

Emerging Trends: Implications for Nutrition and Foods for the Aging Population

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What Is Aging?

Many definitions have been proposed.

- In the broadest sense, it “reflects all the changes that occur over the course of life. You grow. You develop. You reach maturity.” It is part of everyone’s life.
- The aging process is complex, multifactorial, and multifaceted.
- Many terms have been used in describing aging: healthy, successful, natural, pathological aging. This has led to confusion. Lack of agreement on determinants and outcome measures have made study comparisons and interpretations difficult.

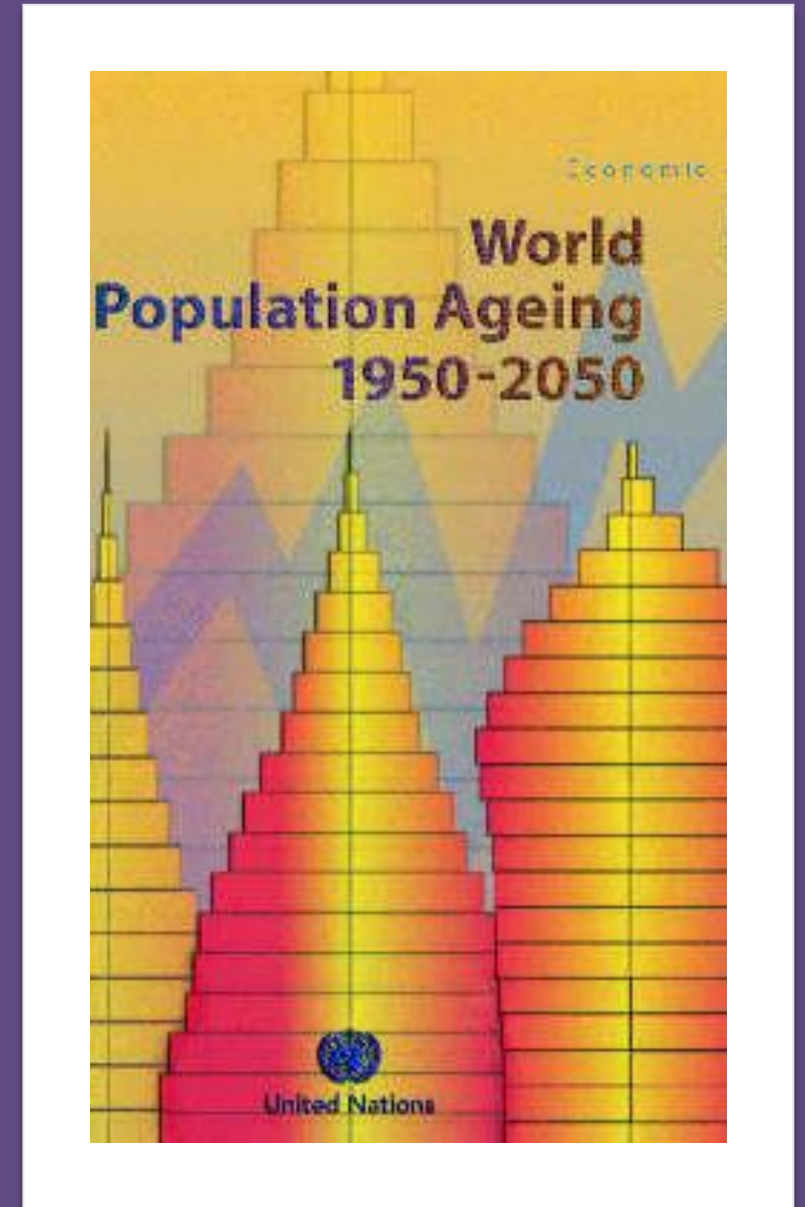
Why the Interest in Aging?

This Planet's Population Is Aging!

For the First Time in Human History, Global
Population Aging Is

UNPRECEDENTED PERVASIVE

PROFOUND ENDURING



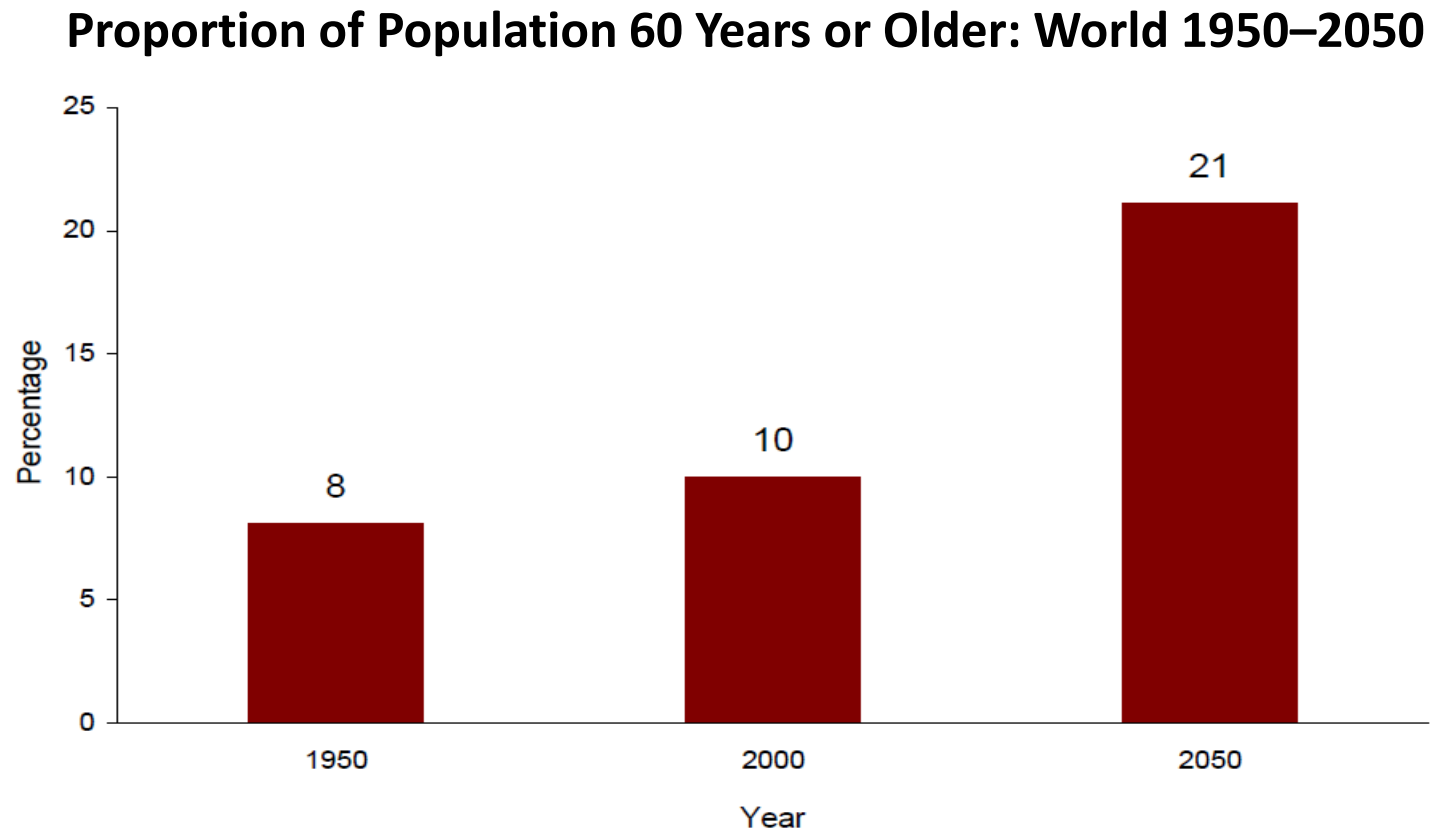
Global Aging in the 21st Century

Population aging is unprecedented.

- By 2050, the number of people aged 65+ years will exceed the number of people 15 years and under.
- Population aging is multigenerational: it affects foundations of society and all facets of human life.
 - ❖ economic growth, savings, investment and consumption, labor markets, pensions, taxation, and intergenerational transfers
 - ❖ social sphere
 - ❖ health and health care, family composition and living arrangements, housing and migration
 - ❖ political voting patterns and representation

Global population aging starts in the 20th century and will continue into the 21st century.

- The proportion of older persons was 8% in 1950 and 10% in 2000. It is projected to reach 21% of the world population in 2050.

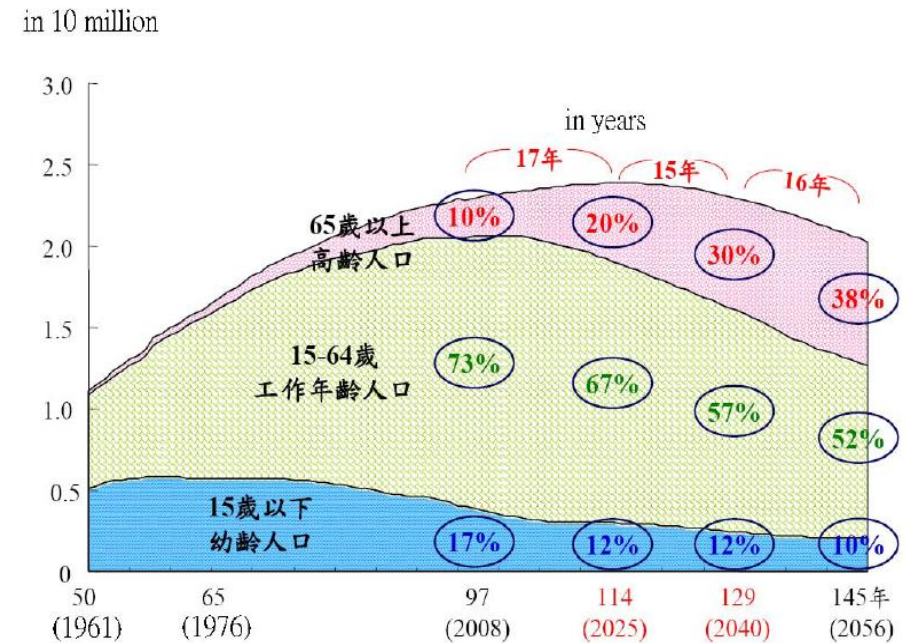


In Taiwan, between 2003 and 2013 the population aged 65+ increased 29% while the 14 and under population declined 25%.

Based on a survey by Taiwan's Department of Health, 88% of Taiwan's elderly suffer at least one chronic illness. The top three most common illnesses are cataracts, heart problems, and hyperlipidemia.

Sources: (1) Taiwan Ministry of Interior. (2) USDA Foreign Agricultural Service. GAIN Report TW14030. http://gain.fas.usda.gov/Recent%20GAIN%20Publications/Emerging%20Opportunities%20for%200an%20Aging%20Population_Taipei%20ATO_Taiwan_8-1-2014.pdf

Projection of Future Population Age Structure in Taiwan



Source: Population Projection 2008–2056 in Taiwan, R.O.C., Council of Economic Planning and Development, 2008.

This aging trend presents one of the toughest grand challenges of the 21st century.

It will need breakthrough solutions that are dynamic, implementable, and economically and resource sustainable.

Such breakthroughs will need scientific communities to work together as cohesive teams, applying a total systems approach to problem solving.

Aging research has been slow, because of its complexity—multifactorial influence and multifaceted impact.

However, many research signals are emerging in various disciplines, providing directional signals to solving the aging puzzle.

Research Signals

- Signals are emerging research/innovations or disruptions in trends that grow in scale with more data.
- They capture emerging events before they become obvious, providing early directions or “views.”
- Signals are useful to anticipate a highly uncertain future.

Early Signals Have Reset Views of the Aging Process

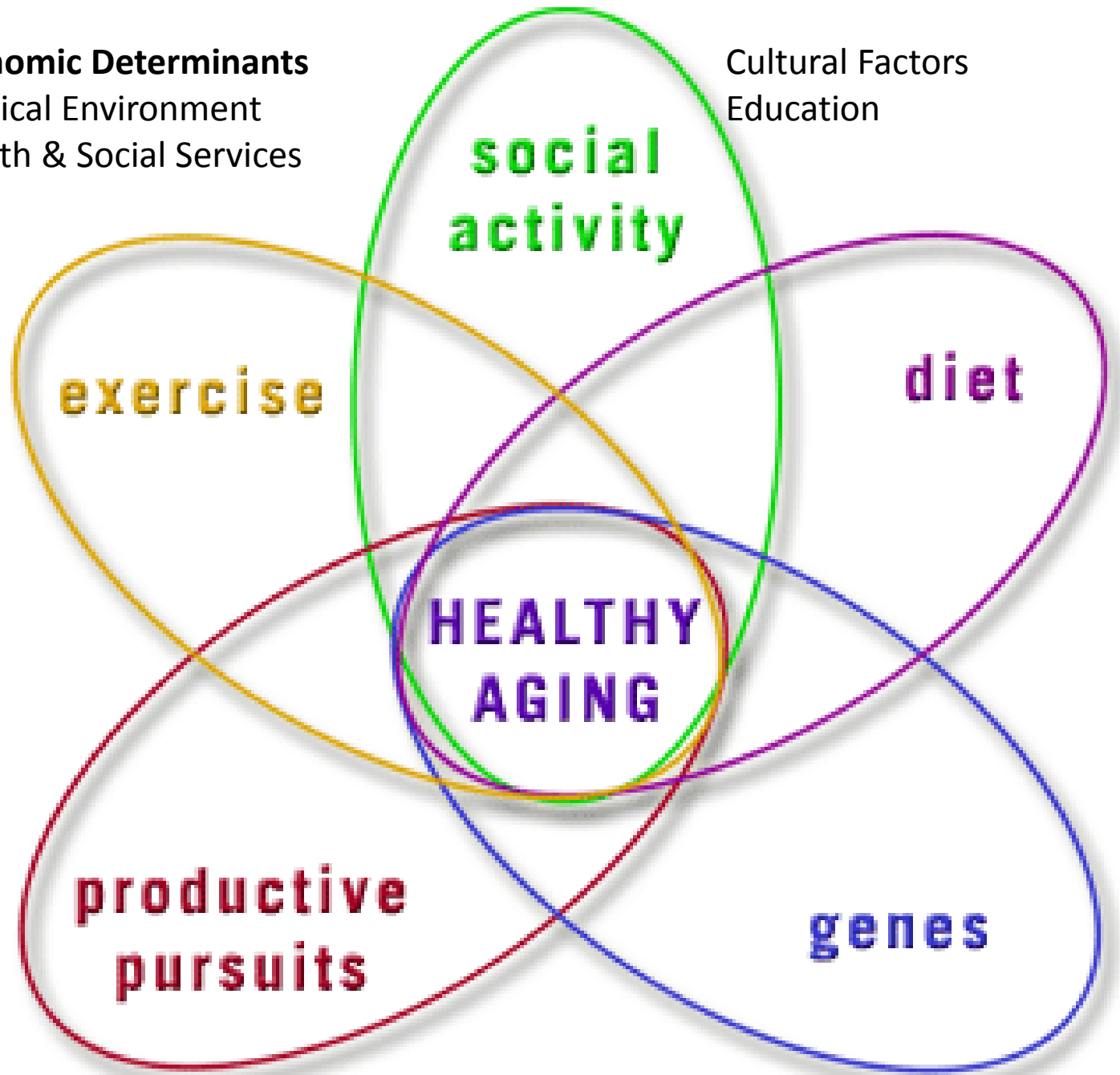
- Breakthroughs in many areas—cellular and molecular biology, socio-psychological studies on food behavior, chemosensory response during aging, and nutritional intakes in the elderly—offer new insights into:
 - ❖ onset, progression, propagation
 - ❖ avenues for improving health and disabilities
 - ❖ critical elements to improving quality of life
- Although many studies are early signals, cumulatively they are reshaping what we know now of aging.

Biology Signals: Resetting Current Views

- Aging is not a disease.
- Aging is the greatest risk factor for chronic disease and vice versa (?).
- It is a continuous process. Aging begins at birth and ends at death.
- Aging is not dependent on chronological age. No two individuals age at the same rate
- The aging process is highly malleable. It can be impacted (delayed or accelerated) and modifiable by extrinsic and intrinsic factors.

Economic Determinants
Physical Environment
Health & Social Services

Cultural Factors
Education



**social
activity**

exercise

diet

**HEALTHY
AGING**

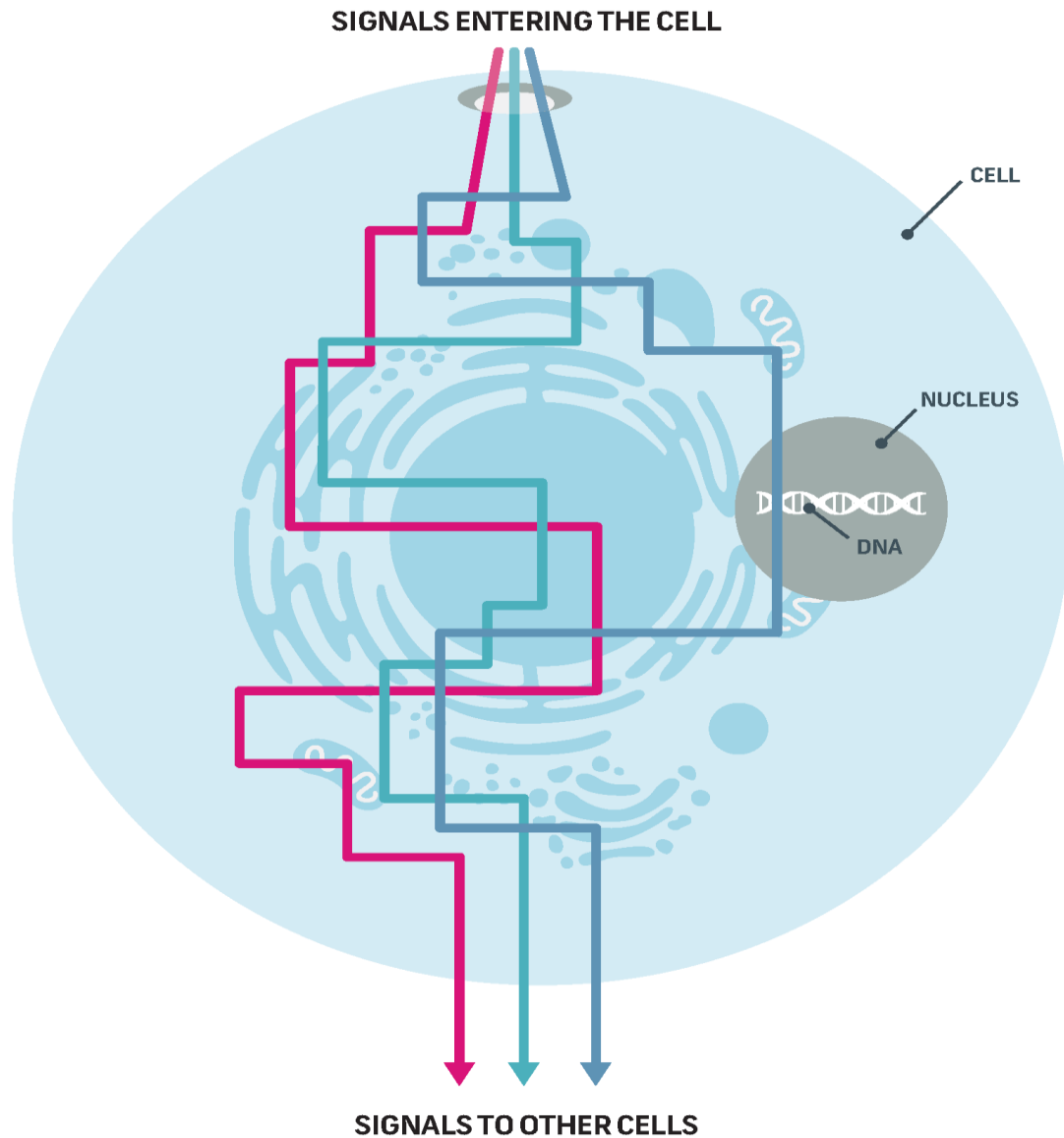
**productive
pursuits**

genes

Source: Permission from Klurfeld D. USDA ARS. Presented at the Pre-Conference Workshop, "Defining Healthy Aging: From Science to Practice, the Link to Diet and Nutrition," held at the 67th Annual Scientific Meeting of The Gerontological Society of America, Washington, DC; November 5, 2014.

Biology Signals: Biological Pathways

- Biological pathways involved in aging are also common pathways for other functions.
- Chronic diseases exacerbate the aging process.
- Interventions that increase lifespan may also extend health span.

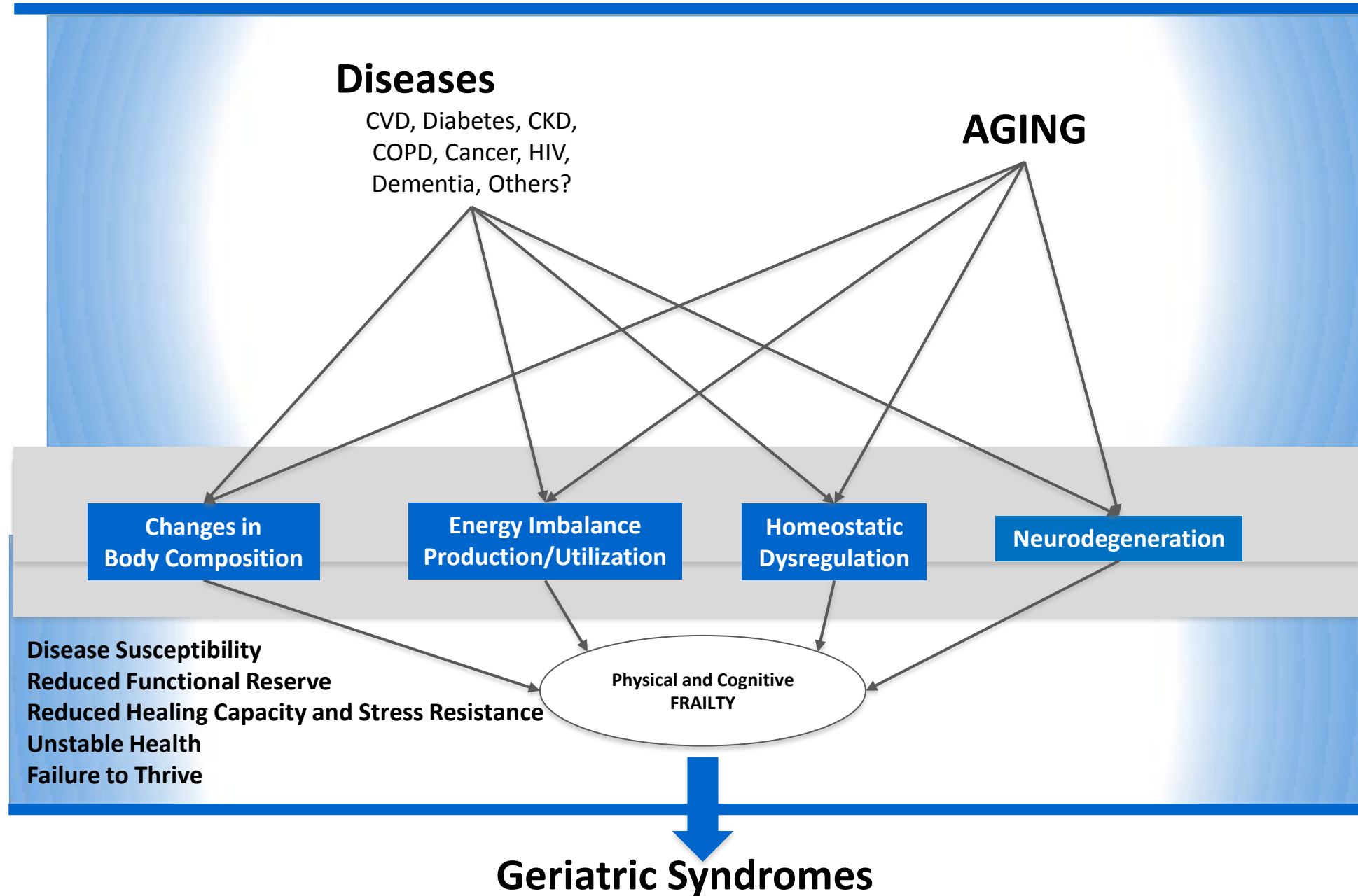


Possible Biological Pathways Leading to Aging

- Cells responding to internal or external cues coming from the body triggered by injury, infection, stress, or even nutrients and foods send and receive signals through biological pathways involved in metabolism, gene regulation, and signal transmissions.
- These pathways may also be important to aging.

**Many Chronic Diseases Affect
Aging Phenotypes**

Chronic Diseases Affect Aging Phenotypes



Mechanisms Where Disease and Aging Affect Aging Phenotypes and Longevity

Several mechanisms have been suggested:

- Cell senescence—where DNA damage from environmental insults (free radicals) and the cell is unable to regenerate itself, eventually causing cell death
- Deregulation of nutrient sensing
- Stem cell exhaustion
- Mitochondria dysfunction
- Telomere shortening—associated with longevity in some animal models, but not humans. Telomere shortening is associated with healthy aging.

Genetic and Longevity

- Longevity can be inherited across generations through epigenetic changes. This implies that parental lifespan and behavior may influence future generations.
- Although aging is influenced by genes (30%?), the majority (70%?) may be due to environmental and lifestyle factors such as diet, activity, stress, or circadian disruption.
- Most longevity genes identified thus far influence one of three pathways in a cell: insulin/IGF-1, sirtuins, or mTOR.

Immunity

Aging is associated with up-regulation of immune function genes.

- Dysregulation of the immune system leading to a pro-inflammatory state is an hallmark of aging.
- This explains why aging is the strongest risk factor for many chronic diseases mediated through dysregulation of the immune system, leading to chronic widespread systemic inflammation.

Systemic Inflammation

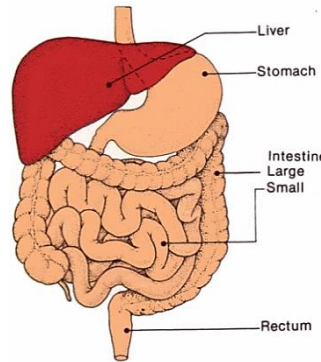
- Occurs when cells damaged by harmful stimuli triggered localized systemic inflammation to bring on repair and healing.
- Localized systemic inflammation can involve multiple organs: GI system, muscles, liver, bone, bone marrow, arteries, and brain.
- In the GI system, systemic inflammation reduces food/nutrient absorption, increases insulin resistance

Systemic Effects of Localized Inflammation



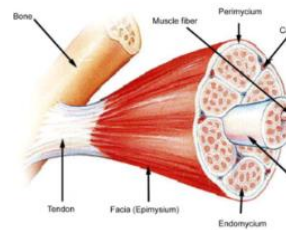
Systemic Effects

G.I. System



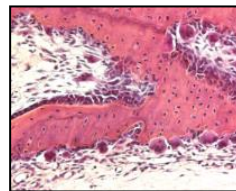
- Reduces food absorption
- Causes insulin resistance
- Stimulates glycogenolysis
- Down-regulates somatostatin

Muscle



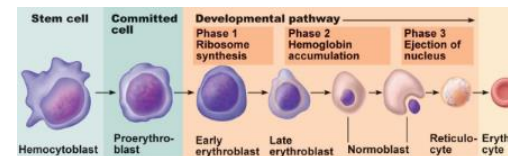
- Inhibits muscle growth
- Down-regulates IGF-1 signaling

Bone



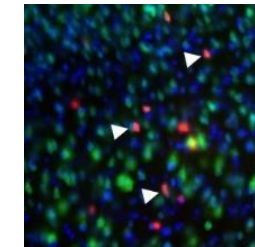
- Stimulates osteoclasts
- Down-regulates Osteocalcin

Bone Marrow



- Inhibits Hematopoiesis
- Down-regulates EPO signaling

Brain



- Activates microglia
- Inhibits Neurogenesis
- Down-regulates BDNF

Arteries



- Stimulates atherosclerosis
- Inhibit endothelial reactivity

Diseases and Disabilities Prevalence

- Aging is associated with increased risk of chronic diseases, such as heart disease, stroke, hypertension, diabetes, osteoporosis, weight gain or loss, or cancer.
- Dental caries, missing teeth, and periodontal diseases are common in older adults.
- Frailty and physical and mental declines are symptomatic of getting old.
- At later life, women will comprise the major proportions of the 80+ population.
- Survey by Taiwan's Department of Health reported that 88% of Taiwan's elderly suffer at least one chronic illness.
- Most common illnesses are cataracts, heart problems, and hyperlipidemia.

Nutrition Signals

- Malnutrition is common in a large proportion of the elderly population. Marginal intakes include omega-3s, vitamins D and E, Ca, Zn, folate, Se, and fiber.
- Dietary supplements on cognitive functions has shown little success in studies funded by the US National Institutes of Health (NIH).
- Beneficial effects with fruit/vegetable intakes have been reported for reducing cardiovascular disease (CVD) risks.
- Limited research on energy and nutritional requirements in healthy and pathological aging and in age-related disparities. This information is important for developing precision meals and eating patterns targeted to specific needs.

Food Signals

- **Food enjoyment**, having company, spiritual, and social support, cost, and nutrient density are critical elements for successful aging.
- **Fortified** and nutrient-dense foods contribute to improving nutritional status and some disability decline in elderly persons
- **Meal patterns** and intermittent fasting (in obese subjects) have been reported to lower blood glucose, a potential biomarker for healthy aging?
- **Caloric restriction** extends life and reduces DNA mutation in some animals
- **Starvation** releases stress responses in normal cells but not in cancer cells, a potential tool for cancer chemo-treatment with little side effects

Food Signals: Food Attributes

A 2014 report on food attitudes in Taiwan showed that older adults (60–70 age group) are:

- price-sensitive
- less brand-conscious
- receptive to certification seals
- receptive to authorities' endorsement on products

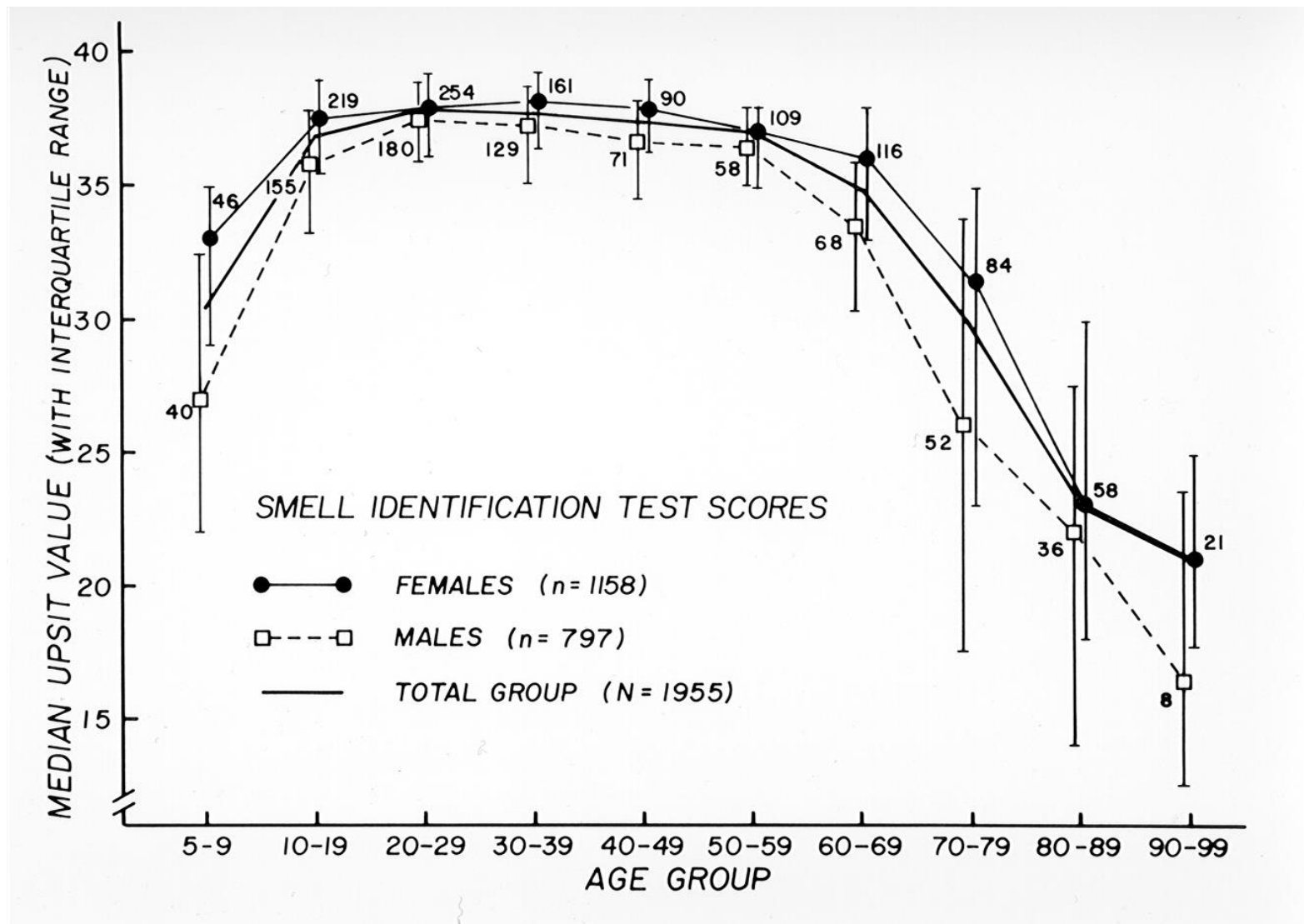
The most mentioned health needs for food/beverages are:

- no preservatives
- low salt
- low sugar
- low cholesterol,
- natural small portion
- softer texture

Sensory Signals

- Several studies in both animals and humans have reported declines in taste, vision, smell, and hearing responses with aging.
- These declines impact food intakes, choices, decisions, acceptance, and enjoyment.
- There have been repeated demonstrations of loss of olfactory functions beginning in the late 60s to early 70s and accelerating thereafter. Decline was more pronounced in men than women.
- Decline in regenerative capacity of olfactory cells may be an early indicator of decline in healthy aging.

Age and Smell Identification Ability



Prevalence of Smell Impairment by Age and Sex

(from a population-based, cross-sectional study of 2491 individuals)

Age	Women	Men	Total
53–59	3.8%	9.1%	6.1%
60–69	11.2%	24.7%	17.3%
70–79	20.8%	40.6%	29.2%
80–97	59.4%	69.5%	62.5%

Sensory Signals: Taste

- Elderly individuals are susceptible to localized losses of taste on the tongue.
- Such loss may be linked to the development of phantom taste sensations, which make some individuals more likely to have generalized taste loss following certain insults (e.g., viral, bacterial, medication-related).

Sensory Signals: Quality of Life Impact

Cowart at Monell found that sensory dysfunctions affected quality of life.

Smell Disorders

- Reduce food enjoyment, change food practice or pattern (add more salt, fat, sugar to flavor foods)
- *Increase safety* concerns (spoiled food, fire, gas leaks)
- Increase concerns about personal hygiene
- Impact job performance (chefs, chemical workers, firemen)

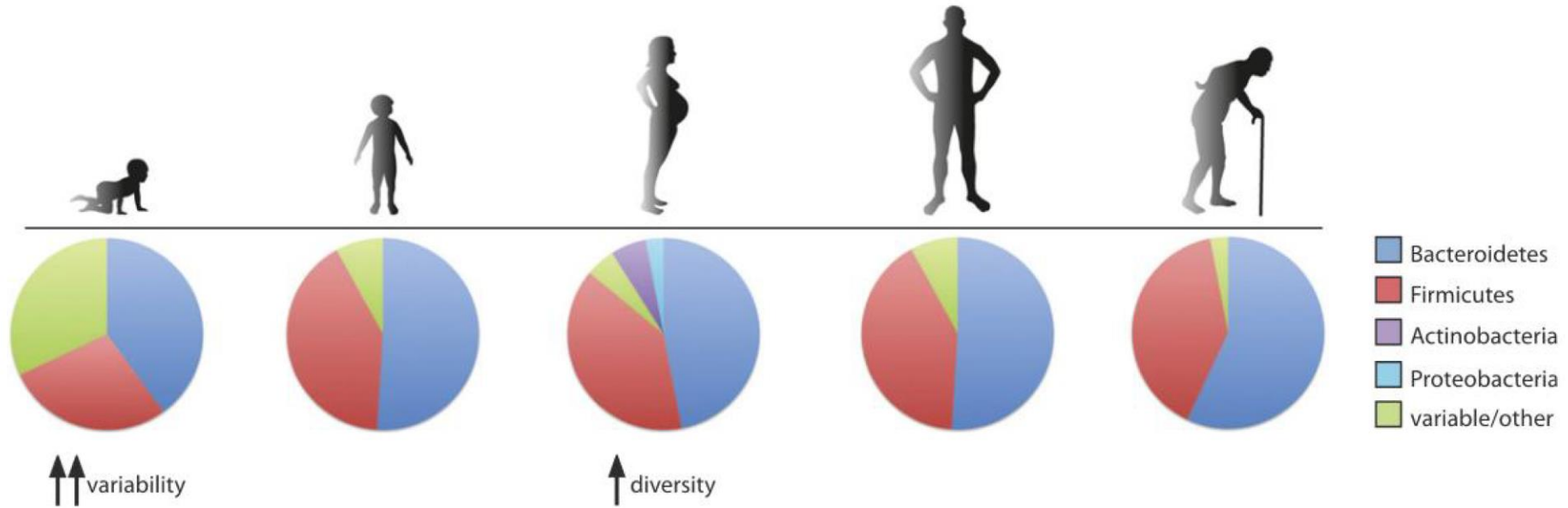
Taste Disorders

- Except for food enjoyment and job concerns for chefs, taste disorders impact quality of life less than smell disorders.
- However, taste disorders cause greater food intake difficulties and have a greater negative impact on affect than do smell disorders.

Microbiome Signal

- The human gut microbiome changes with age and may play a role in the process.
- Gut microbiota are modified by nutrition, food components, diet quality and quantity, stress, and activity.
- Like aging, no two individuals have the same microbiome. As a result, it is extremely difficult to define what is a healthy microbiome.
- Gut microbiome is genetically linked—human genetics shape the gut microbiome.
- The mode of action between food and the gut microbiome, as well as prebiotics and probiotics, remains an area of active research.
- Recent attention has expanded to the gut microbiome in disease pathogenesis, connected to brain, eye, immune system, and oral functions.

Though the human microbiome is a fixed feature, it is also a variable trait.



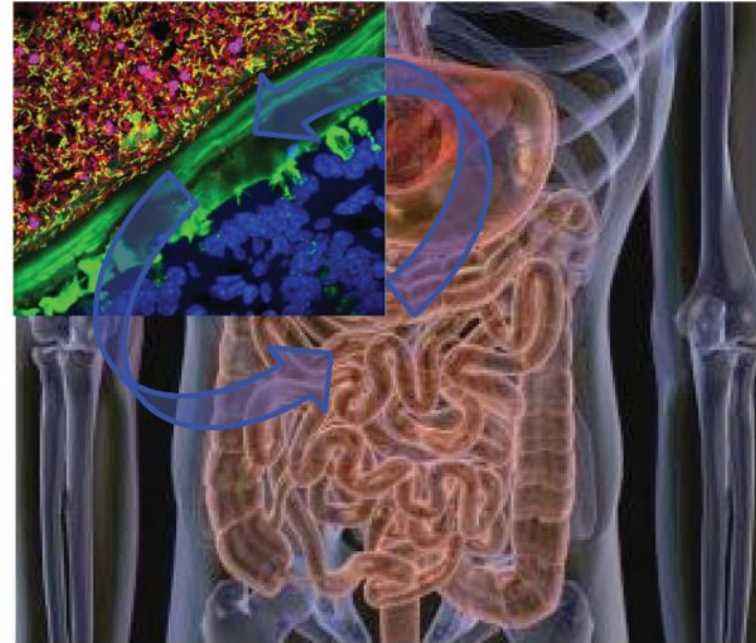
- ✓ Between generations
- ✓ Throughout our lifetimes
- ✓ Between health and disease

Unlike the human genome, the microbiome is naturally mutable.



Microbiota and host *interact* to regulate human health.

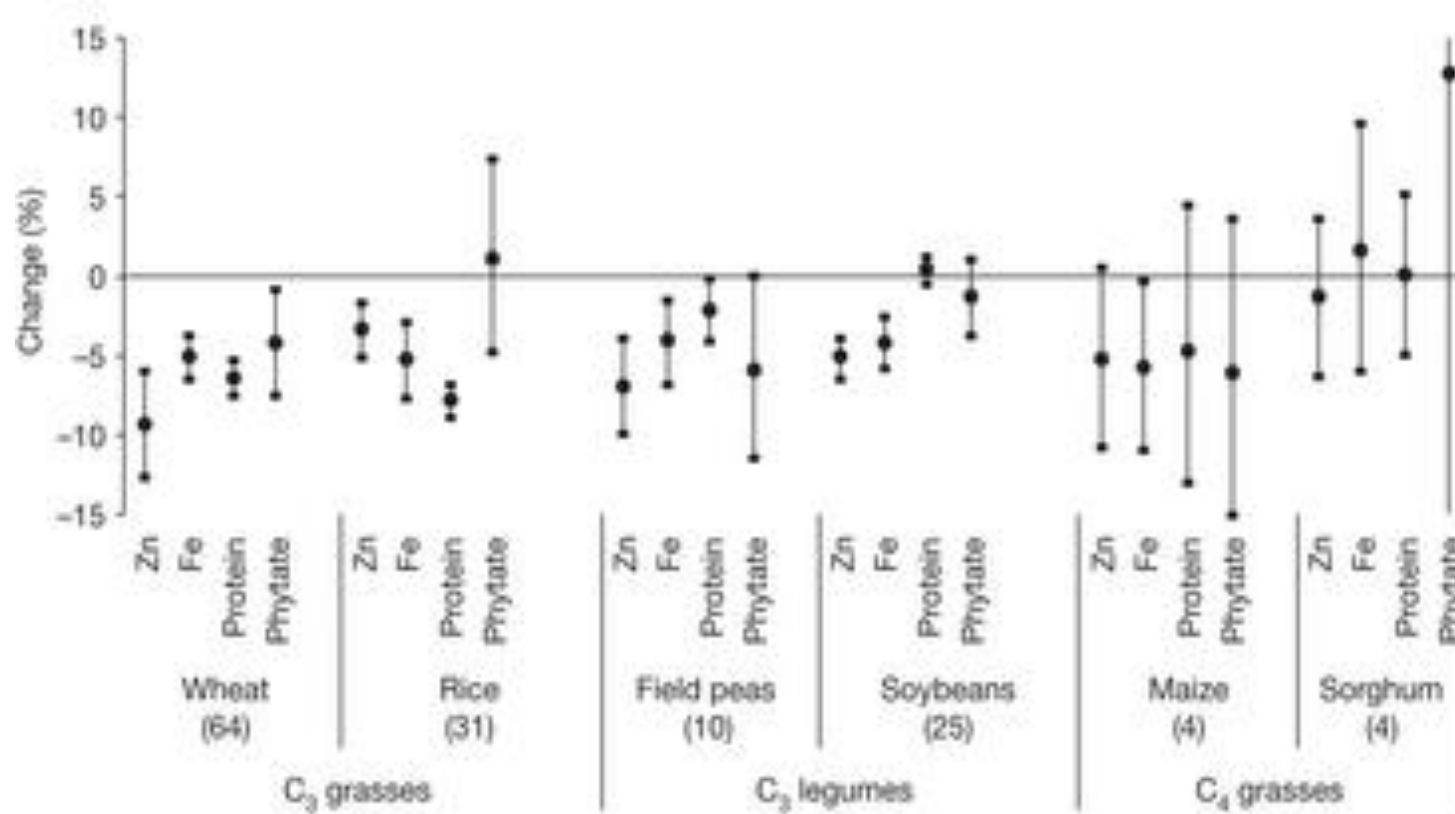
- ✓ 'educates' the immune system to recognize self from nonself,
- ✓ digests the 'indigestables' (ex. plant material, host cells, mucus),
- ✓ produces energy substrates for host cells (ex. SCFAs),
- ✓ metabolizes drugs,
- ✓ produces beneficial compounds (ex. vitamins, antimicrobials)
- ✓ produces signaling molecules which communicate with the host,
- ✓ gut microbiota communicate with the brain



Climate Change Signals

- Older populations are most vulnerable to climate and environmental changes (rising atmospheric temperature, environmental pollution, water quality and scarcity, food microbiological and chemical contamination).
- These environmental changes increase the risk of respiratory distress, CVD, allergies, decreased resiliency to food-borne pathogens, and mental depression.
- Increasing atmospheric CO₂ and temperature in research with different plant models showed reduction in nutritional quality (Fe, Zn, protein, and phytate contents) of some C3 grasses (wheat, rice) and C4 legume plants. C3 and C4 grasses are common food sources of nutrition and energy for elderly populations in regions of the world.

Percent Change in Nutrient Content at Elevated [CO₂] Relative to Ambient [CO₂]



Percent change (95% confidence intervals) in nutrients at elevated [CO₂] relative to ambient [CO₂]. N refers to the number of comparisons where replicates of a particular cultivar grown at a specific site under one set of growing conditions in one year at elevated [CO₂] have been pooled and mean nutrient values for these replicates are compared with mean values for identical cultivars under identical growing conditions except grown at ambient [CO₂]. In most instances, data from four replicates were pooled for each value meaning that eight experiments were combined for each comparison.

Other Emerging Signals

- Circadian rhythms, sleep disruption
- Emotional stress
- Physical activities
- State of hydration

Technology Signals

Many technologies are emerging that may be of importance for future research in foods and nutrition for the aging population.

- **Genomic tools:** omics, whole genome sequencing, KO mouse model, gene editing CRISPR
- **Cell therapy:** stem cells, cell regeneration
- **Imaging:** optogenetics, clarity, combination imaging for brain mapping
- **Big and Small Data and analytics:** body sensors and wearables
- **Food intake assessment:** cameras, population-specific mini food assessment tools
- **Sensory:** fMRI
- **Food technology:** nutrient fortification, biofortification, nanotechnology, high-throughput screening, 3D food printing

Research Enterprise

- Building the right research enterprise and network is critical for success in aging research.
- The complexity and long time frame of geriatric and gerontology research necessitates the involvement of multiple disciplines working in tandem.
- One such example is the formation of the Trans Geroscience Networking Group to maximize cross-functional research participation and cross-training and to promote information sharing and networking.

Building the Food-Nutrition Research Framework

- Taiwan is faced with unprecedented elder growth in the near future.
- The long-term food and nutrition solutions necessitate breakthroughs to solve the multifactorial and complex problems associated with a rapidly aging population.
- Successful solutions need thoughtful resourcing and must be economically sustainable.
- Evaluations of demonstrated success for interventions must be implemented to anticipate course corrections.
- Success is dependent on identifying the focal research needs and establishing clear, realistic, and measurable outcomes with defined benefits.

Resetting Thinking: Framing a Bold and Audacious Agenda for Food and Nutrition

The emerging signals offer opportunities to reset thinking of future approaches for food development and nutrition interventions that could improve and sustain successful aging.

1. **Prevention:** delay onset of aging, prevent disease onset and functional decline (across all age continuum?)
2. **Treatment:** delay aging progression/propagation of aging and diseases and functional decline (precision diet and pattern?)
3. **Promotion:** quality of life improvement and maintenance (diet/nutrition customized to lifestyle?)

Framing Aging and Food-Nutrition

Research Needs: Examples

- Aging begins at birth. Should prevention strategies to delay aging and prolong healthy aging start at childhood?
- Aging is a continuum. Should food programs take into account age disparities and disease status? If so, how?
- Aging is a malleable process and food and nutrients can modify this process. What research must be conducted to understand the role that food/diet plays in aging biological pathways/mechanisms, disease etiology, and reduction of functional decline?
- What gaps in guidelines are needed to develop optimal foods/diets customized to age phenotypes, lifestyles, and sociocultural and economic needs?
- What critical food attributes are necessary to satisfy intrinsic (physiological) and extrinsic (psychological, sociological, economical) requirements to increase chances of acceptance and longer-term compliance and success?

Framing Aging and Food-Nutrition Research Needs: Examples

- Aging is a major risk factor for chronic diseases and diseases exacerbate aging. Should current nutrition and dietary guidelines be refined or do new sets of guidelines need to be developed to provide more optimal and specific guidance for older age cohorts (70–100 years)?
- How and what changes occur in the sensory system (e.g., taste, smell, vision) with aging? How do we apply these learnings to food product development and communication?
- How would these foods be positioned, distributed, and regulated? Aging food/dietary landscape?
- What new skill sets are needed to prepare future investigators/developers for careers in food and gerontology or geriatrics programs?

Because aging is multifactorial, complex, and lifelong, food and nutrition research must be long term with sustainable funding. Clear and measurable objectives and end points, deployment of multidisciplinary approaches and skill sets, and evaluation measures of success and failures are all necessary ingredients.

Building the Food-Nutrition Framework

Success will entail the scientific communities to work as cohesive teams, applying a total systems approach to problem solving.

- *Transdisciplinary teamwork, cross-functional knowledge sharing, joint implementation*
- *Shared risks and success (skin in the game), public-private partnerships*

Why Is Such a Framework Important?

“Knowing is not enough; we must apply. Willing is not enough; we must do.”

—Goethe

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