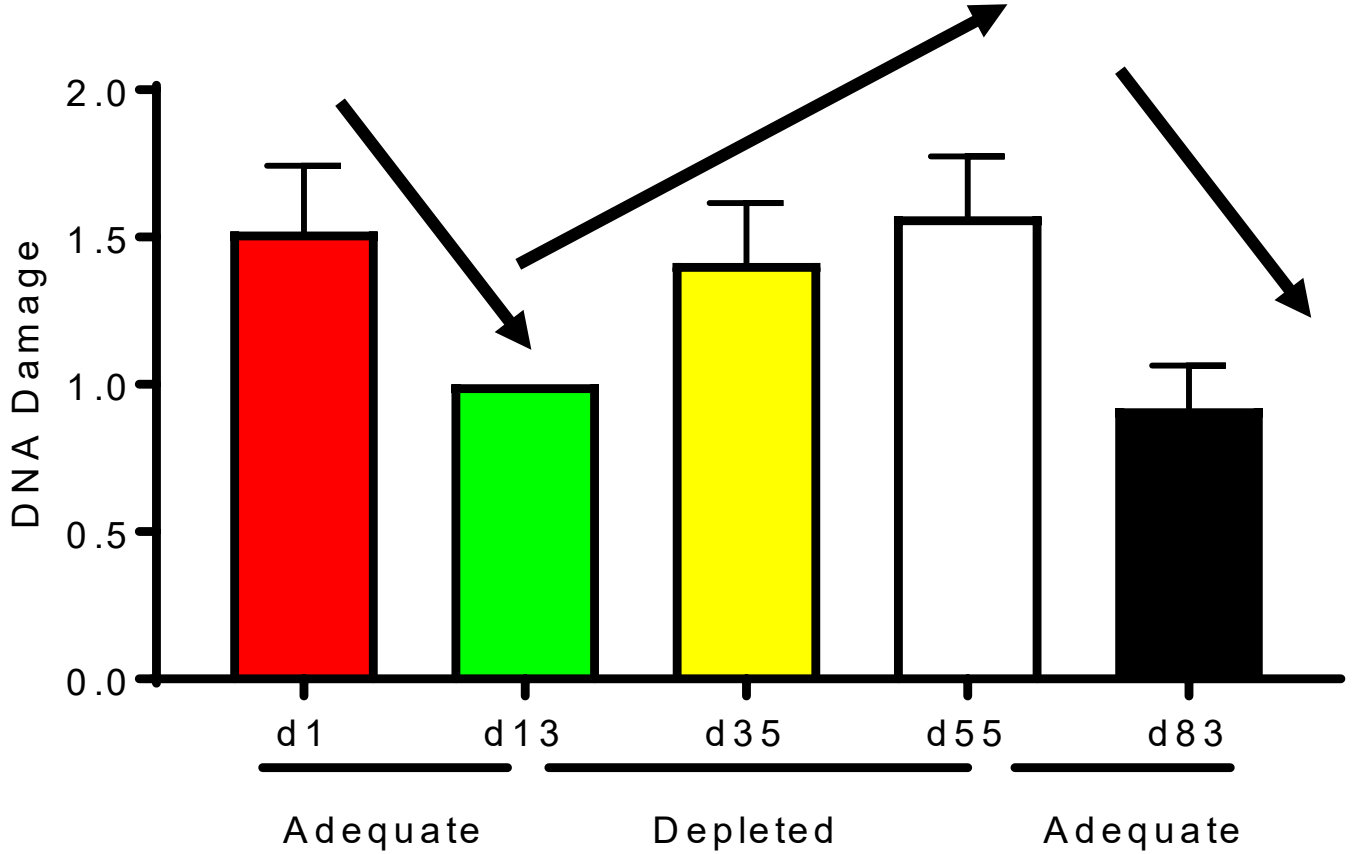


No change in plasma zinc!



Song et al, AJCN, 2009

But lack of zinc does cause some functional changes…



Song et al, AJCN, 2009

Zinc

Why take extra? Zinc is important for may parts of your immune system. You can take an extra zinc supplement if you feel a cold coming on, especially if your multivitamin does not have any.

How should I take it? Take zinc supplements 1 or 2 hours after a meal if it doesn't upset your stomach.

What do I need to know? Make absolutely sure you do not get more than 40 mg of zinc from your diet and supplements each day. Taking too much zinc will make it harder for your body to absorb copper and calcium.

Zinc
up to 40 mg per day

Zinc and COVID-19 – What's the evidence?

Is zinc beneficial in a viral infection?

Yes. Zinc helps support the immune system and may slow viral replication.

Can taking zinc prevent or treat COVID-19?

Perhaps. It may be important for maintaining a healthy immune system and could slow progression, but evidence in people is still limited.

Know The FACTS

- Make sure you are getting adequate zinc daily
- You can take extra zinc as supplement
- Too much zinc can also be bad for your health

Know The FACTS

- While zinc is important for the immune system, zinc alone cannot prevent or cure COVID-19 infections

- Still a lot more to learn about zinc and coronaviruses – we are learning more every day

The Immune System Foundation

The LPI recommendations are for adult men and adult women who are not pregnant or breast-feeding. These recommendations are from food and dietary supplements combined.

Vitamin A
(including beta carotene)
Men: 900 µg/day
Women: 700 µg/day

Vitamin B_6
Men and Women:
1.3 mg/day

Vitamin E
Men and Women:
15 mg/day

DHA
Eat oily fish
2 times per week

Vitamin B_{12}
Men and Women:
2.4 µg/day

Folate
Men and Women:
400 µg/day

Copper
Men and Women:
900 µg/day

Selenium
Men and Women:
55 µg/day

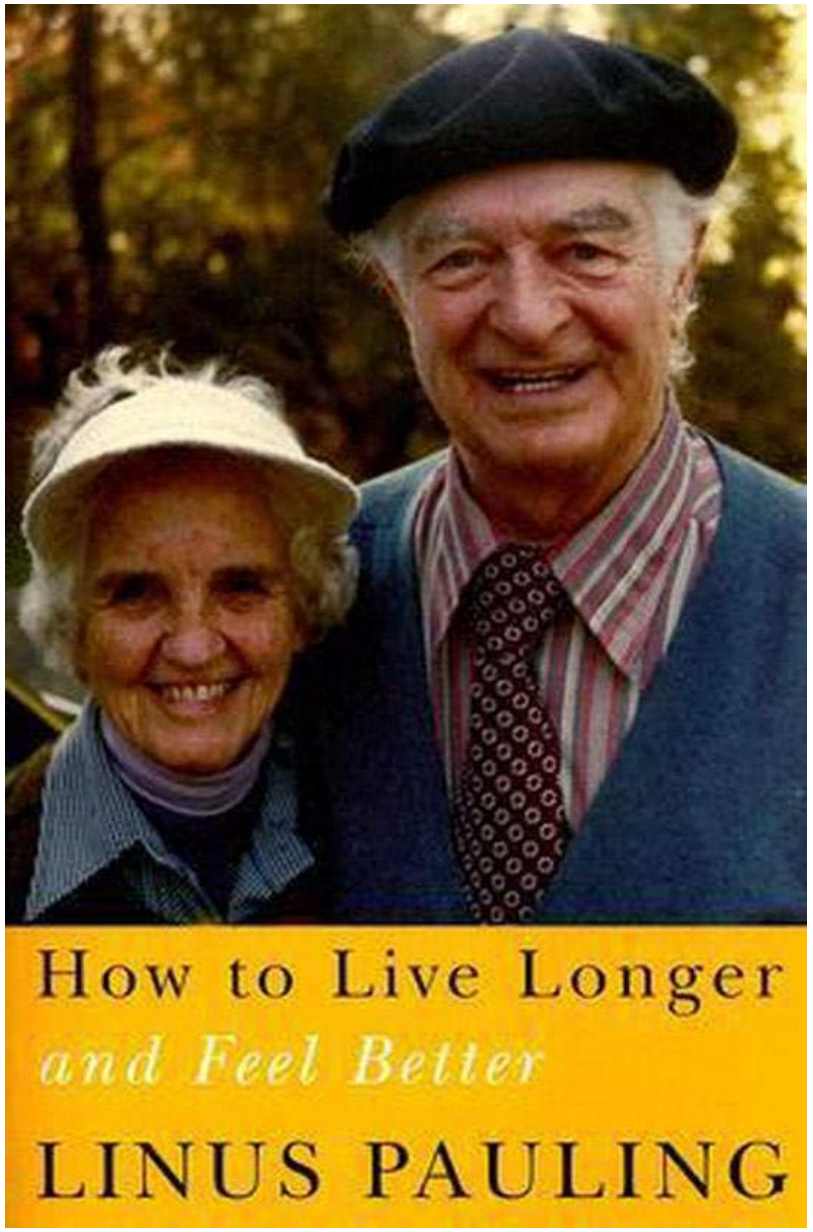
Vitamin C
Men and Women:
400 mg/day

Vitamin D
Men and Women:
2,000 IU/day

Iron
Men: 8 mg/day
Women: 18 mg/day
(See note below)

Zinc
Men: 11 mg/day
Women: 8 mg/day

Special note:
Before menopause, women need 18 mg of iron per day. Following menopause, this recommendation decreases to 8 mg per day.



Helping you live better longer…

Oregon State University
Linus Pauling Institute

Resources

- Immunity in Brief: https://lpi.pub/ImmunityBrief
- Immunity in Depth: https://lpi.pub/Immunity
- Nutritional Strategies to Support the Immune System: https://lpi.pub/ImmuneNutrition
- Micronutrient Information Center Article on Zinc: https://lpi.pub/MICzinc

THANK YOU

Questions? Comments?

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- Ask the Micronutrient Information Center
- Email to lpi@oregonstate.edu

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