

# Physiology of aging. How does the geriatric patient differ?



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# What is Aging?

**Ageing** (British English) or **Aging** (American English) is the process of becoming older

- Normal aging is not a disease
- Chronologic age & physiologic age are not the same
- Individuals “**age**” at different rates with significant variability

# Spectrum Of Aging

- **Aging**, with disease and disability
- **Usual aging**, with the absence of overt pathology, but with some declines in function
- **Successful aging** or *healthy aging*, with little or no pathology and little or no functional loss

## Both in their 90's



# Our Objectives

Outline the main aging theories

Describe major age-associated changes in physiology

Understand the importance of impaired homeostasis

Be able to assess nutritional status of older adults

Be able to compare usual to successful aging

# Two Main Aging Theory Categories

- **Programmed Theories**

Aging has a biological timetable or internal biological clock

- **Error Theories**

Aging is a result of internal or external assaults that damage cells or organs so they can no longer function properly.

# Programmed vs. Error Theories

## Programmed Theories

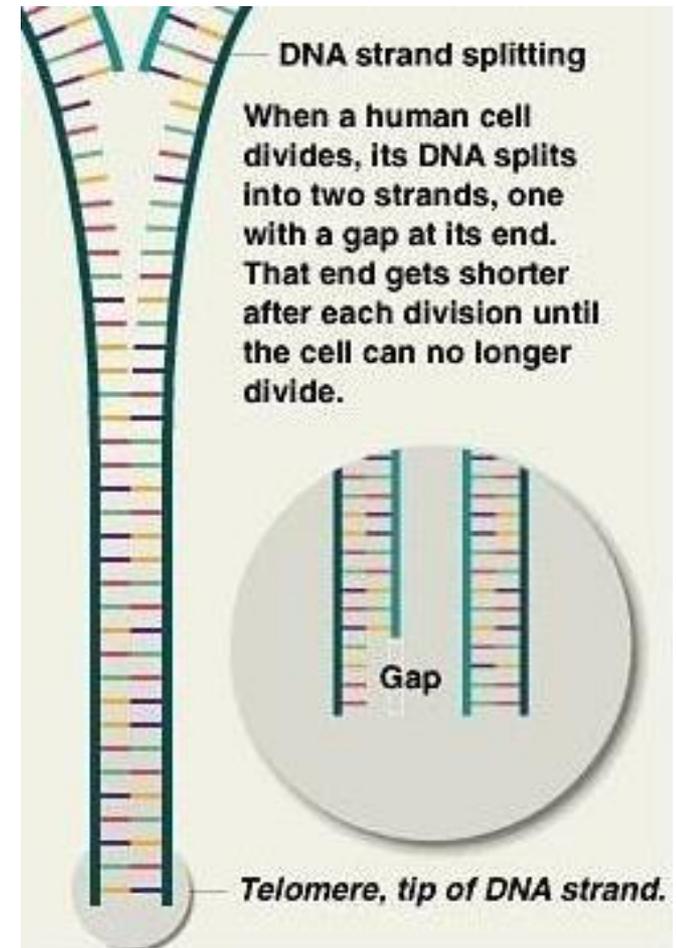
- Programmed Senescence Theory
- Endocrine Theory
- Immunology Theory

## Error Theories

- Wear and Tear Theory
- Rate-of-Living Theory
- Cross-linking Theory
- Free Radical Theory
- Error Catastrophe Theory
- Somatic Mutation Theory

# Telomeric Theory

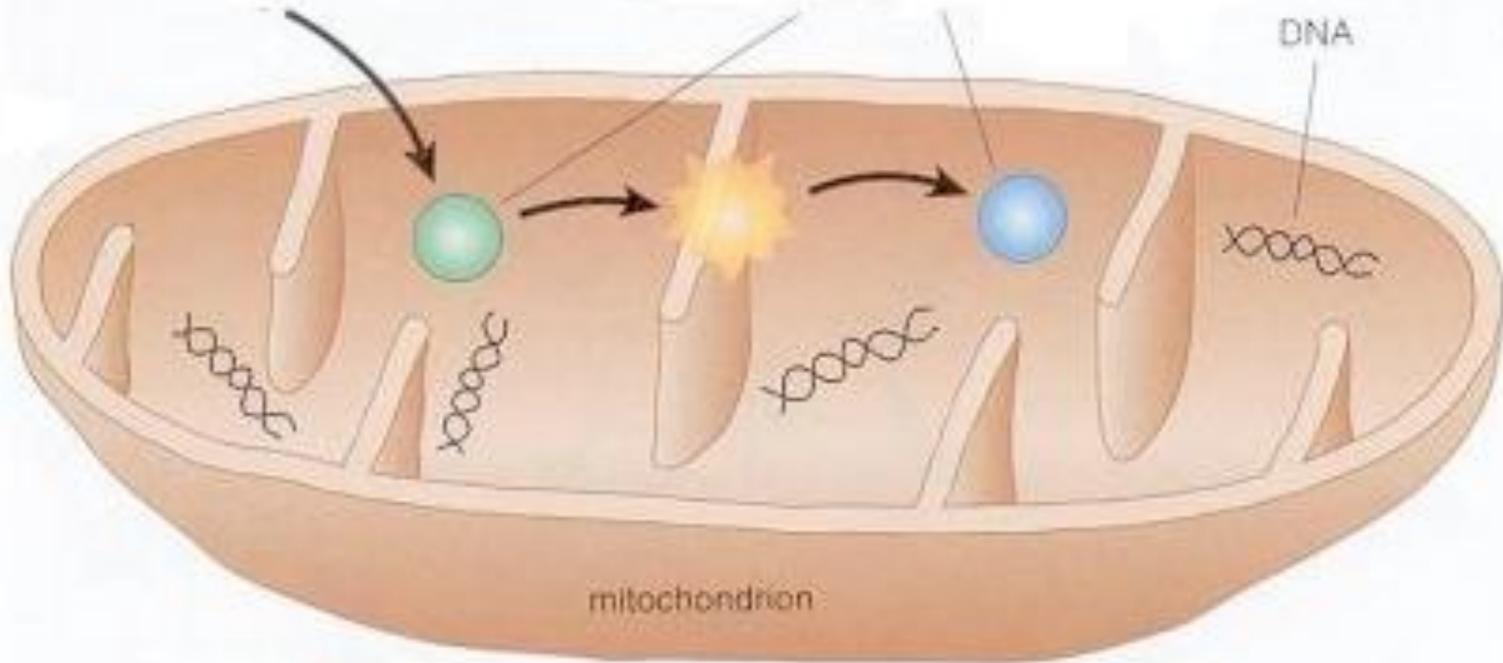
- The enzyme, telomerase, fills the gap by attaching bases to the end of the chromosomes.
- With time, telomerase levels decrease.
- With decreasing telomerase levels, the telomeres become shorter and shorter.



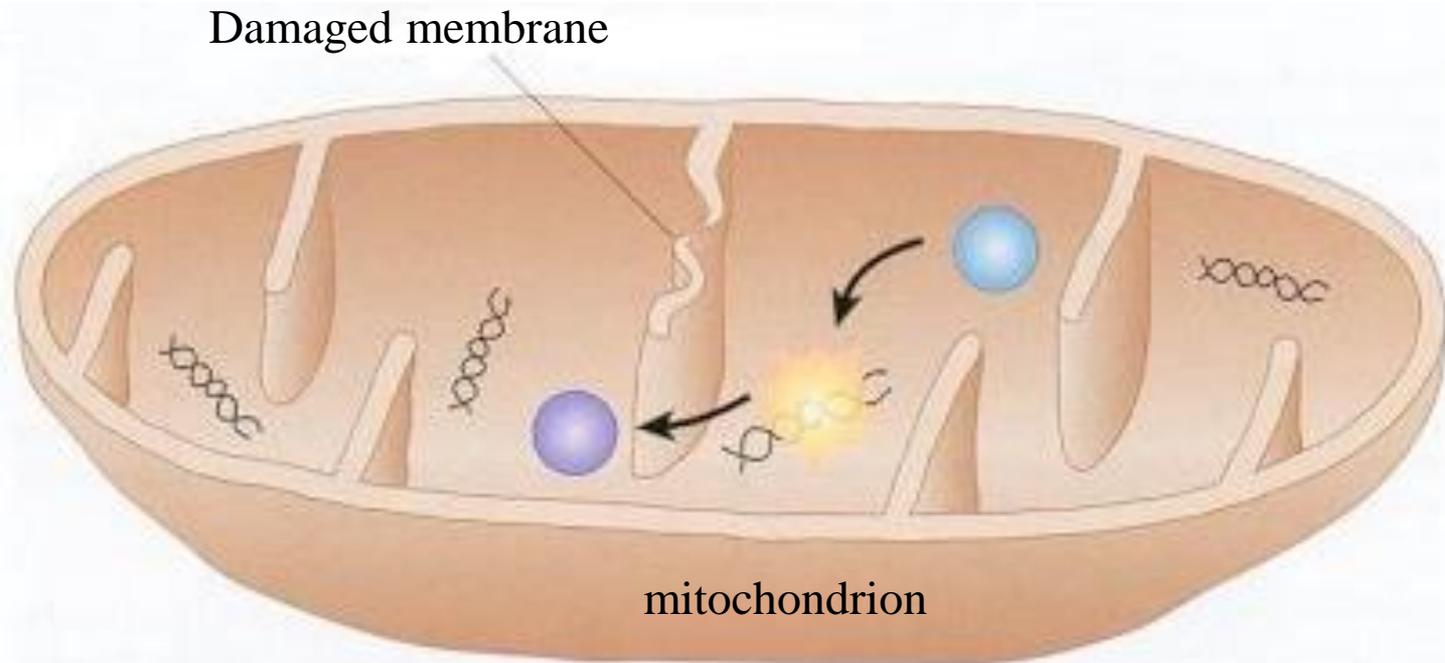
# Free Radical Theory

- During aging, damage produced by free radicals cause cells and organs to stop functioning
- The free radical theory of aging proposes that, little-by-little, small amounts of damage accumulate and contribute to deterioration of tissues and organs

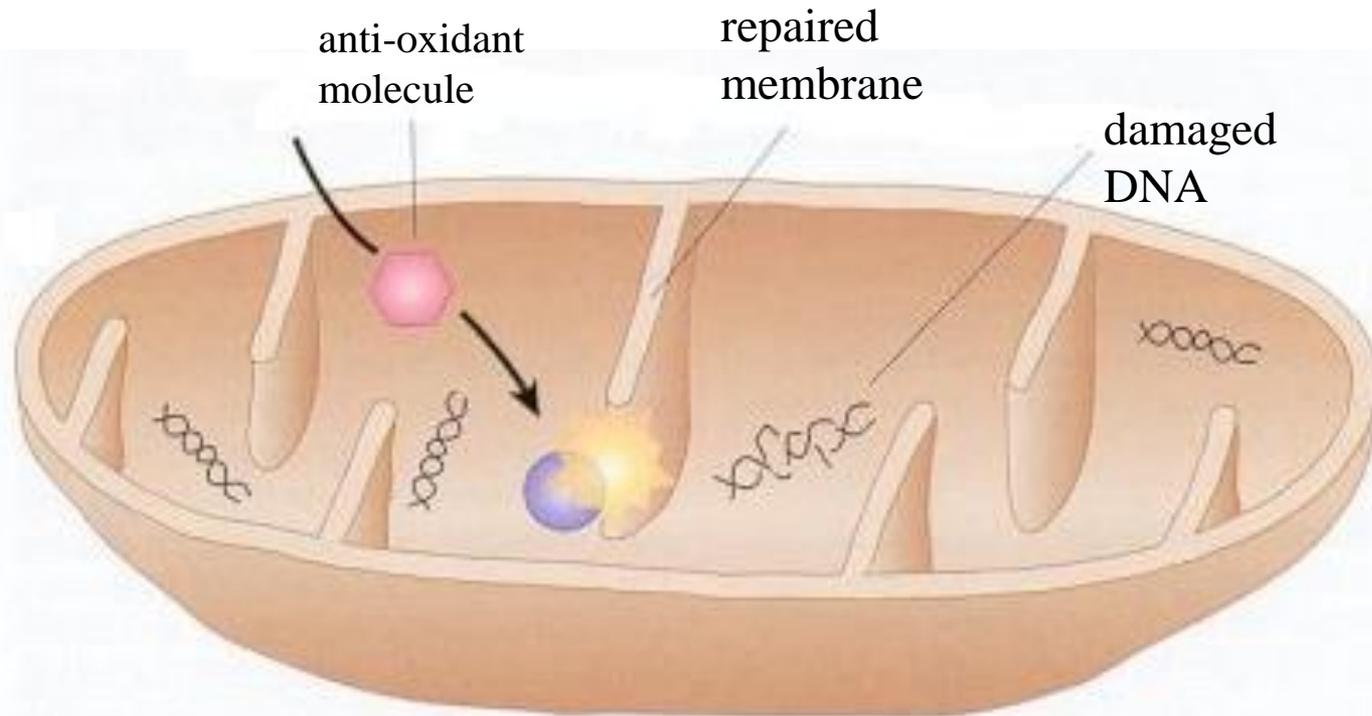
# Free Radicals



As the free radical (green) attacks the membrane it can release another type free radical (blue).

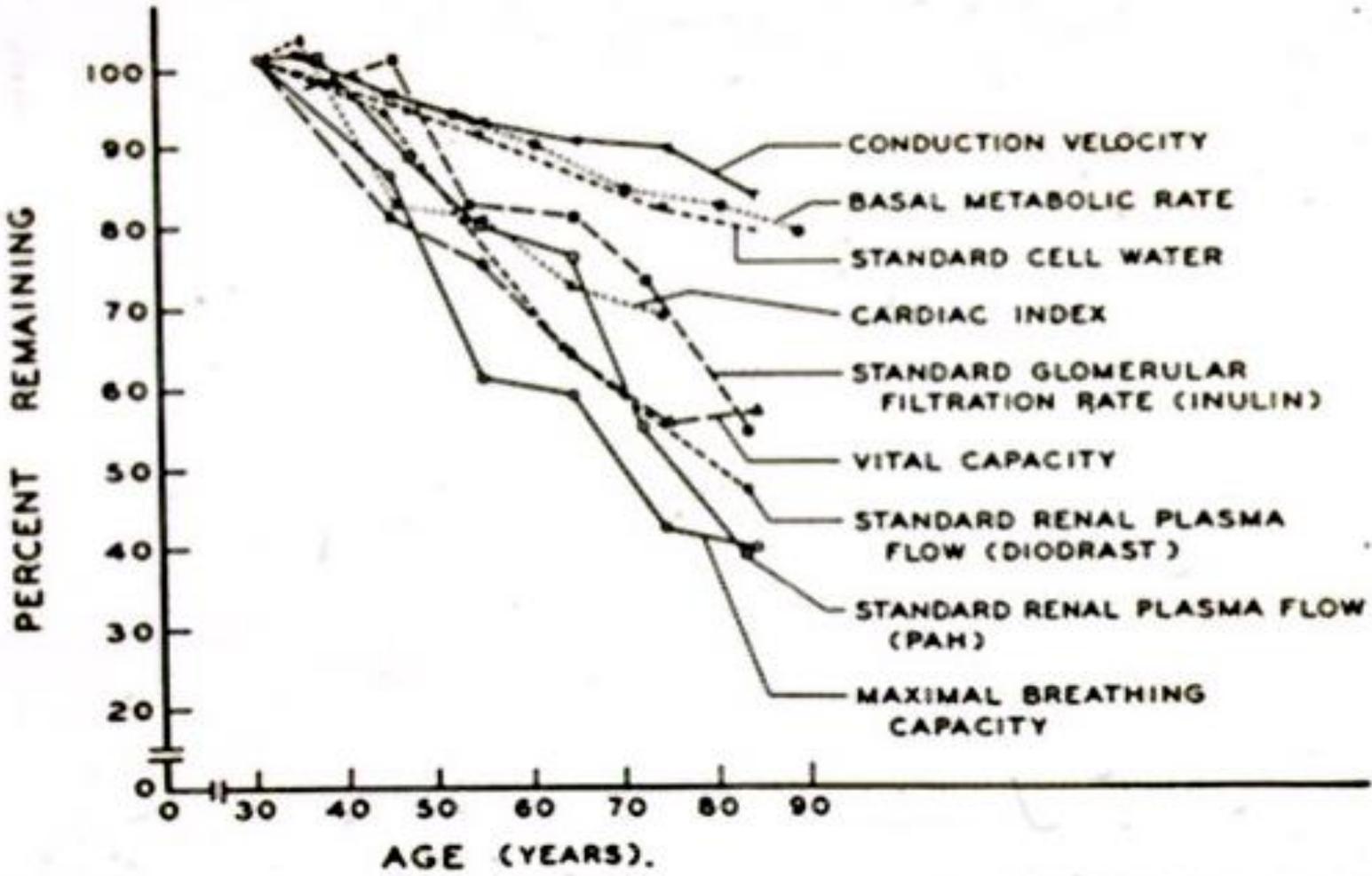


The free radical (blue) attacks the DNA releasing another free radical (purple).



The anti-oxidant molecule destroys the damaging free radical. The membrane repairs itself, but the DNA remains damaged, impairing the cells function. In addition, the anti-oxidant molecule now has an unpaired electron and thus becomes a new radical.

# Physiology of aging: everything slows down after 30

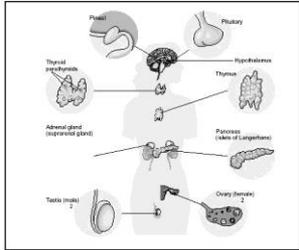


# Overview of Altered Aging Physiology

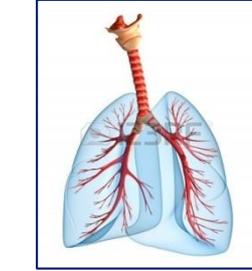
Vision



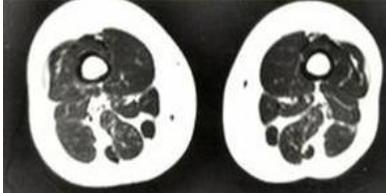
Endocrine system



Skin



Pulmonary system



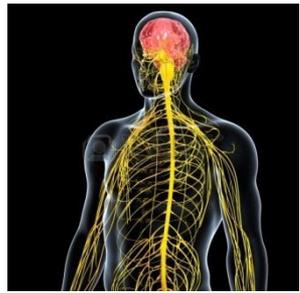
Sarcopenia



Renal system



Cardiovascular



Nervous System

# Cardiovascular system



## Changes in mechanics

Increase in collagen-connective tissue

Thickened & stiff heart valves

Decreased vascular compliance

Increased systolic blood pressure

Left ventricular hypertrophy



# Cardiovascular system



## Changes in “control mechanisms”

Decreased responsiveness to catecholamines

Decreased maximum heart rate response

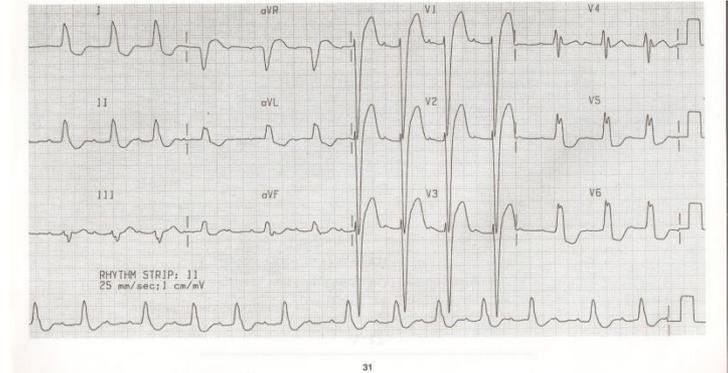
Possible congestive heart failure

$$\text{CO} = \text{SV} \times \text{HR} \{\text{preload dependent}\}$$

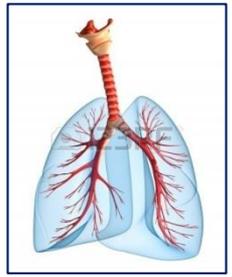
Co = cardiac output

SV = stroke volume

HR = heart rate



# Pulmonary system



## Reduced chest wall compliance

- increased work of breathing
- reduced maximum minute ventilation

## Reduced response to hypoxia by 50%

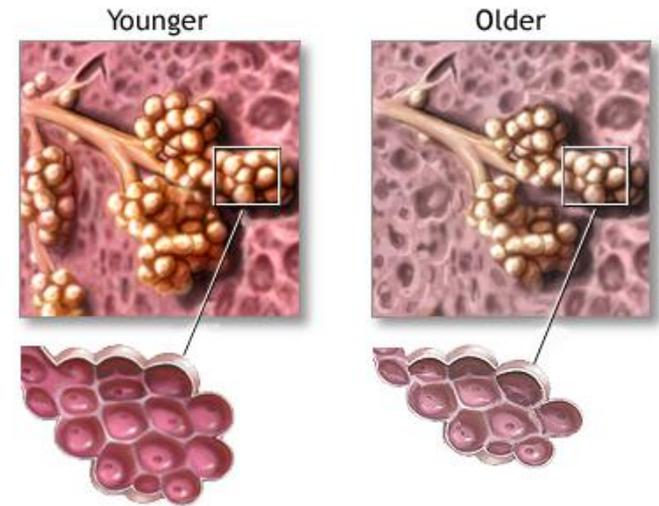
- impaired chemoreceptor function

## Reduced cough and swallowing function

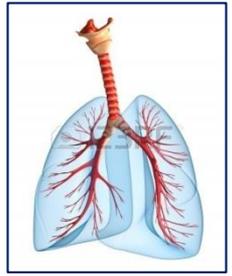
- Decreased number of nerve endings in larynx

## Reduced functional alveoli

- the wall become thin, the alveoli enlarge and less elastic



# Pulmonary system



Pulmonary arteries thicken & enlarge  
resistance to blood flow in lungs

**↑ Pulmonary artery pressure**

Less functional alveoli (same number)  
less surface area for  $O_2$ - $CO_2$  exchange

lower  $O_2$  to supply vital organs

**Especially after major trauma**

- Partial pressure of oxygen drops by 10 mm Hg per decade after age 60
  - 60 yo → 80 mm Hg
  - 70 yo → 70 mm Hg
  - 80 yo → 60 mm Hg
  - 90 yo → 50 mm Hg

# Renal system



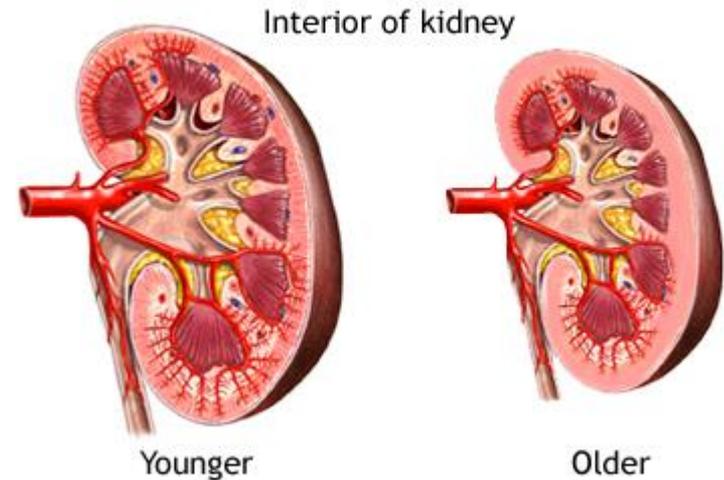
Decreased renal blood flow  
**600ml/min** (40y) to **300ml/min** (80y)

Kidney size decreases  
20-30% by age 90

Decreased Glomerular Filtration Rate  
50% by age 75

Old kidneys have difficulty to:

- maintaining circulating blood volume
- removing excess acid
- regulate sodium homeostasis
- adjust to: hypovolemia, hemorrhage & hypotension



# Renal system



Creatinine clearance vs normal serum creatinine

90 year old woman, 50 Kgr

Serum creatinine = 1.0

Estimated creatinine clearance is?

- > 90 ml/min
- 70-90 ml/min
- 50-70 ml/min
- 30-50 ml/min
- < 30 ml/min

## Creatinine Clearance Calculator

Sex:  Male  Female

Weight:  Kilograms ▾

Age:  Years

Serum Creatinine:  mg/dL

Results: **29.51 mL/min is your estimated creatinine clearance.**

Creatinine Clearance =  $[[140 - \text{age}(\text{yr})] * \text{weight}(\text{kg})] / [72 * \text{serum Cr}(\text{mg/dL})]$   
Multiply by 0.85 for women

# Neurologic Changes

Brain neuronal loss throughout life

- basal ganglia atrophy
- loss is gray matter (not white matter)

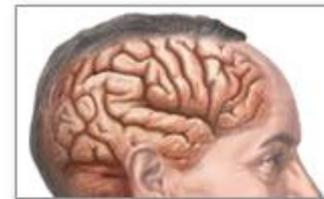
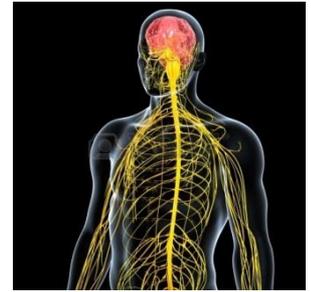
↓ neuronal transmission

↓ dopamine & ↑ muscular rigidity

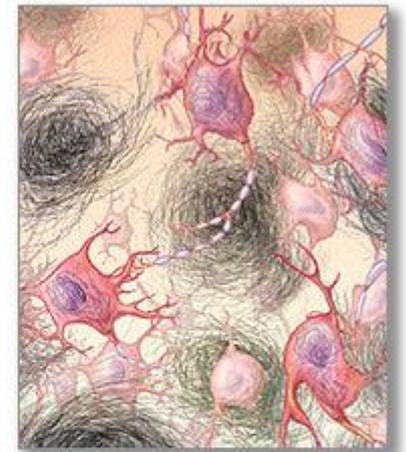
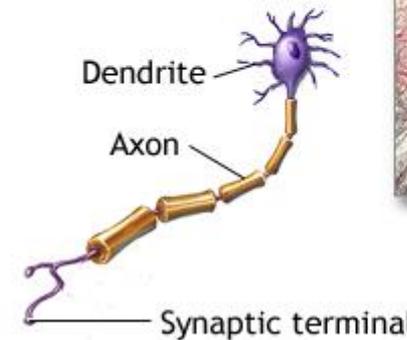
Impaired hearing, smell decreases

## Changes in sleep cycle:

- longer to fall asleep,
- less total time of sleeping
- awakenings throughout the night

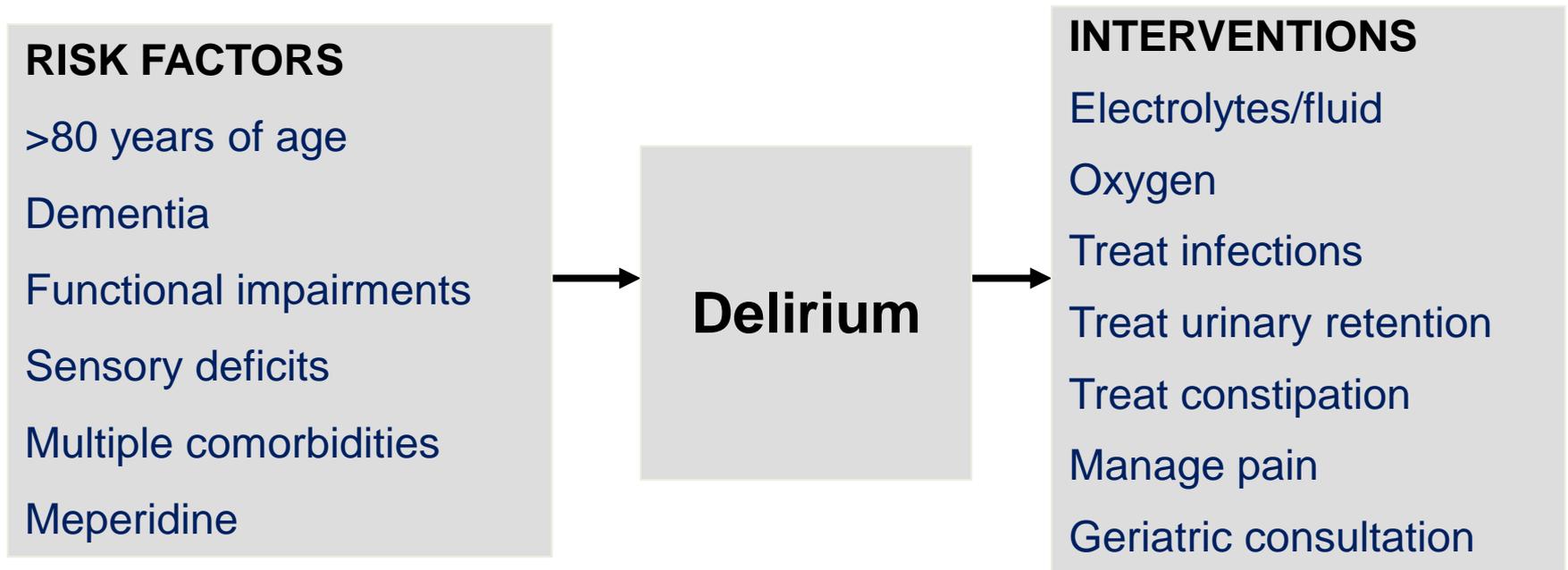


Aging brain



Neurons in aging brain

# Delirium: a Geriatric syndrome

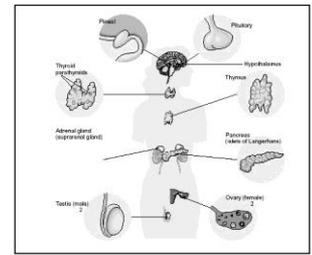


Inouye Ann Intern Med 1993

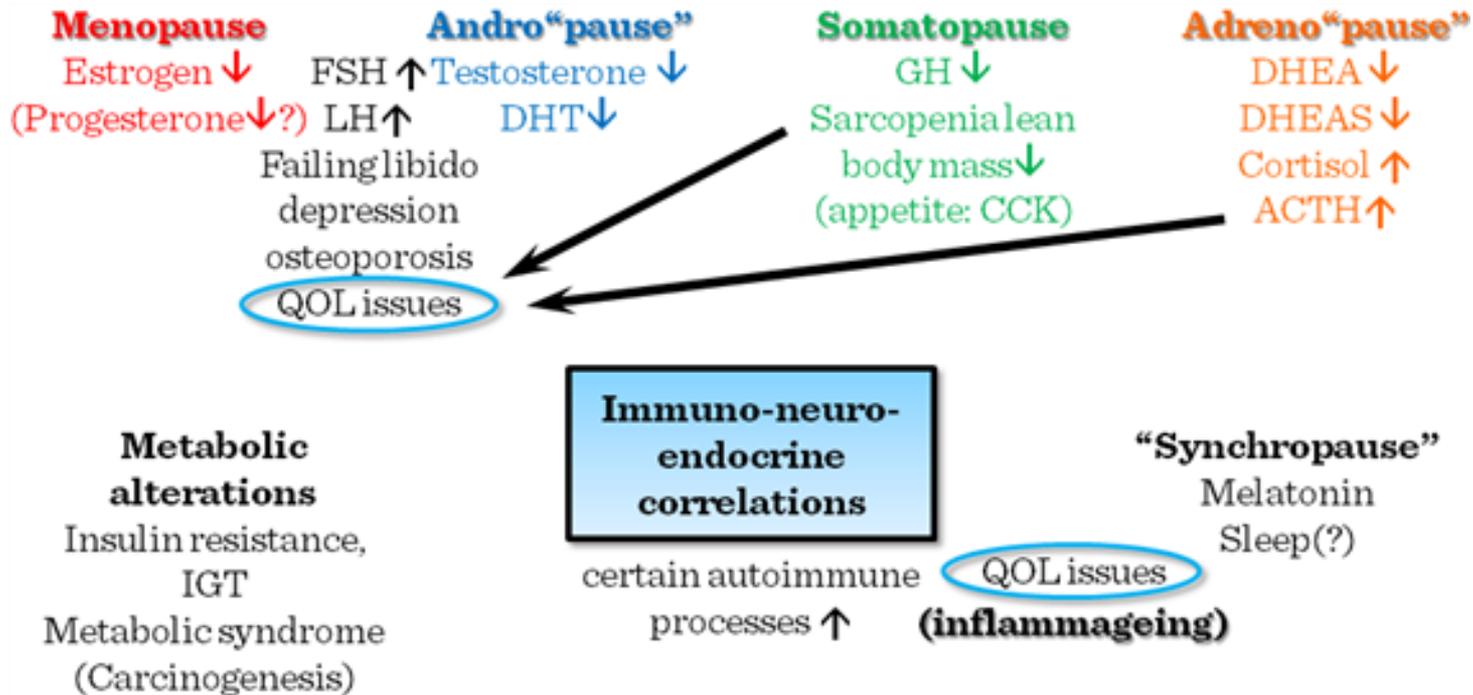
Siddiqi Cochrane Database Sys Rev 2007

McGory Annals of Surgery 2009

# Endocrine system

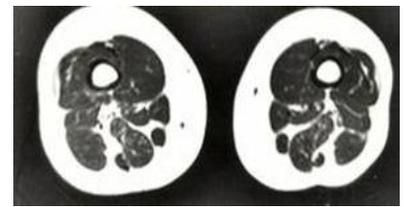


In most glands there is some atrophy & decreased secretion with age, but the clinical implications of this are not known



**Not "normal" ageing process, but common:**  
 subclinical hypo- and hyperthyroidism in the elderly

# Musculoskeletal System



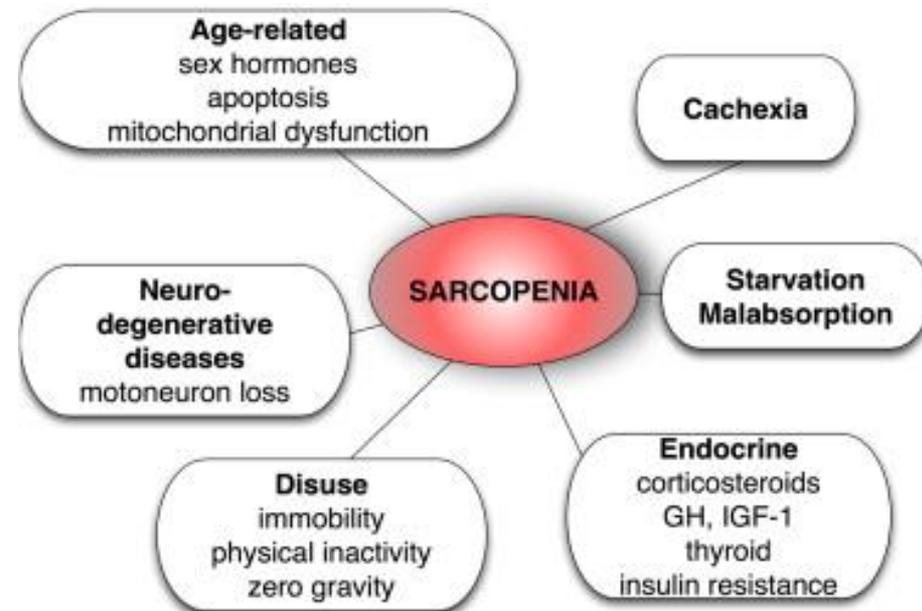
## Sarcopenia

- ↓ muscle mass & contractile force
- reduced growth hormone production

increased fatigue & risk of falling

Sarcopenia affects all muscles

- respiratory muscles (↓ breathing)
- GI tract (constipation).



# Visual changes



## Visual acuity

- cataracts, macular degeneration

## Decreased lens compliance

- Reduced accommodation
- Presbyopia

## Reduced tear formation

- dry eyes

## Reduced pupil size

- reduced night vision

## Loss of cones

- reduced color vision



Predisposition to falls

# Aging skin



Delayed wound healing

More easily damaged

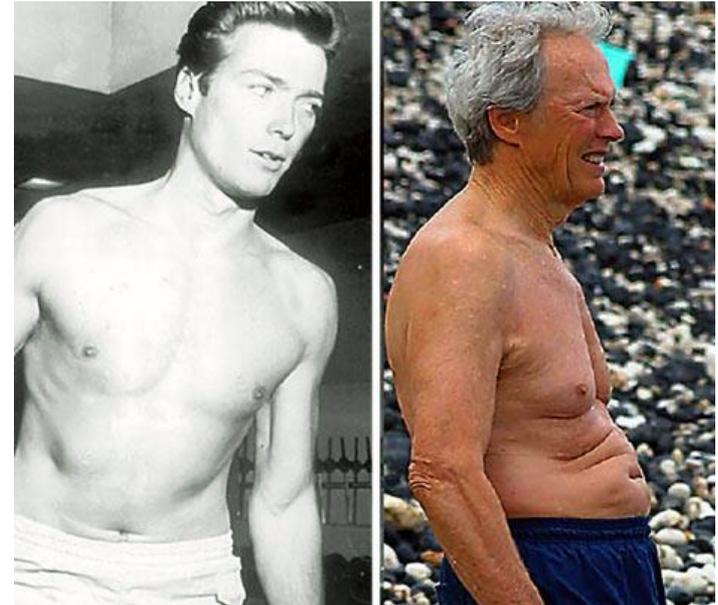
Altered thermal regulation

Decreased sensitivity to pain-pressure

Decreased inflammatory response

Wrinkling, sagging skin

Easily stretched under low loads



# Malnutrition Among Older Persons

- 5-12% in community
- 30-61% hospitalized
- 40-85% in long-term care facilities.

# Importance of Nutrition for Older Adults

Older Adults are at increased risk of inadequate diet from:

- Diseases - acute/chronic
- Physical limitations
- Inability to chew and poor oral health
- Social isolation/depression/low income
- Impaired functional status
- Alcohol use and abuse
- Drug - nutrient Interactions

# Lifestyle modification.....



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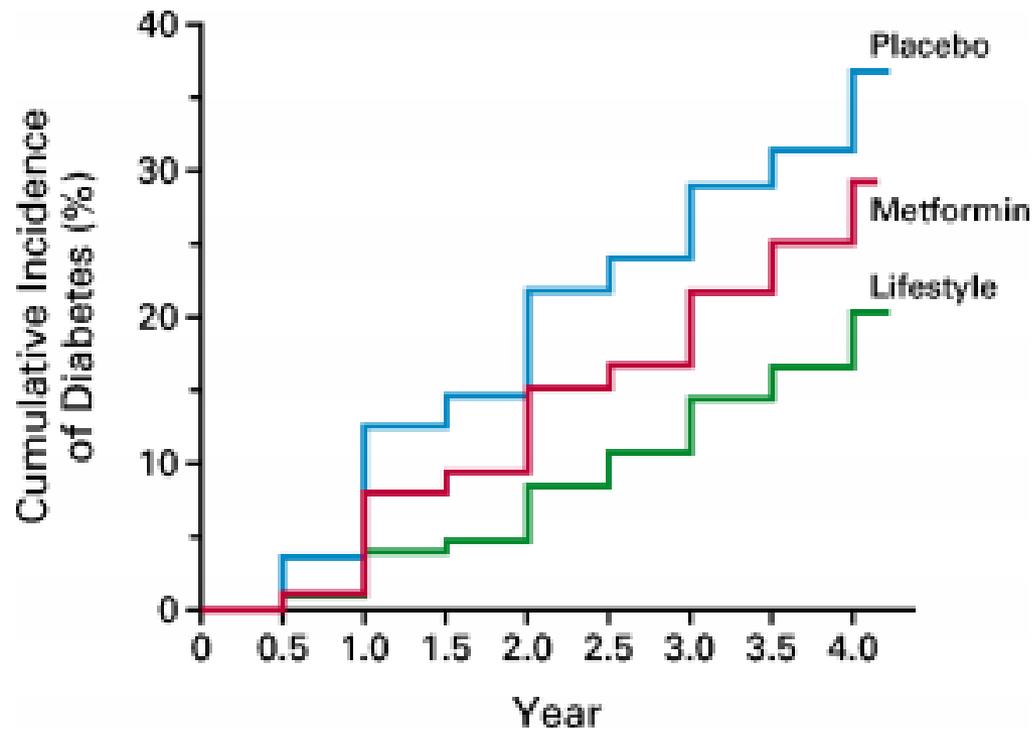
Published in final edited form as:

*N Engl J Med.* 2002 February 7; 346(6): 393–403.

NIH-PA Author Man

## REDUCTION IN THE INCIDENCE OF TYPE 2 DIABETES WITH LIFESTYLE INTERVENTION OR METFORMIN

Diabetes Prevention Program Research Group\*

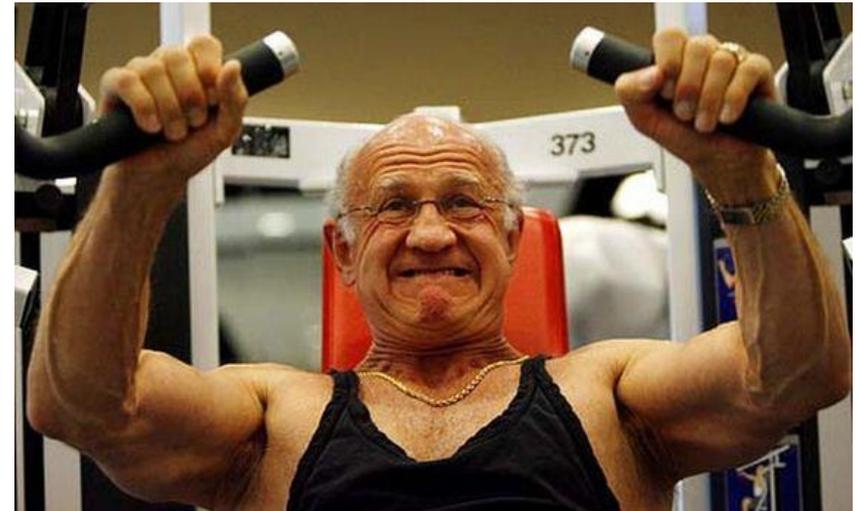


# Stay Active.....



# Benefits of Exercise

- Weight loss (↓ central adiposity)
- Blood pressure decline
- Aerobic capacity increase
- Insulin sensitivity increase
  
- Increase bone mass
- Increase muscle strength
- Increase perceived well being



# What works better?

Regular Exercise

Reasonable body weight

“Eat your vegetables and fruit”

Don't smoke

Remain Socially Engaged

Regular preventive health visits

-vision, blood pressure, cholesterol, diabetes

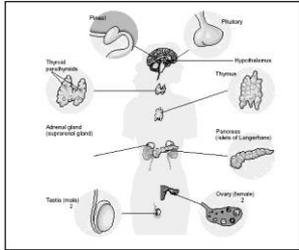


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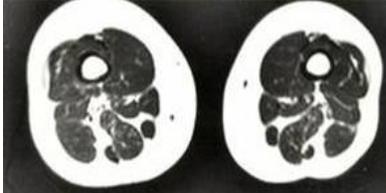
Vision



Endocrine system



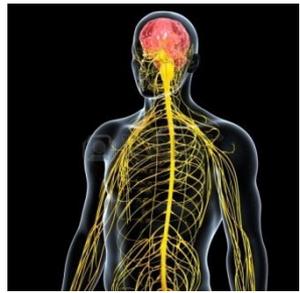
Skin



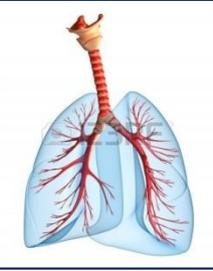
Sarcopenia



Cardiovascular



Nervous System



Pulmonary system



Renal system

# Summary

- Aging is associated with reduced functional reserve and a compromised ability to cope with stressors
- Elderly are a heterogeneous group and there is great individual variability
- Always think of interventions which may be useful in helping patients cope with and/or overcome some of the changes brought by normal aging
- Start building your reserves NOW