

# Regulation of Body Temperature: An Update

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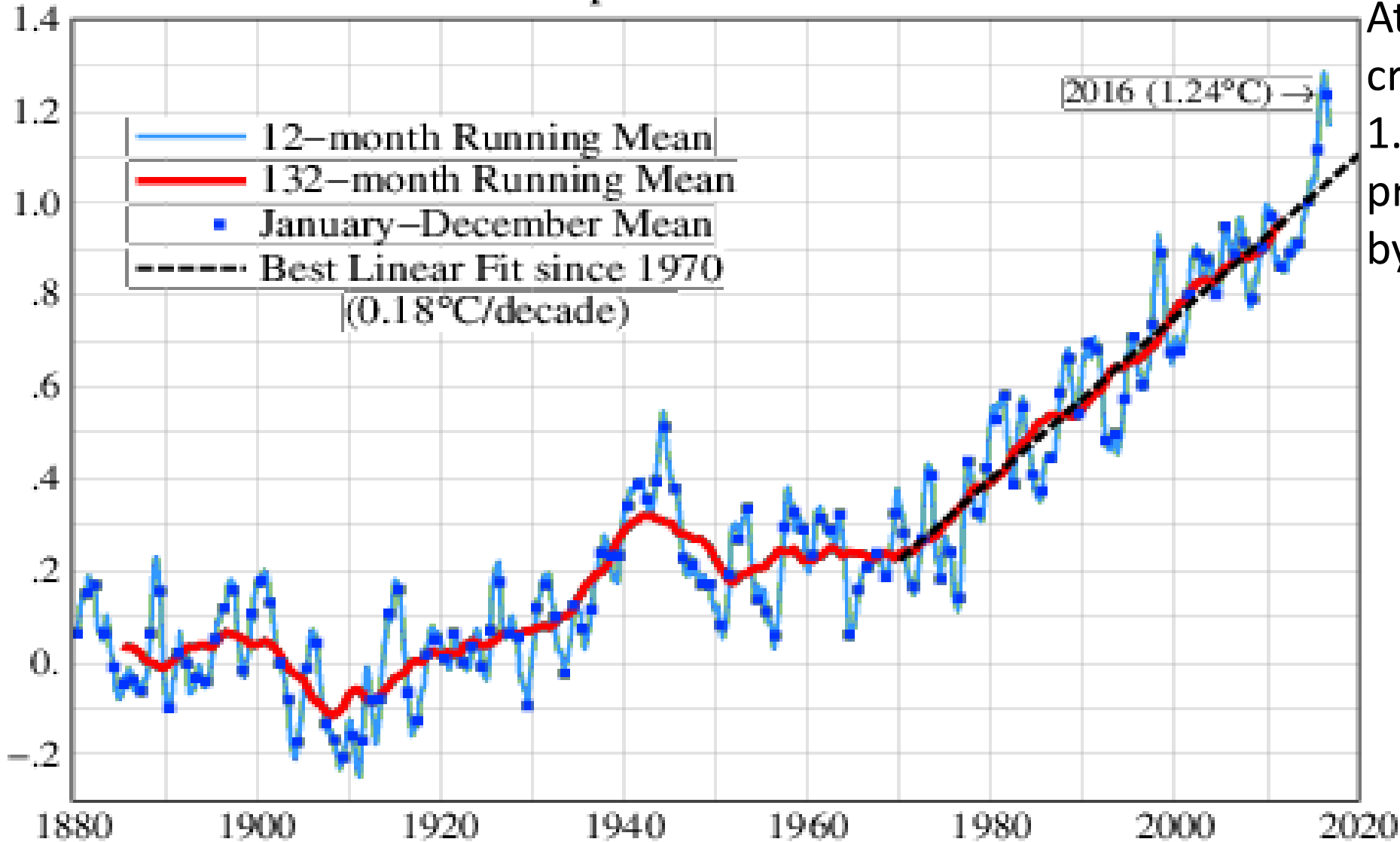
Copy of full Presentation in web site: *danielray.site*

Under presentations click on:

Body Temperature Regulation Update.pdf

Anomaly = deviation from average over a given period of time.

Global Surface Temperature: 1880–1920 Base Period

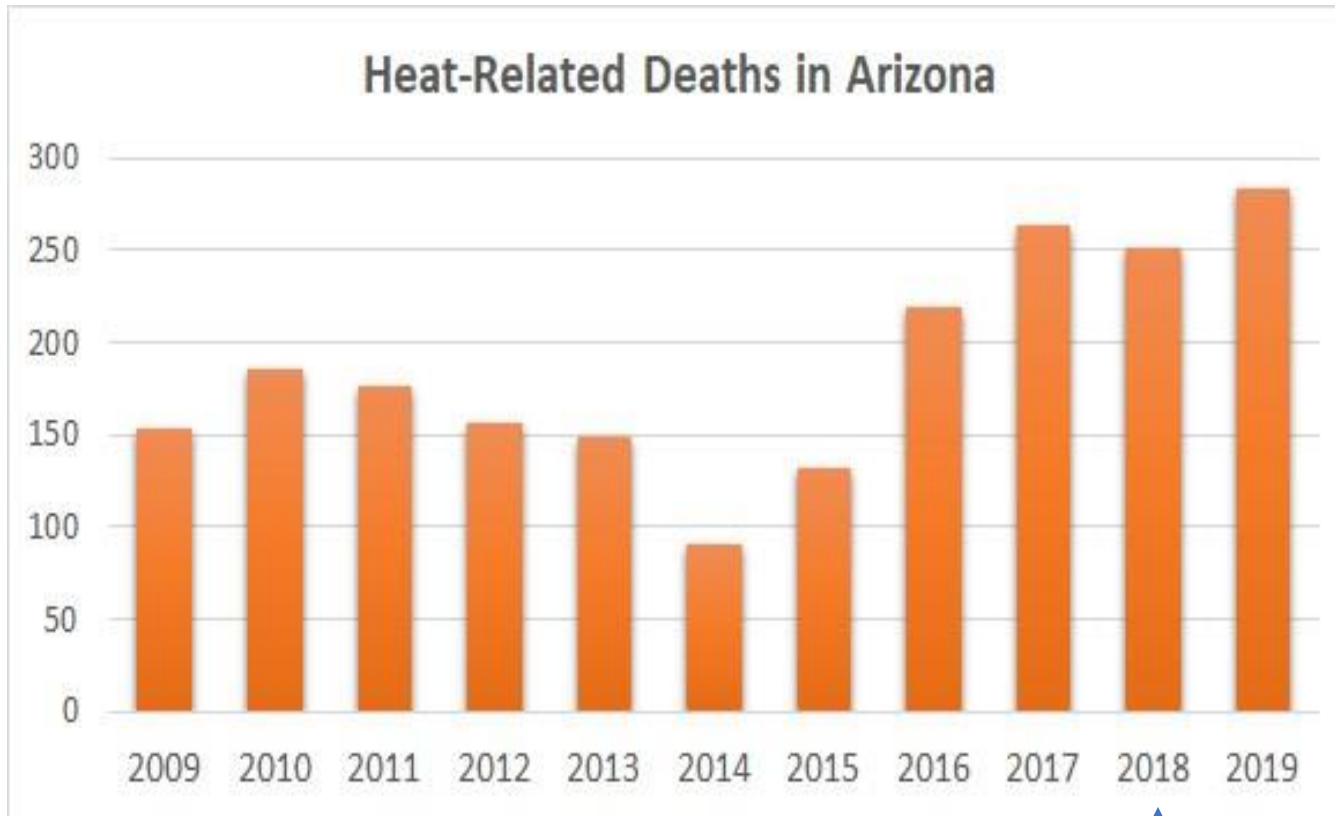


At present conditions, critical increase of 1.5 deg C (2.7 deg F) predicted to be reached by 2035 (UN report)

However, present conditions may be changing.

In 2022 electricity generated in the US by renewable energy surpassed that produced by coal!

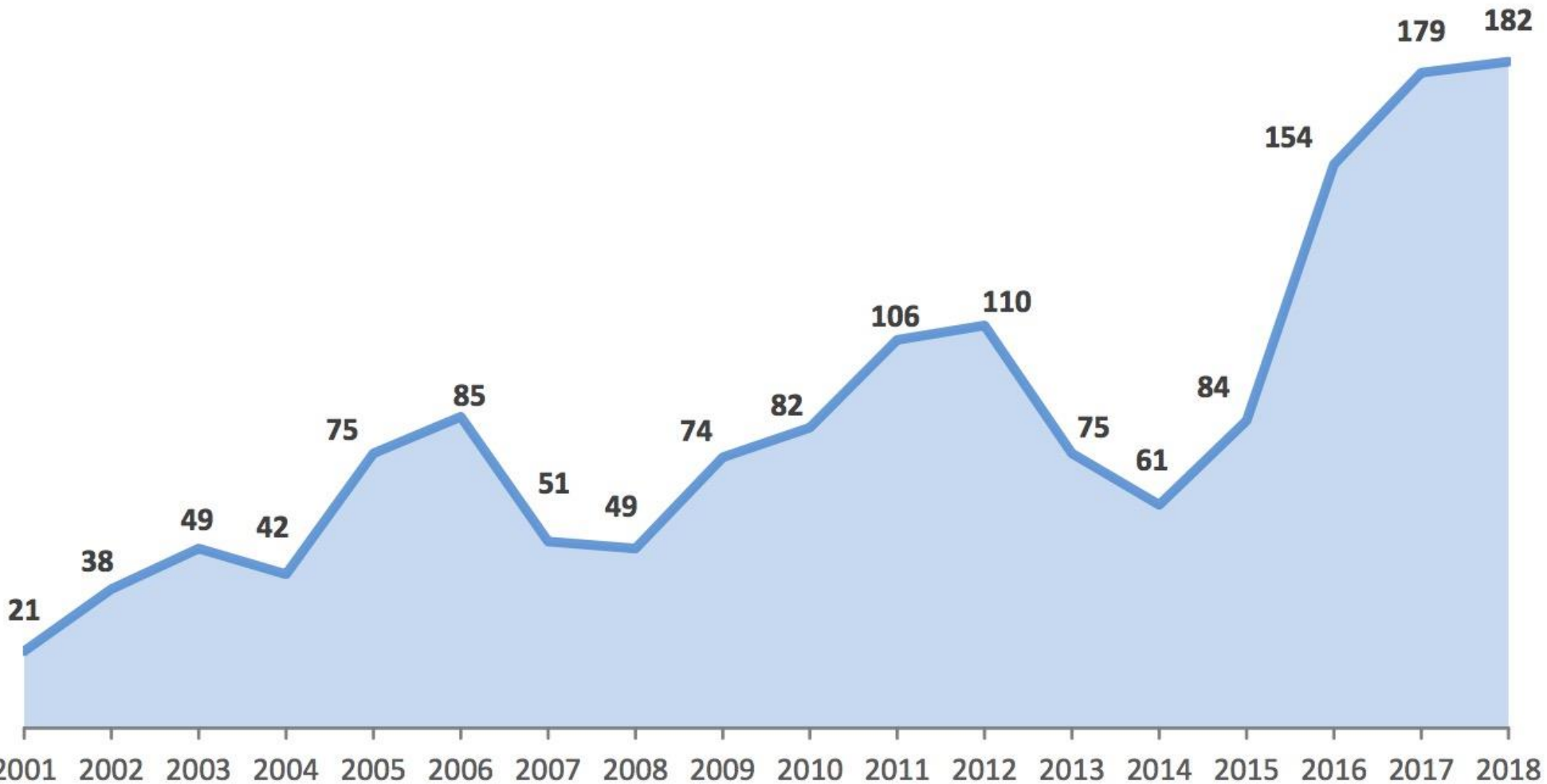
AZ Republic March 30, 2023



182 heat related deaths in the Phoenix metropolitan area in 2018

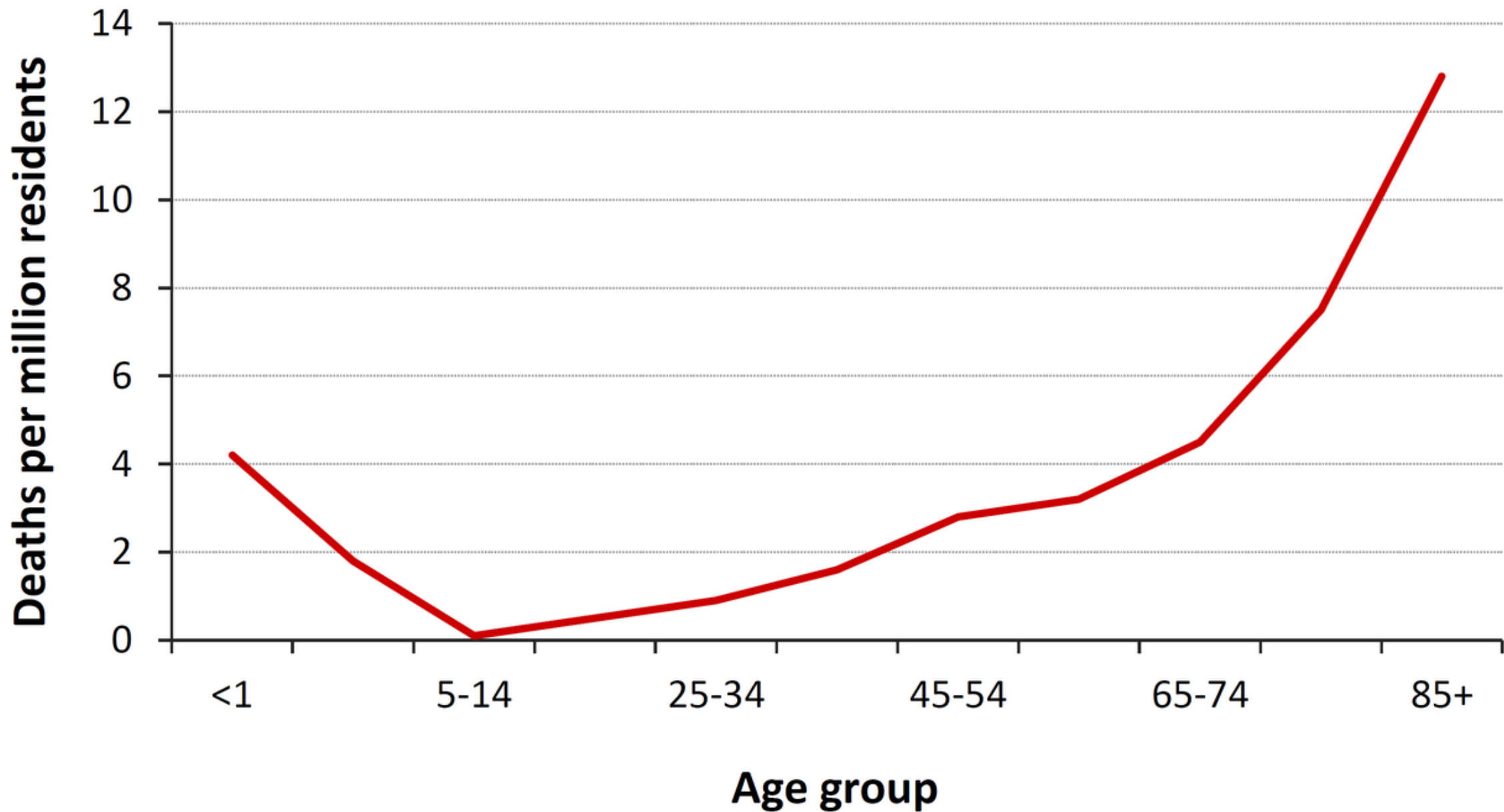
# Heat-Associated Deaths by Year in Maricopa Co, AZ

Graph 1. There were 182 heat-associated deaths reported in 2018.



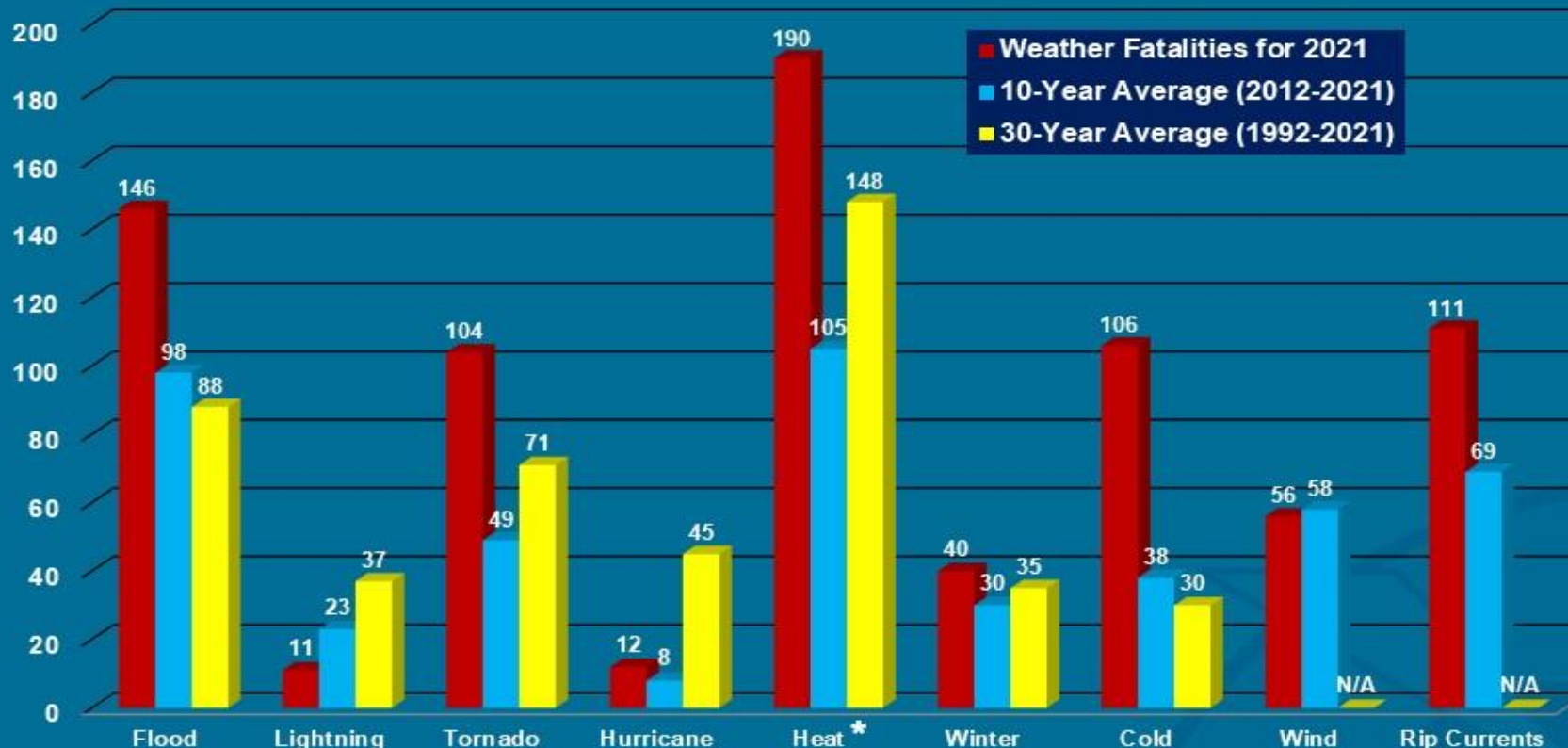
Relative to population  
2014 – 14.9/million  
2018 – 41.4/million

# Heat-Related Death Rates in the U.S., 2006-2010





# Weather Fatalities 2021



*\*Due to an inherent delay in the reporting of official heat fatalities in some jurisdictions, this number will likely rise in subsequent updates.*

Why is heat worse than cold

The Arizona Republic, Sept 16, 2019

*“Humans are much more adapt at battling the cold instead of the heat.”*

*At a body temp of 98 deg F, are you more comfortable at:*

*123 deg F (25 deg above body temp of 98F)?*

*or*

*73 deg F (25 deg below body temp of 98F)?*



# ***Living organisms produce heat as a byproduct of metabolism***

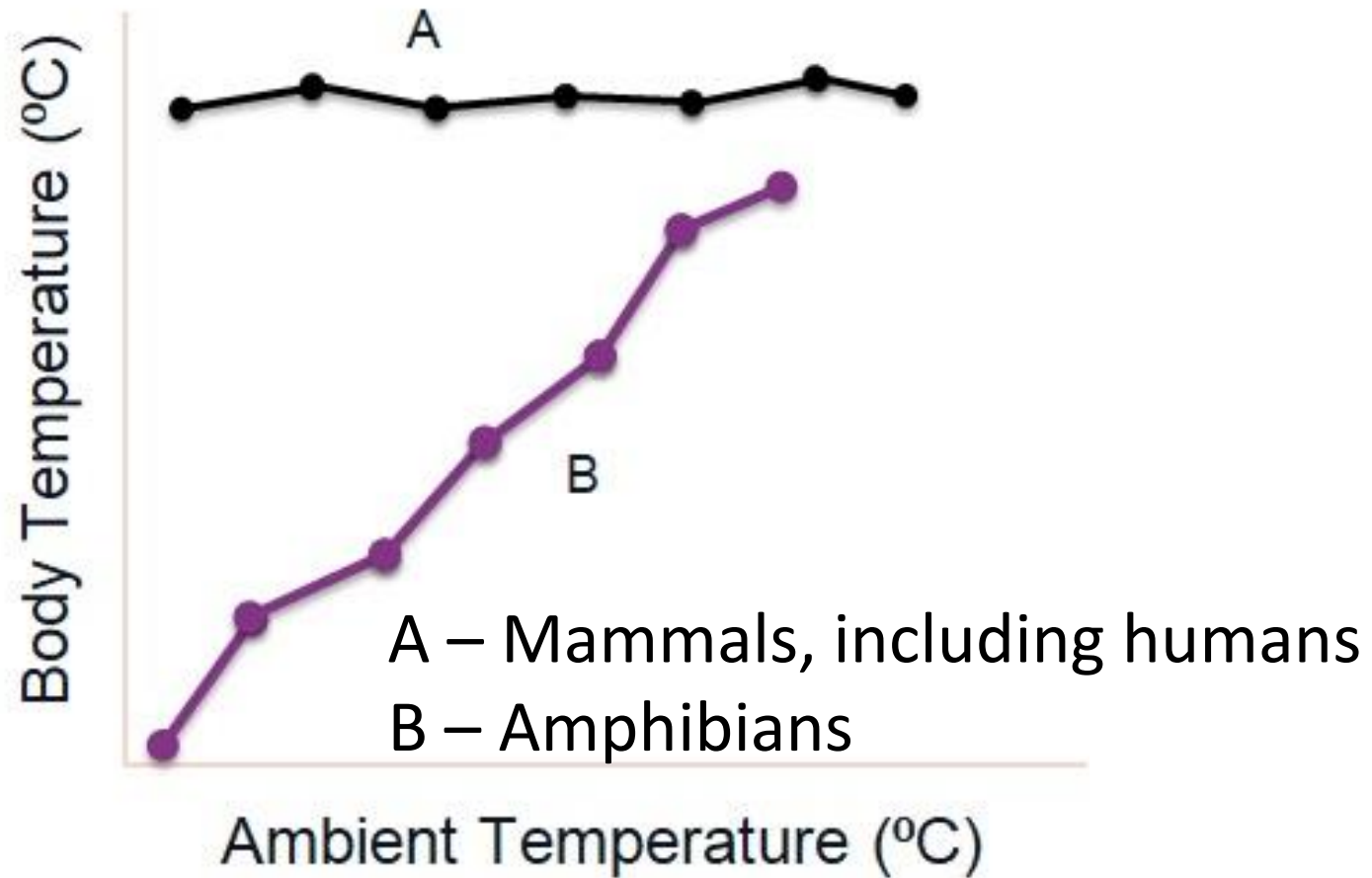
body metabolism → heat production

*In mammals (including humans)*

heat production = heat loss (balance)

heat loss > heat production (hypothermia)

heat loss < heat production (hyperthermia)



Source: Byju's Multinational Education Co.

# Modes of body temperature regulation:

Physiological

Maintains body temp in cool to warm environments

Behavioral (dressing for heat or cold, etc) + Physiological

Maintains body temp in cold and hot environments

## *Environmental temperature*

Too cold

The Goldilocks zone

Too hot



# Adaptation

Mammals, such as humans, exposed to a changing environment will, to a degree, adapt to the new environment.

*Mechanism involves environmental induced modification of genes.*

Short term (seasonal) adaptation involves physiological adjustments.

Long term (several generations) adaptation involves anatomical and physiological adjustments.

For humans adapting to seasonal changes in heat or cold, there are no “one size fits all” guidelines. Depends on age, health and prior exposure.

A place to start for heat adaptation: [time.com/6207087/improve-heat-tolerance/](https://time.com/6207087/improve-heat-tolerance/)

# Examples of evolutionary modification of body structure

Fennec (Desert) Fox

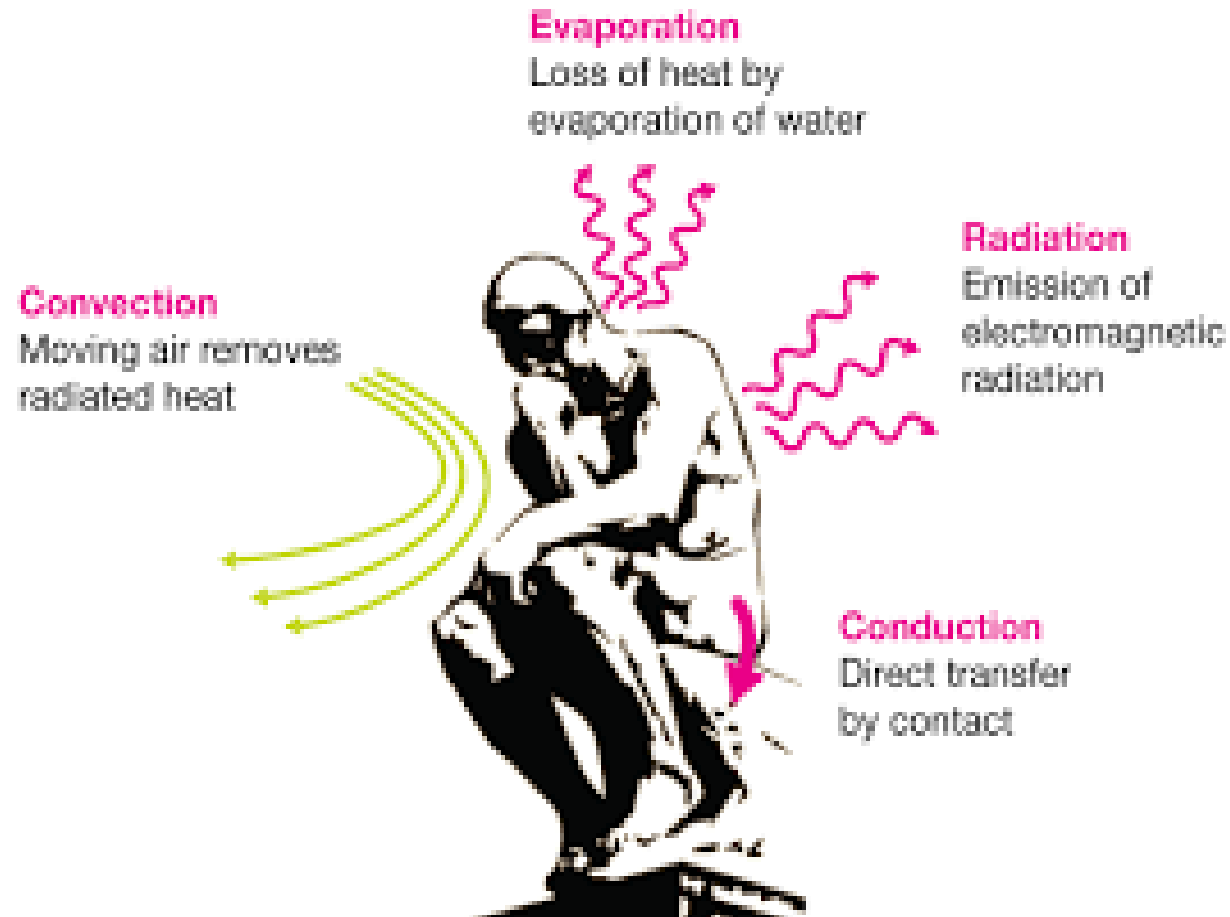


McFly and Noelle on display at Phoenix Zoo

Polar (Arctic) Fox



# Mechanisms of body temperature regulation



Radiation and conduction  
are bi-directional.  
(gain as well as loose heat)

When environmental temperature is above body temperature, evaporation becomes the main, or only in still air, source of heat loss.

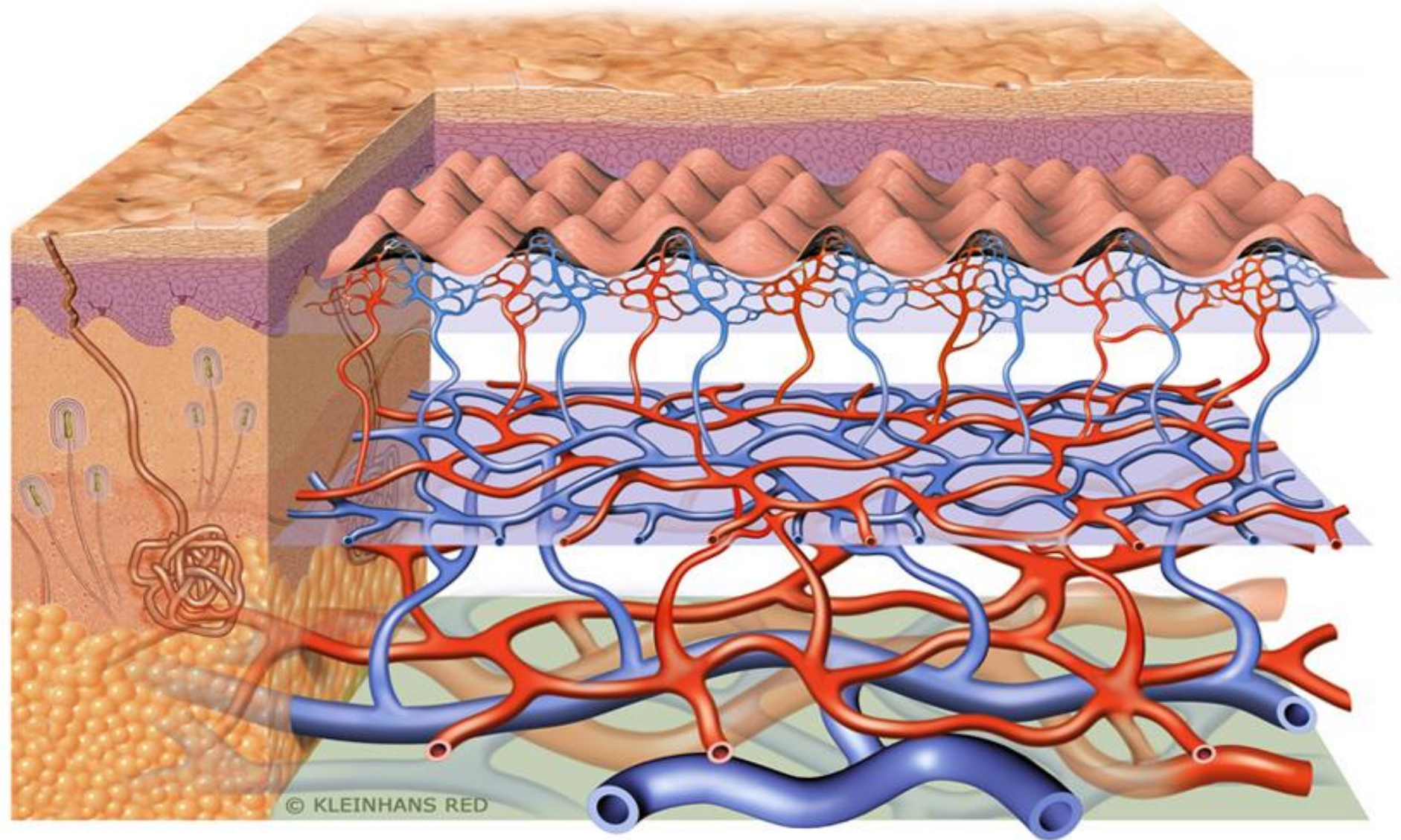
Example: being outside on just about any summer day in the “valley”.

Humans sweat, dogs pant and cats lick their fur for evaporative cooling.





Heat exchange occurs across the skin



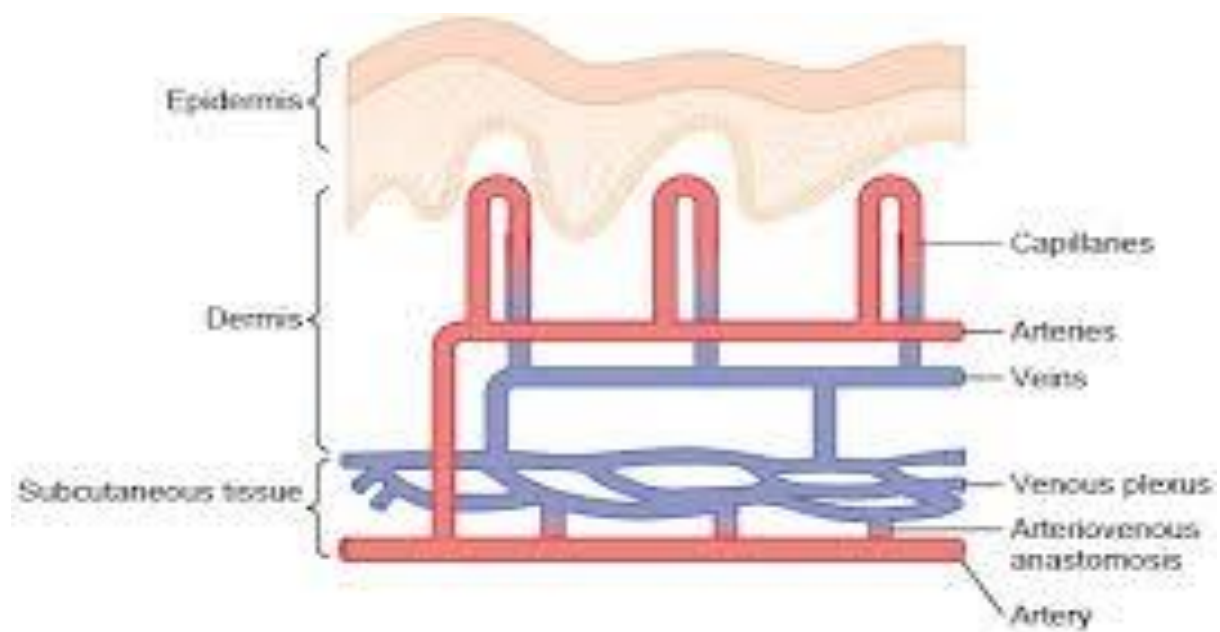
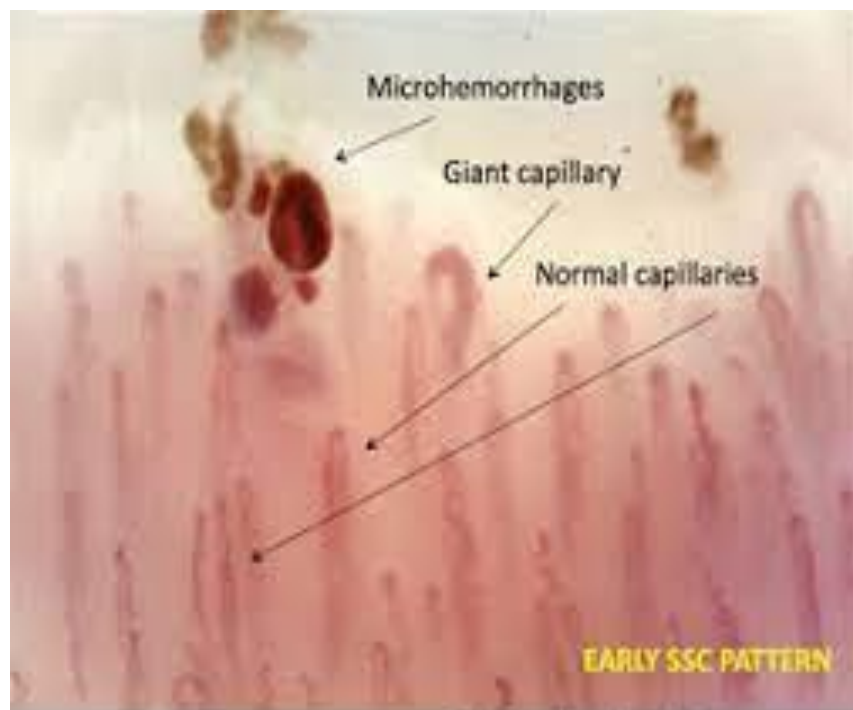


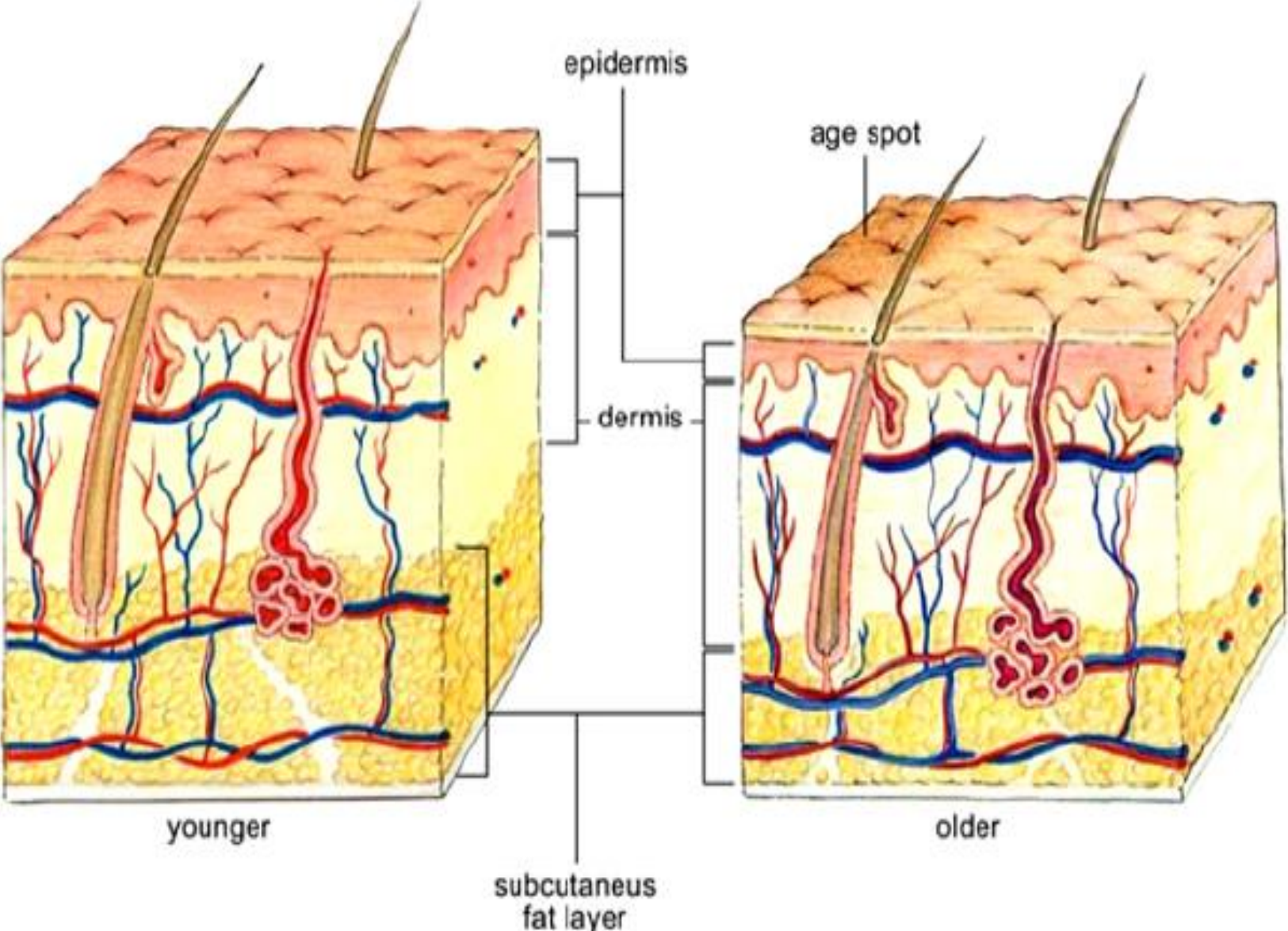
Figure 73-2

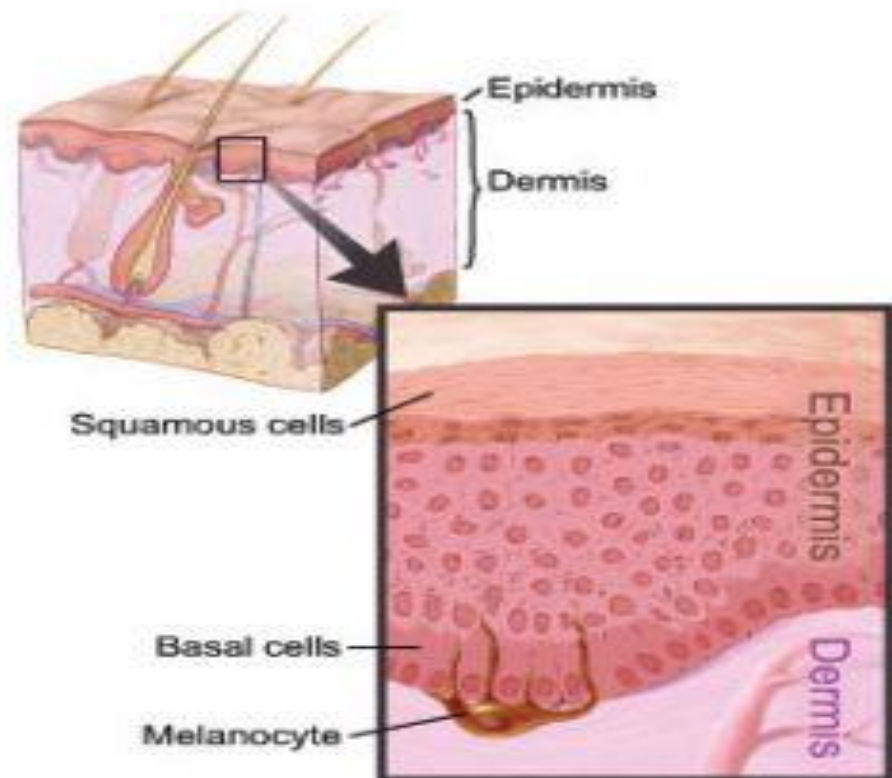
Skin circulation.



Todd Davison/illustrationsource.com

# EFFECT OF AGING ON SKIN STRUCTURE





Decrease in thickness of epidermis with age:

Due to decrease in metabolism of basal cells

Results in decrease in epidermis turnover

*Exfoliation exceeds formation of new basal cells*

Thinning of the epidermis:

Results in sub-epidermal blood vessels being closer to the surface

Assists in convective cooling in warm environments

Exacerbates heat loss in cold environments

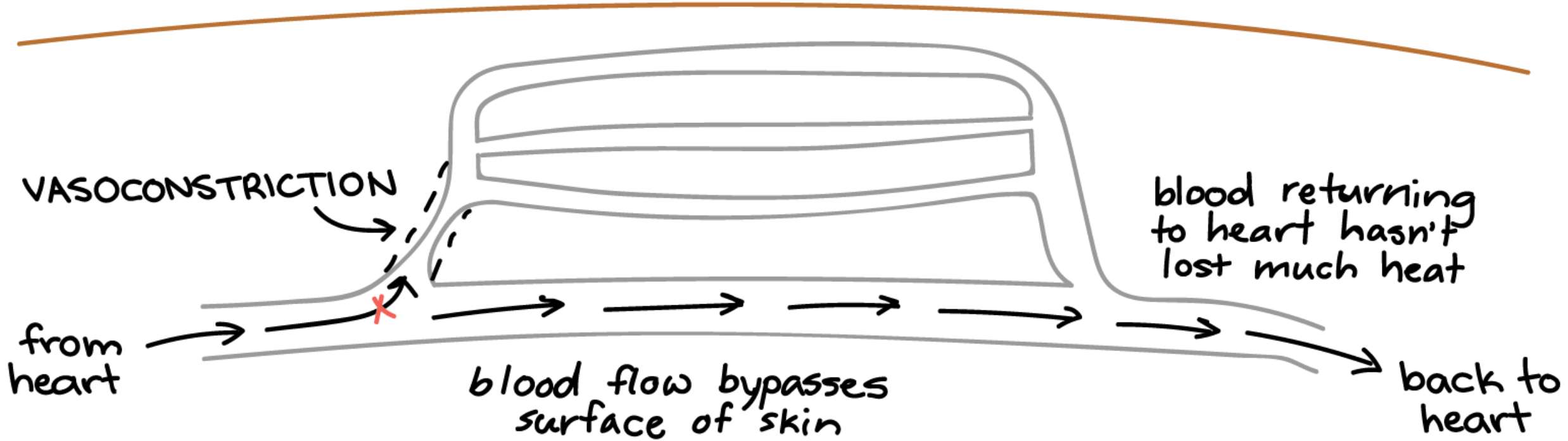
Yes parts of Arizona do get cold winter weather



Winter wonderland at our home in Tonto Village – 100 miles NE of Phoenix

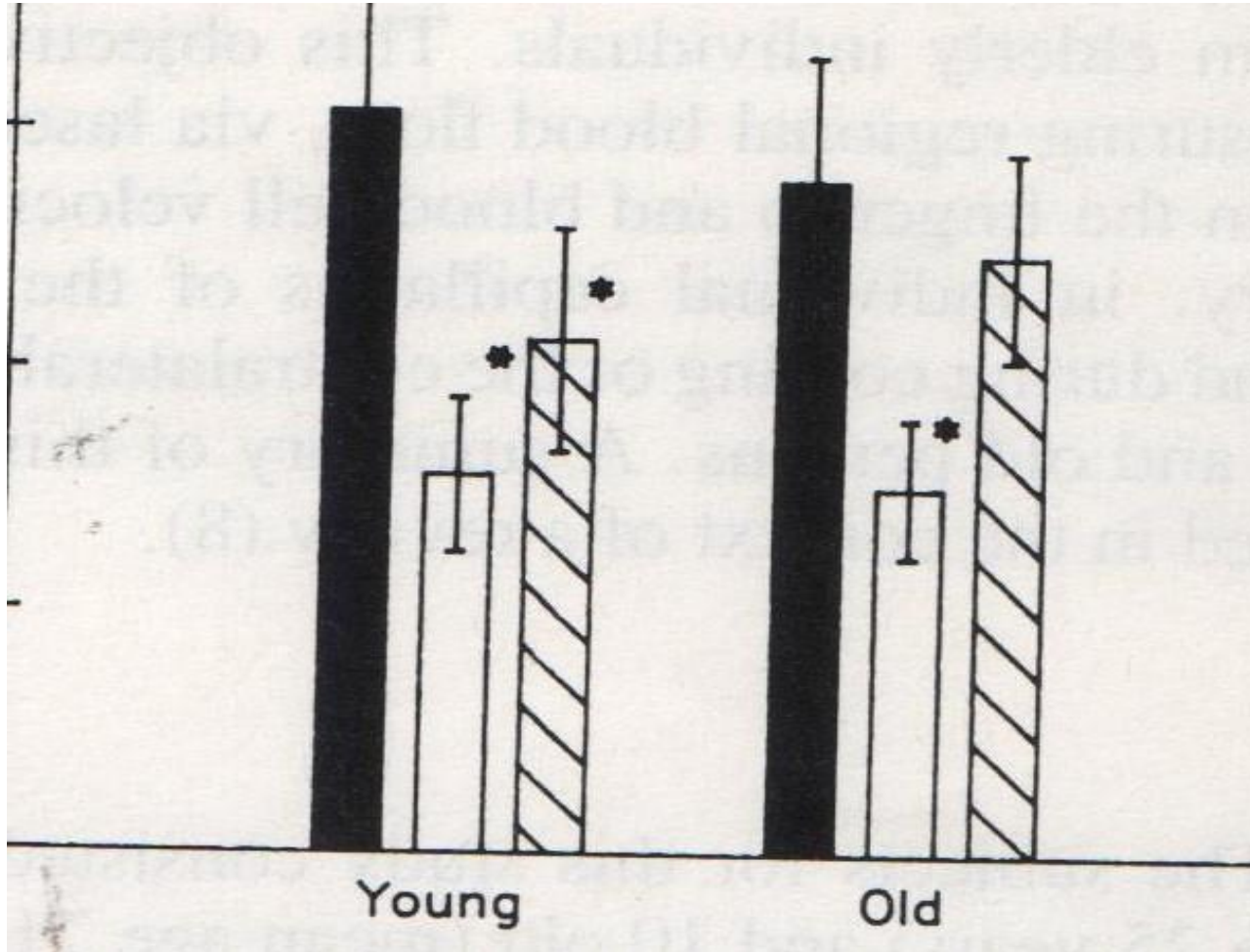
# Temperature regulation in response to cold

skin surface





Skin blood flow in the fingers of young (av 25 yr) and older (av 75 yr) subjects in response to cooling (15 deg C) of the opposite hand.



Solid bar = room temp control

Open bar = 1 min of cooling

Hashed bar = 5 min of cooling

J. Gerontology, 47: M211-M214, 1992

# Warning Signs of Hypothermia



Confusion



Shivering



Difficulty  
Speaking



Sleepiness



Stiff  
Muscles

[weather.gov/cold](http://weather.gov/cold)

# Recovery from hypothermia

Heat **MUST** be added to the person

remove then replace any wet clothing

wrap in warm blanket

move into or create a warm environment

administer a hot drink

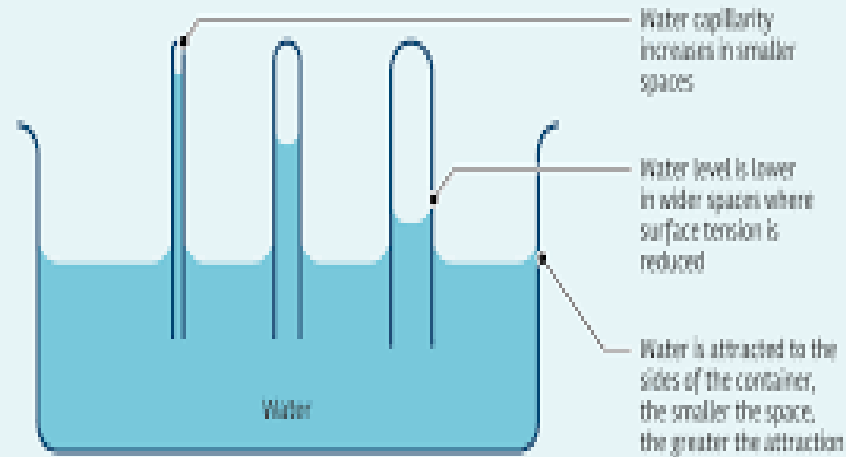
**MONITOR**

Dressing for cold:  
Do Layers of clothing that wick (breathe)

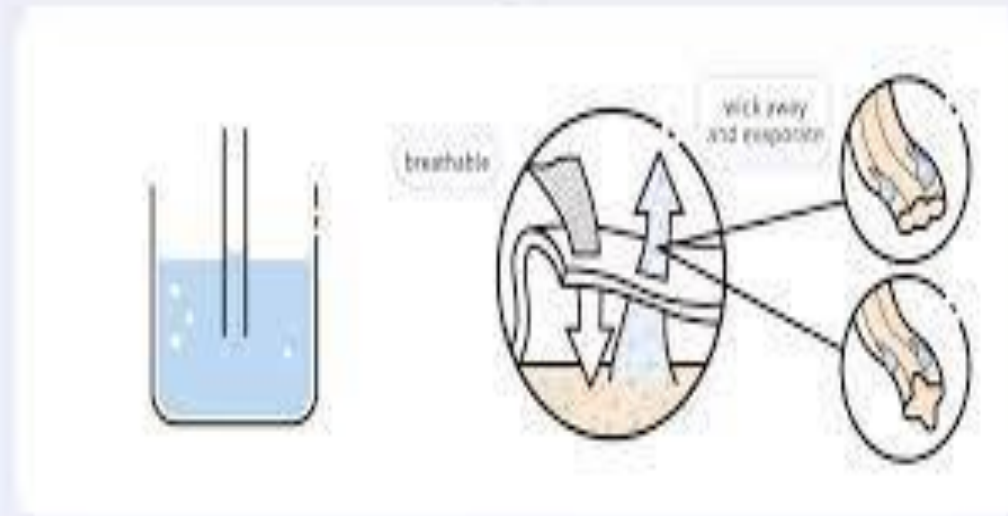


# Capillary action, aka wicking

## Capillary Action Illustrated



## • How Wicking Yarn Works •



Put a tube in water, the water in the tube is higher due to capillaries effect.

Little tubes in the yarn wick away sweat, which can evaporate into the air.

# Temperature regulation in response to heat

## *Two main mechanisms*

### *Evaporation*

Body heat is carried away as water vapor.  
Occurs mainly, *but not exclusively*, by sweating.

### *Convection*

Air currents carry away heat from the body

# *Sweating*

Which of the following is the *best* answer?

Sweating occurs when:

The body needs to loose heat.

Sweat glands contract.

# Sweat glands

Humans have from 2 to 5 million sweat glands

Eccrine glands are the vast majority

Occur throughout the skin

most numerous in hands, feet & forehead

Secrete a watery sweat

*About a 15% loss with age*

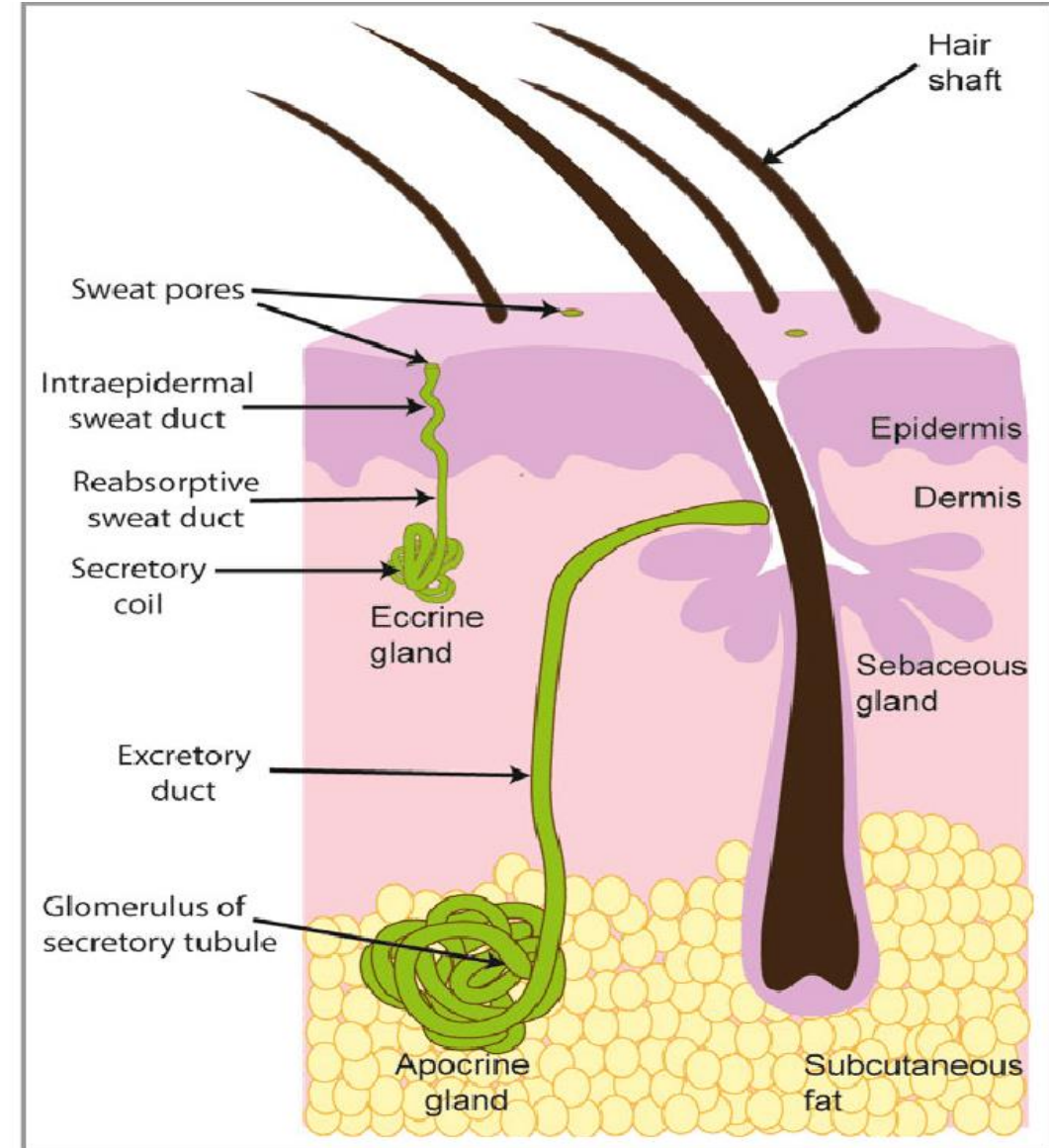
Apocrine glands occur in arm pits and genital regions

Secrete an oily sweat in response to:

Heat and/or emotional stress

Broken down by bacteria

Produce a musty odor





The 15% decrease in sweat glands with aging is in part compensated by an increase in convective cooling resulting from a thinner epidermis.

## Sweating initiated when:

Environmental temperature increases

Usually starts around 80 degrees F

Performing physical work

Yes, even in the cold

Experiencing nervous tension

Individual and highly variable



shutterstock.com · 1849142284

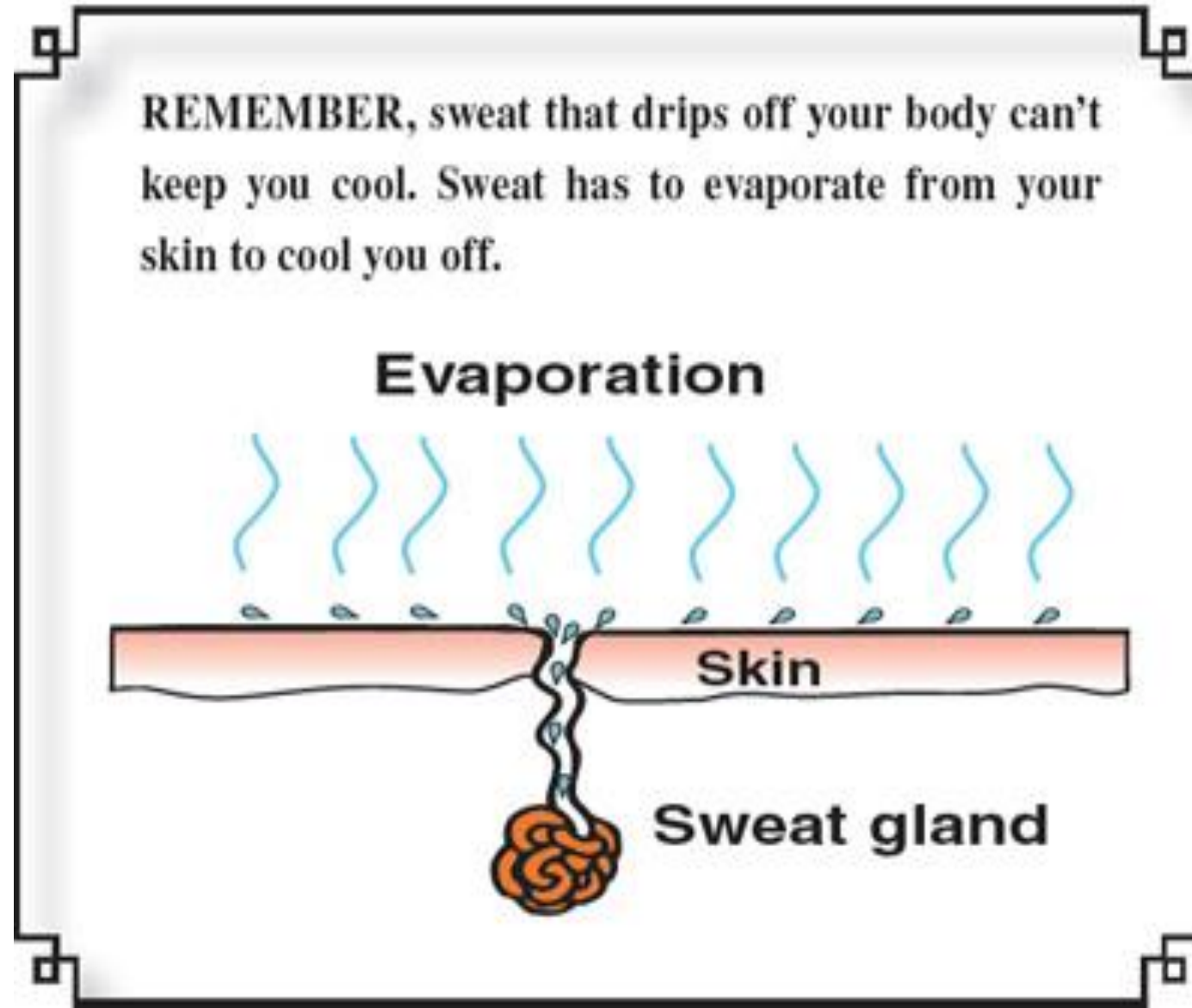


Sweating is maximal when performing work in the heat!!!



Can be dangerous in a low humidity (dry) environment. Why?

In low humidity evaporative heat loss is imperceptible!



How sweating works to take away body heat:

Sweat glands secrete water onto surface of the skin

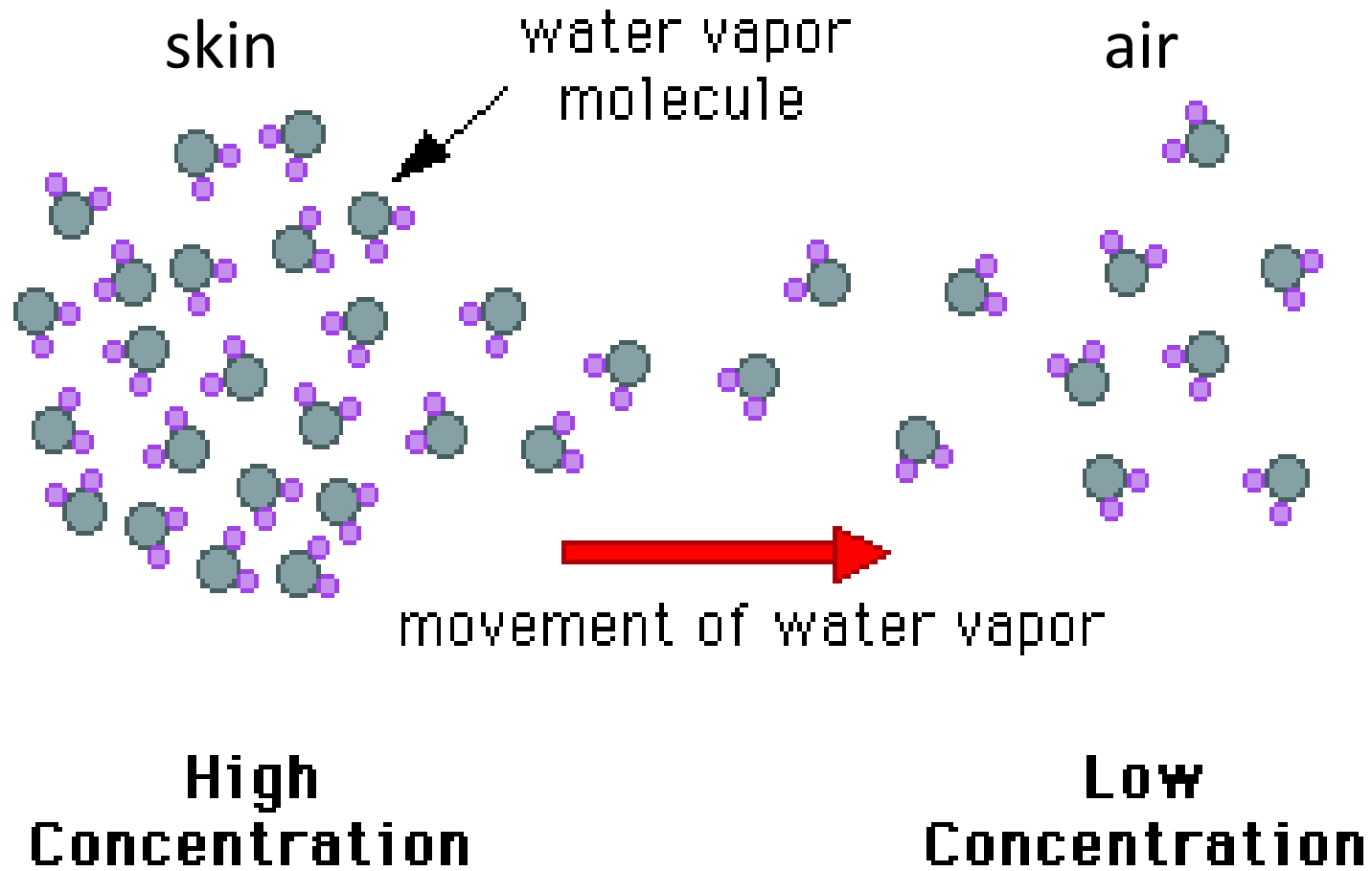
The water then draws heat from blood near surface of the skin

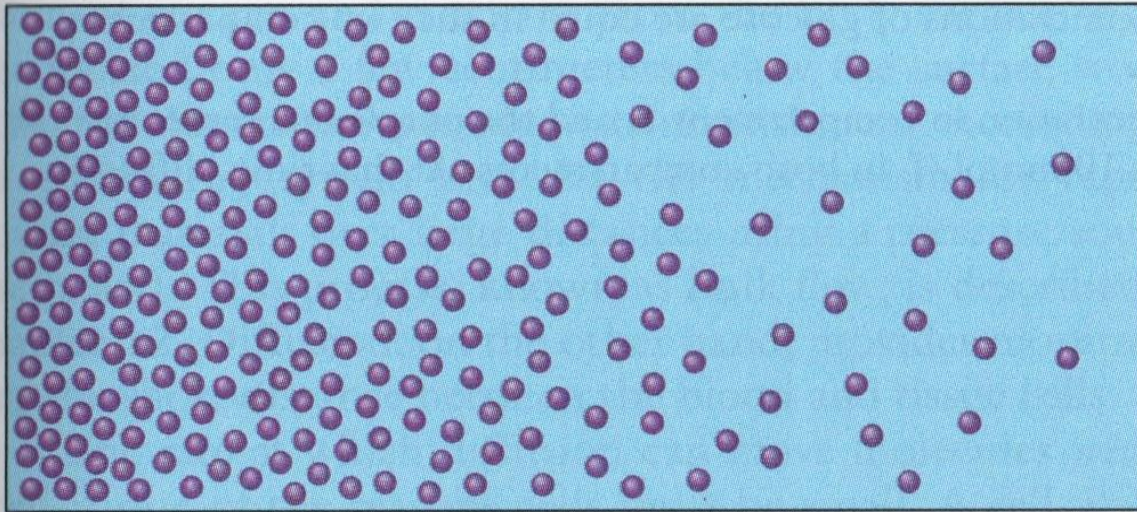
Causes the water to evaporate

Displaces heat from the body to the environment

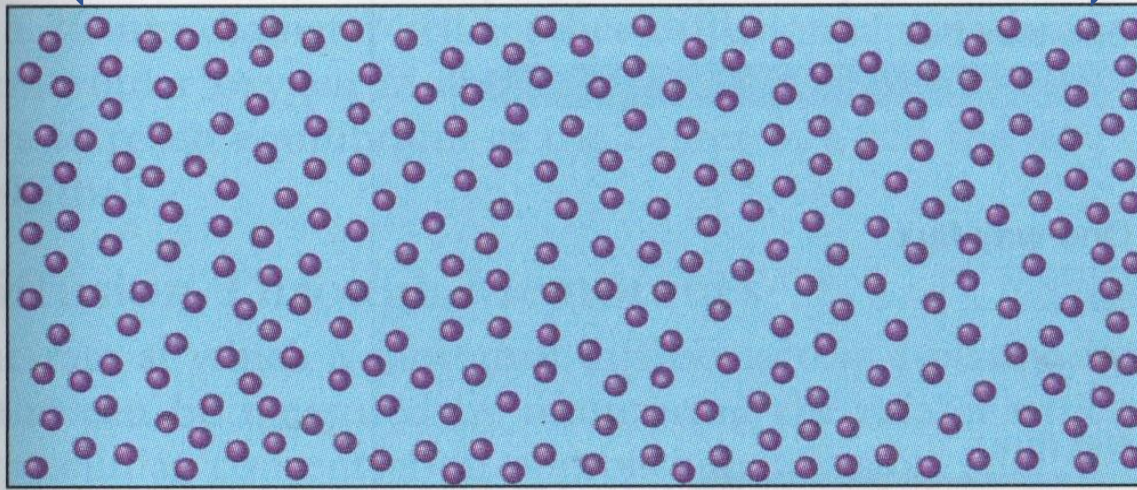
***The evaporation of sweat is inhibited by high humidity***

# Diffusion of Water Vapor





(a)



(b)

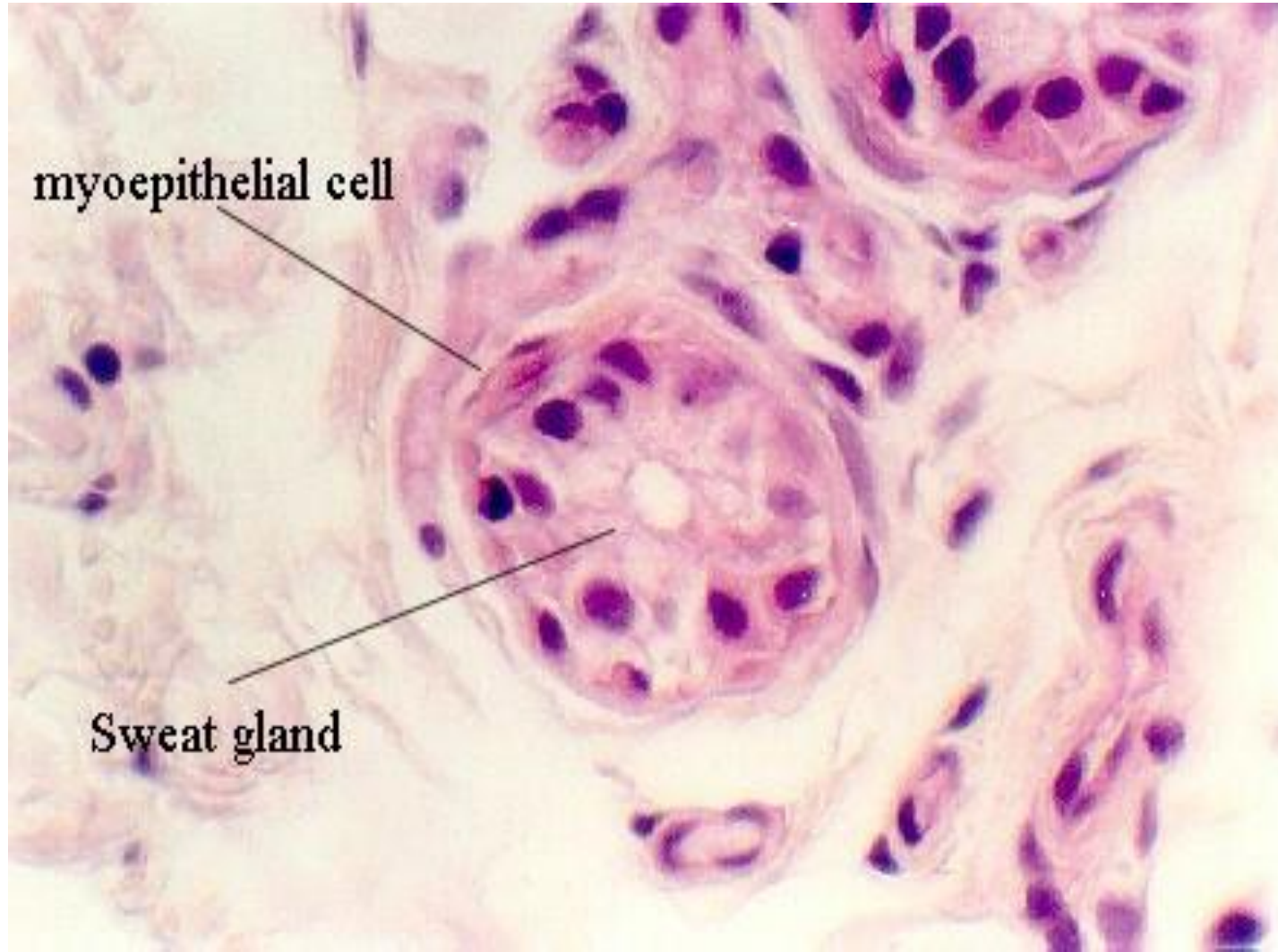


Evaporation is assisted by wind currents (convective cooling)

more rapid removal of water vapor from surface of skin

## Mechanism of sweating:

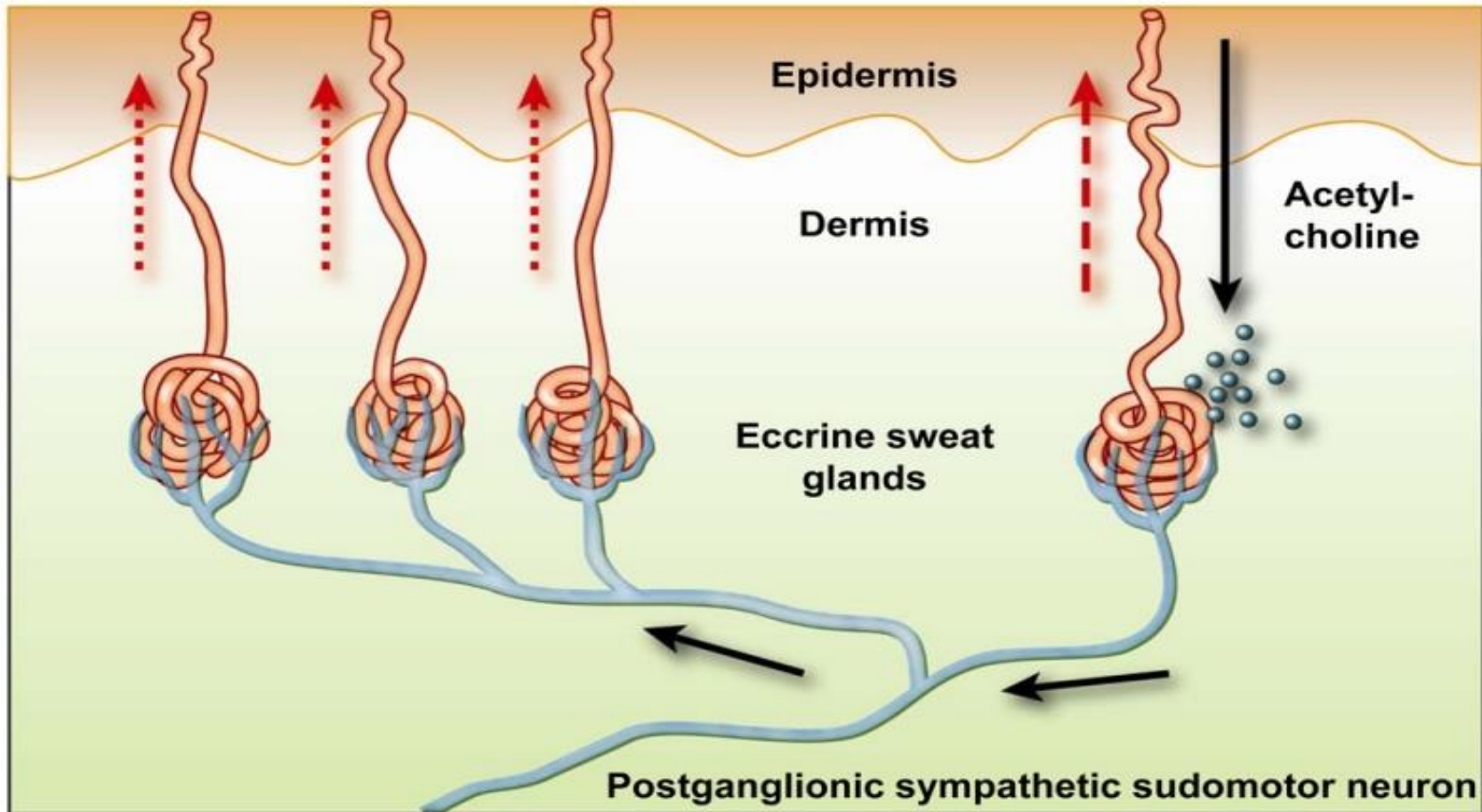
Contraction of myoepithelial cells on sweat glands elicits sweating



# Sudomotor neurons elicit contraction of myoepithelial cells on sweat glands

physical activity    emotional stress

heat stress → body temperature → brain → sudomotor neurons



Considerable evaporative cooling occurs in the head.  
However, there can also be heat gain by radiation from the sun.  
Solution, wear a ventilated hat.



Q: How does evaporative cooling occur through hair, and clothing?

A: By wicking of water through tightly packed hair and clothing fibers.



# Pathology of heat

## Heat exhaustion:

Heavy sweating resulting in:  
Cool moist (clammy) skin  
May have goose bumps  
Dizziness and fatigue  
Rapid pulse  
Headache  
Nausea

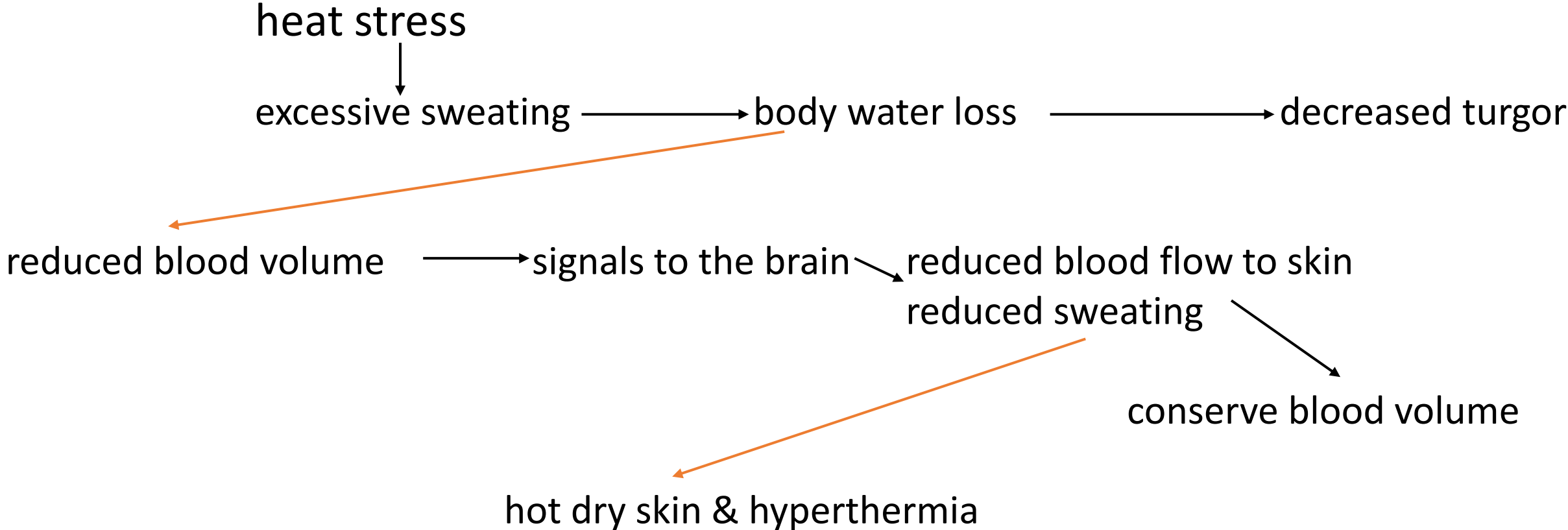
## Heat stroke:

Reduced sweating resulting in:  
Hot dry skin  
Severe hyperthermia (102-104)  
Dizziness and fatigue  
Rapid pulse  
Headache  
Nausea and vomiting  
Negative turgor test

# Decreased (negative) turgor a sign of dehydration



# Scenario of heat stroke:





# First Aid for Heat Pathology

## *For heat exhaustion*

If possible get into water or hose yourself off, particularly head and neck

Or place water soaked towel on head and neck

Move into shade or air conditioning

Lay down with legs and feet slightly elevated

Helps blood to return to the heart

Remove extra clothing and loosen tight clothing

Sip chilled water or *decaffeinated* sports drink

# First Aid for Heat Pathology

*For heat stroke* (much more serious)

Call 911. Until they arrive:

Put person in water, or cool shower,  
or spray with hose, or sponge with cool water

Place ice packs or cool wet towels on neck, arm pits and groin

When done with the water things, cover with cool damp sheets

If the person is conscious and alert offer chilled water  
or *decaffeinated* sports drink

# *To Beat the Heat*

Dress for heat

Stay hydrated

# *Dressing for heat*

*Ventilated hat*

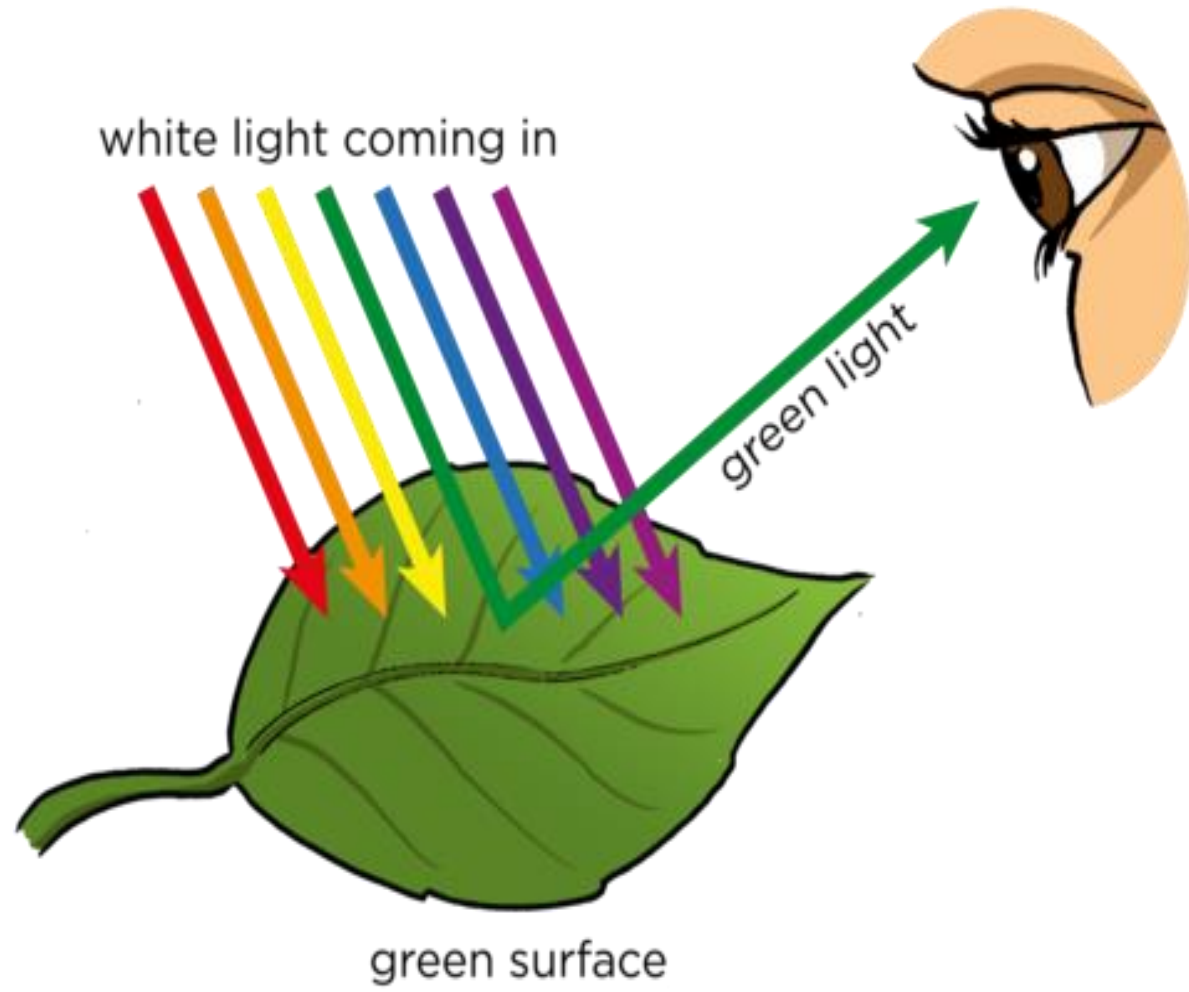
*Clothing that satisfies the three L's*

Light in weight.

Loose fitting.

Light in color. White is best! Why?





# Absorption and reflection of light



A red object reflects red and absorbs other colors of white light.

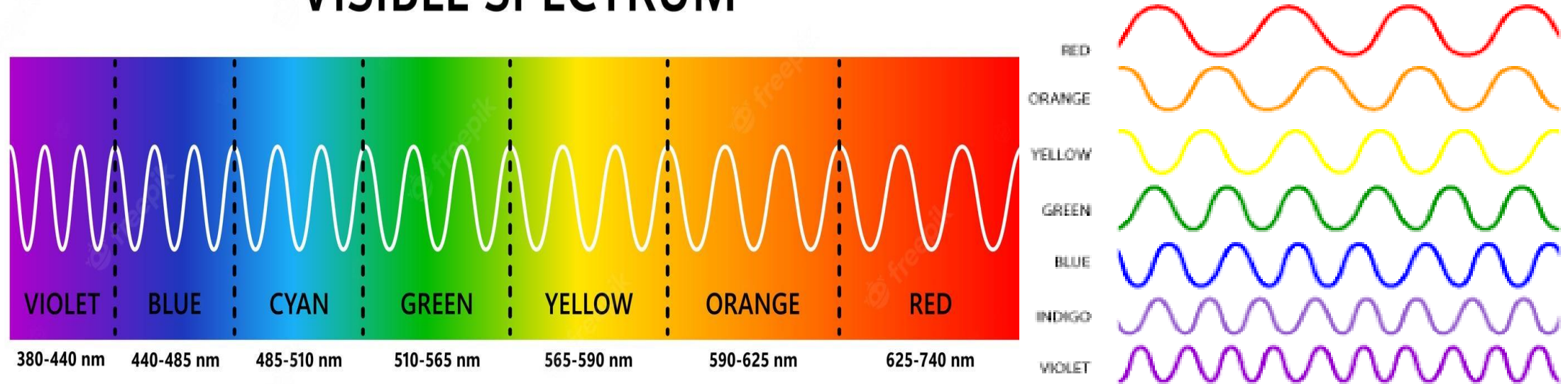


A white object reflects all colors of white light equally.



An object is seen as black if it absorbs all colors of white light.

# VISIBLE SPECTRUM



Energy of light waves = wave frequency

Blue light (high freq) has more energy than red light (low freq)



## *Staying hydrated*

Dehydration triggers the sensation of thirst

If you're thirsty, you're dehydrated

Sensation of thirst diminishes with age

if us senior citizens are thirsty, we're really dehydrated

don't let yourself get thirsty

Other indicators of dehydration

dizziness

muscle cramps

dark color of urine

# URINE COLOR CHART (chart)



HYDRATED



VERY GOOD



GOOD



FAIR



LIGHT  
DEHYDRATED



DEHYDRATED



VERY  
DEHYDRATED



SEVERE  
DEHYDRATED

## How much liquid is needed for hydration:

During rest to light activity in a neutral temperature (the Goldilocks' zone) the two closest recommendations are:

- 1) Drink one third your body weight in ounces per day  
180 lb person would drink 60 oz  
7.5 cups @ 8oz/cup
- 2) Drink five 8 oz glasses per day (40 oz or 5.0 cups)

1) from: WebMD

2) from: "Seniors at Home" a division of Jewish Family and Children Services

During physical activity in a hot environment:

Drink before, every 15 to 20 min during and after activity such that you keep yourself from getting thirsty.

Monitor how you feel: alert, not dizzy, no cramping.

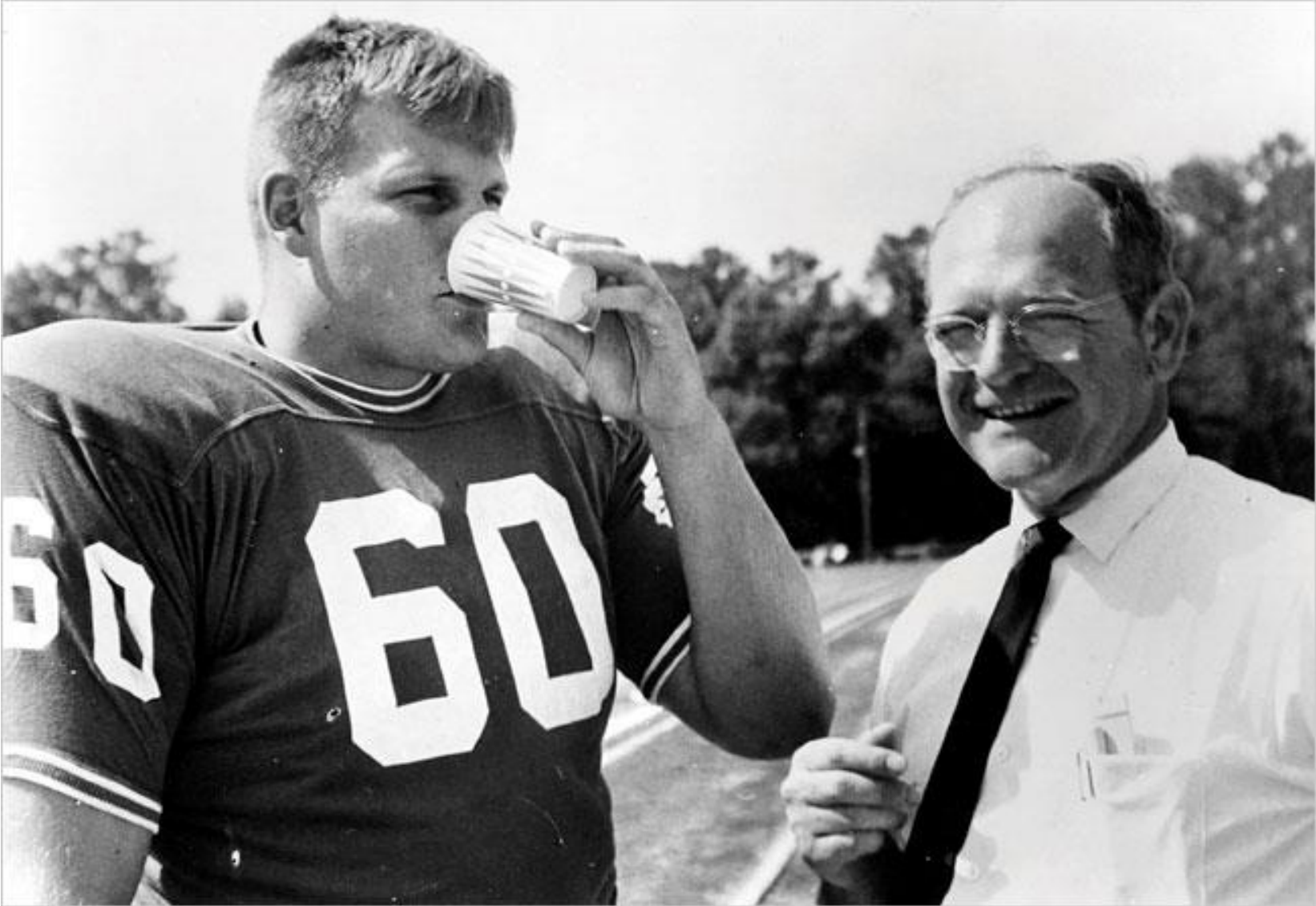
Check your urine color if the opportunity arises.

# What to drink

Water is OK, but when you sweat you're losing more than water



Robert Cade, Professor of nephrology, University of Florida (circa 1965)



To replace salt and water, drink a sport drink such as Gatorade



Warning! 20 oz bottle of regular Gatorade has 34 grams of sugar (about 7 tsp)

However: Gatorade Zero is sugar free





La Fin