Adapting to a Warmer World 2025

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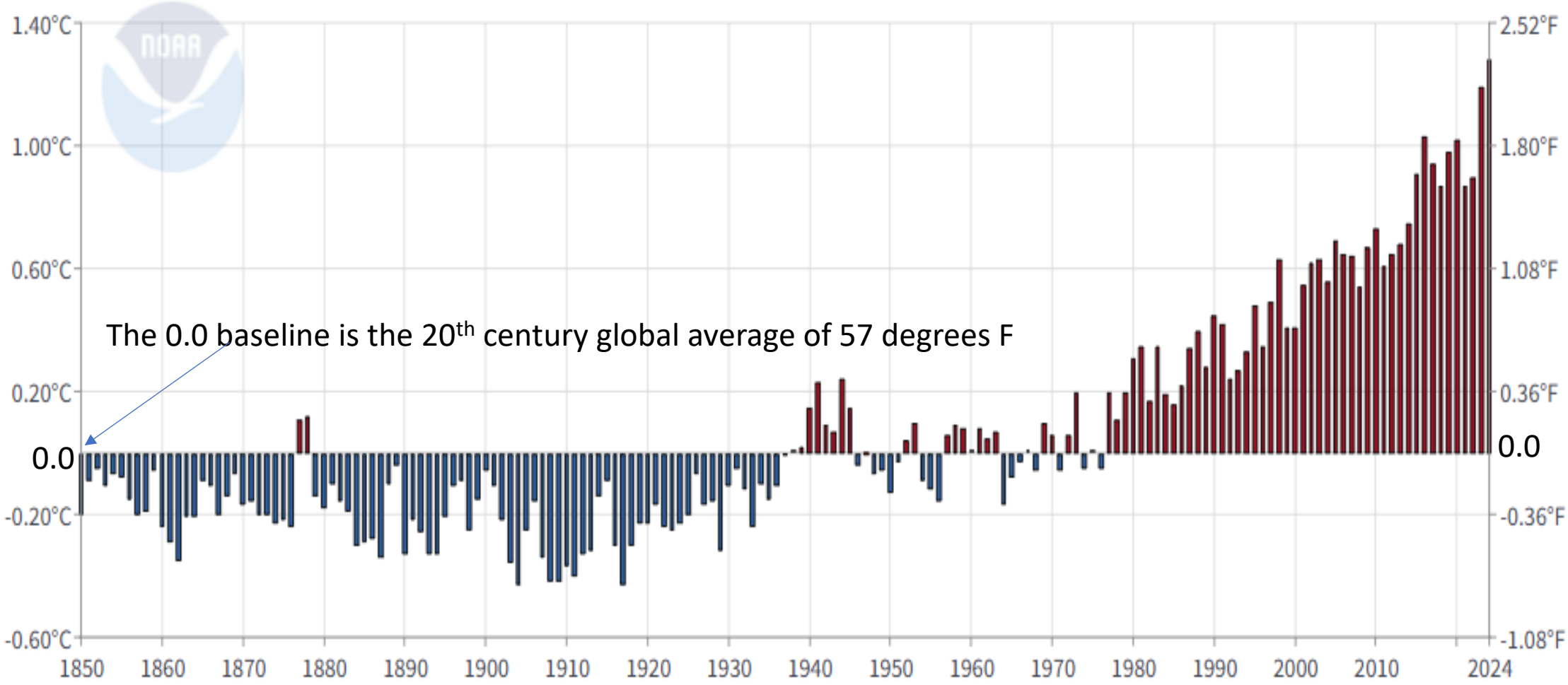
A copy of this presentation can be found in the web site: *danielray.site* Under presentations click on: *Adapting to a Warmer World 2025*

A similar but longer presentation with figure descriptions titled *Adapting to a Warmer World*, originally scheduled For Spring 2024, can be found at the same site

Global Land and Ocean Average Temperature Anomalies (Change from 20th century average)

January-December



What is Global Temperature:

Global temperature is a value determined by averaging land and ocean surface air temperature year around from multiple weather stations on land and sea world-wide in both northern and southern hemispheres.

Temperature data from these stations are analyzed by the National Oceanic and Atmospheric Administration (NOAA) who present the results usually on a daily basis, as well as averaging them over a given year to give an annual global temperature.

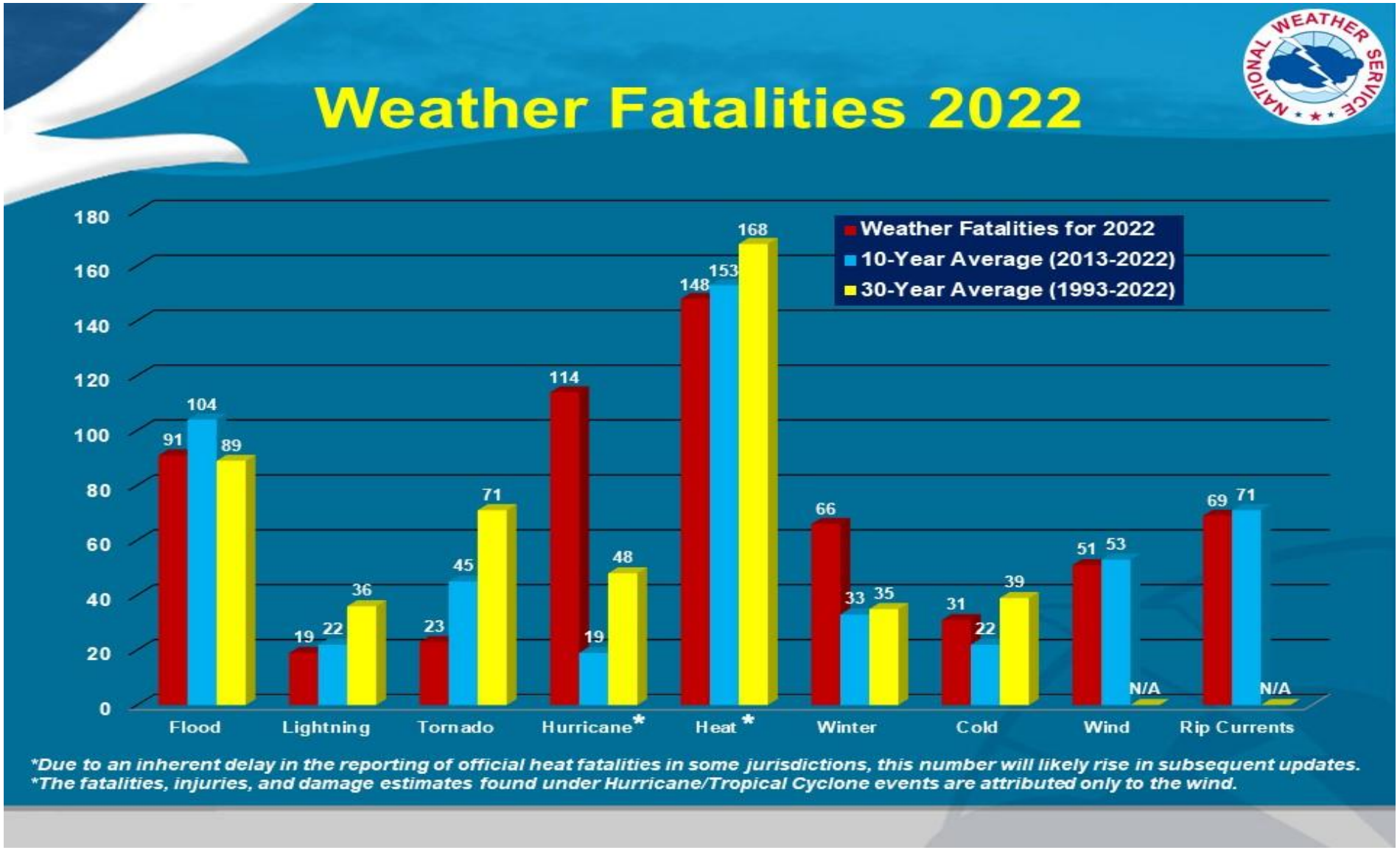
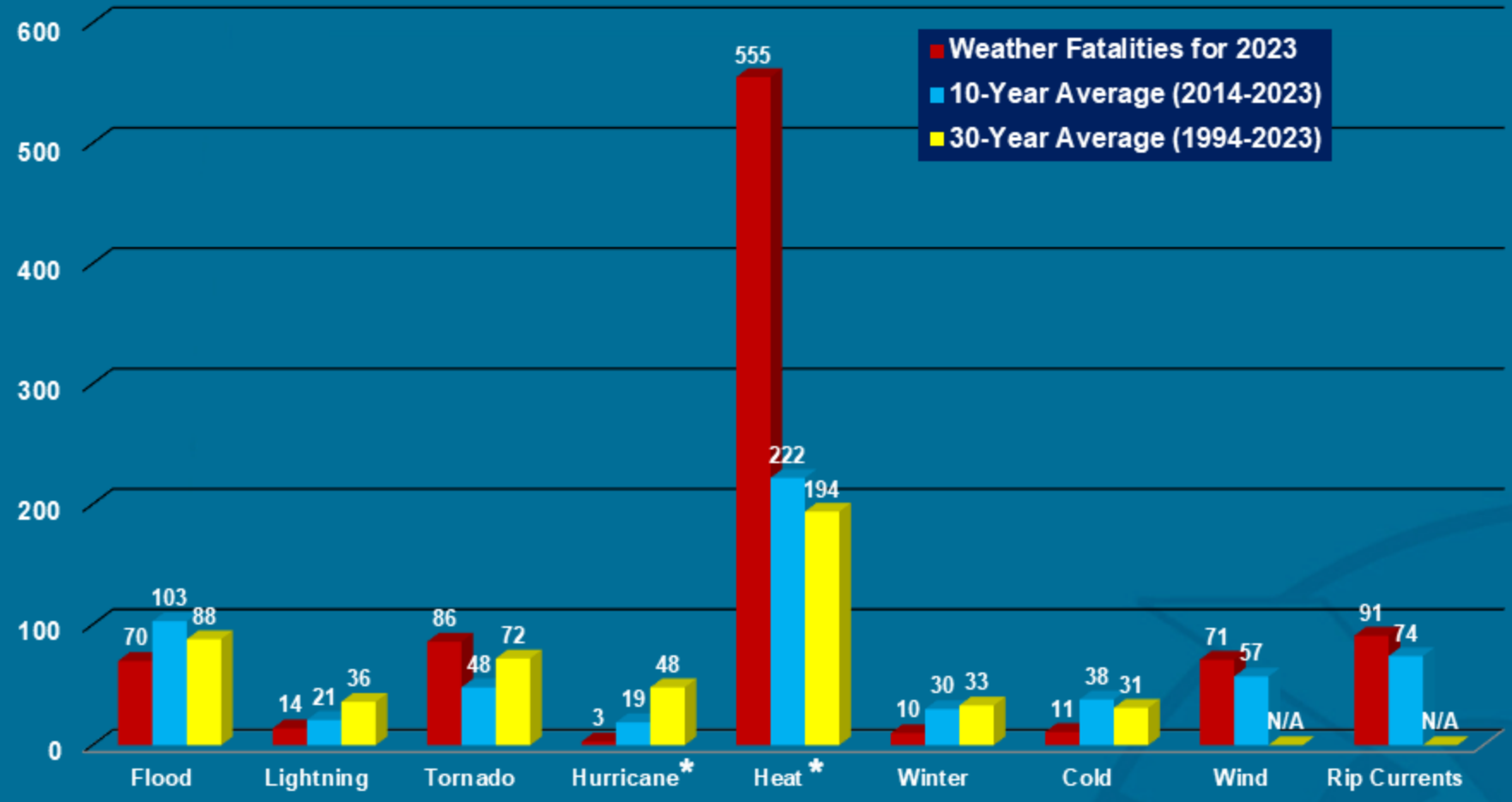
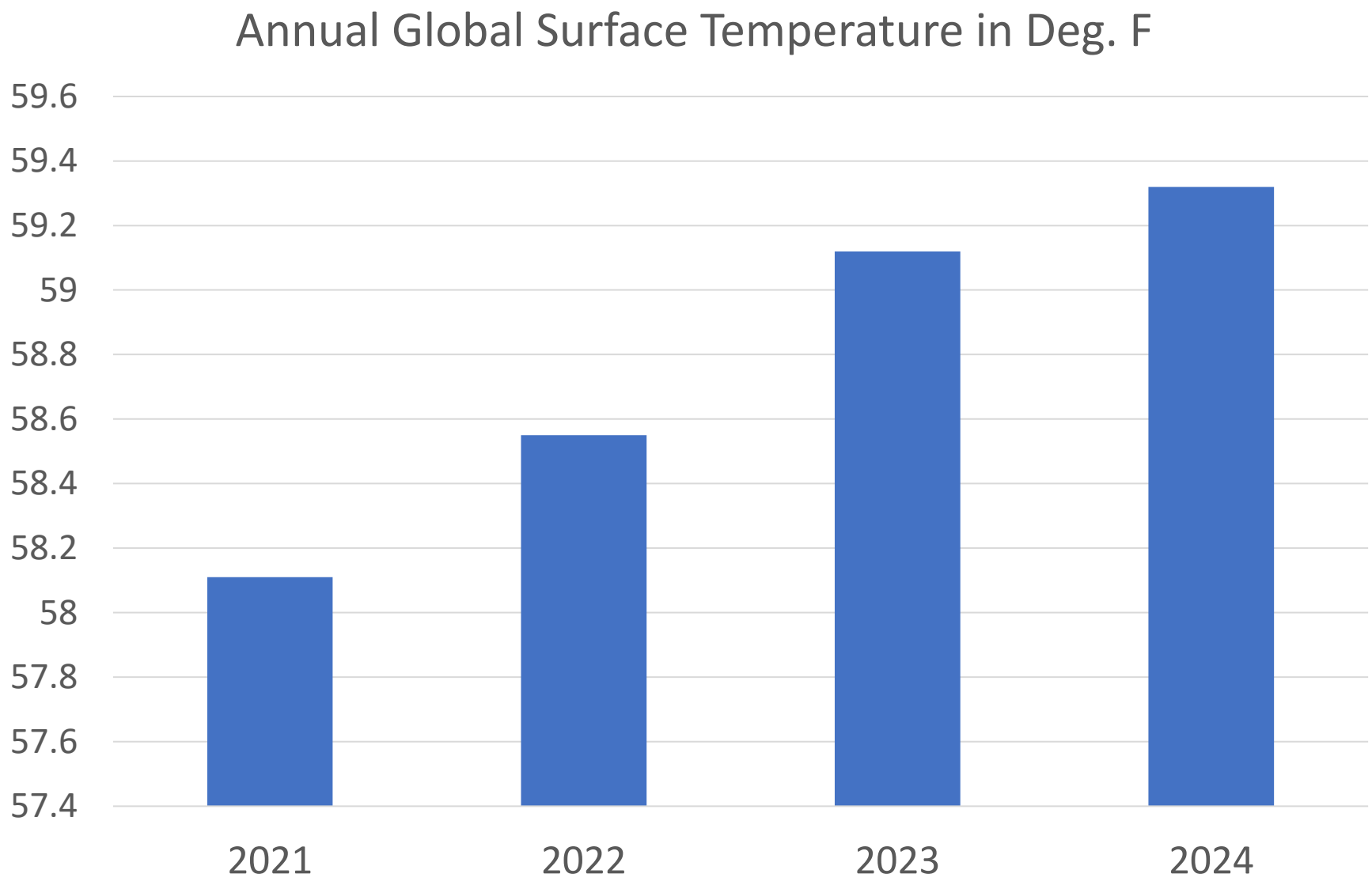


Figure 3: The bar graph shown here presents weather-related fatalities for a single year (2022) and for 10 and 30 year averages. Note that all three time frames show that heat is our most lethal weather-related phenomenon.

Weather Fatalities 2023

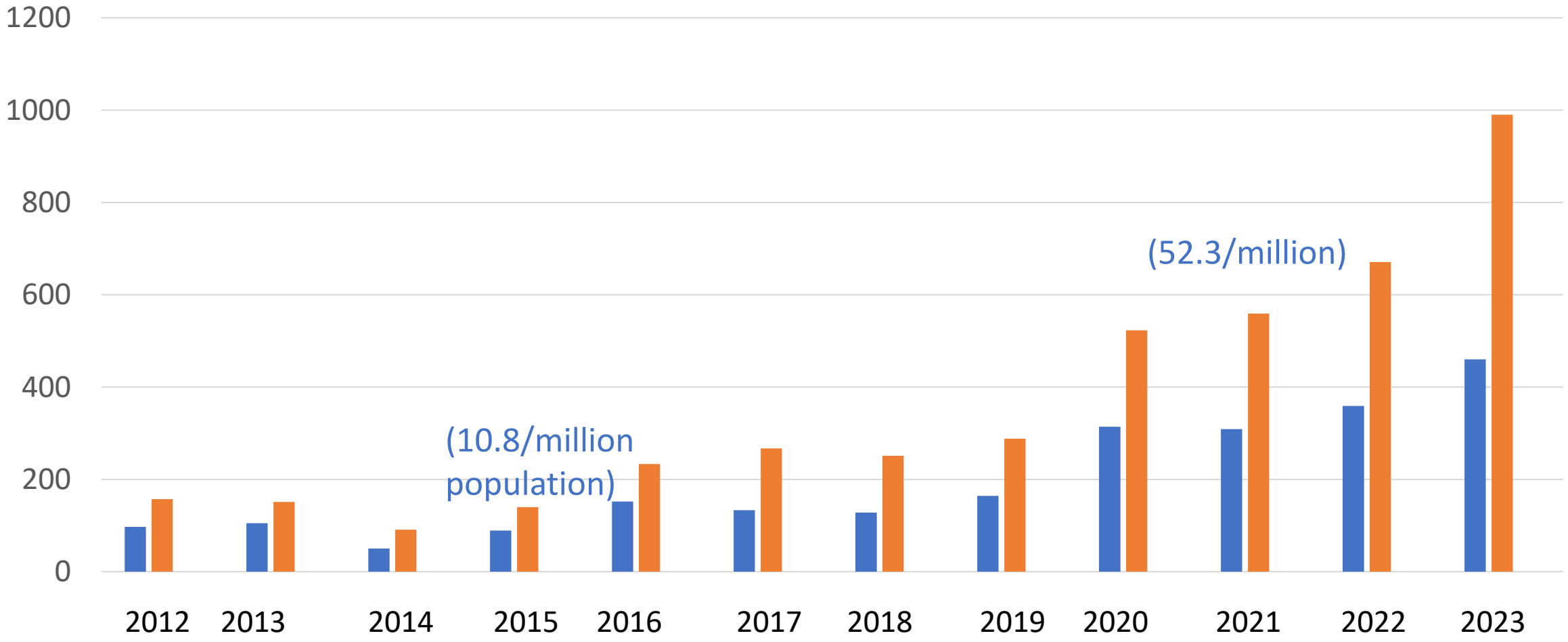


*Due to an inherent delay in the reporting of official heat fatalities in some jurisdictions, this number will likely rise in subsequent updates.
*The fatalities, injuries, and damage estimates found under Hurricane/Tropical Cyclone events are attributed only to the wind.


Annual Global Surface Temperature in Deg. F
59.6
59.4
59.2
59
58.8
58.6
58.4
58.2
58
57.8
57.6
57.4
2021
2022
2023
2024

Number of Heat Caused (blue) and Heat Related (orange) Deaths in Maricopa County Arizona

(From: Arizona Dept. Health Services)

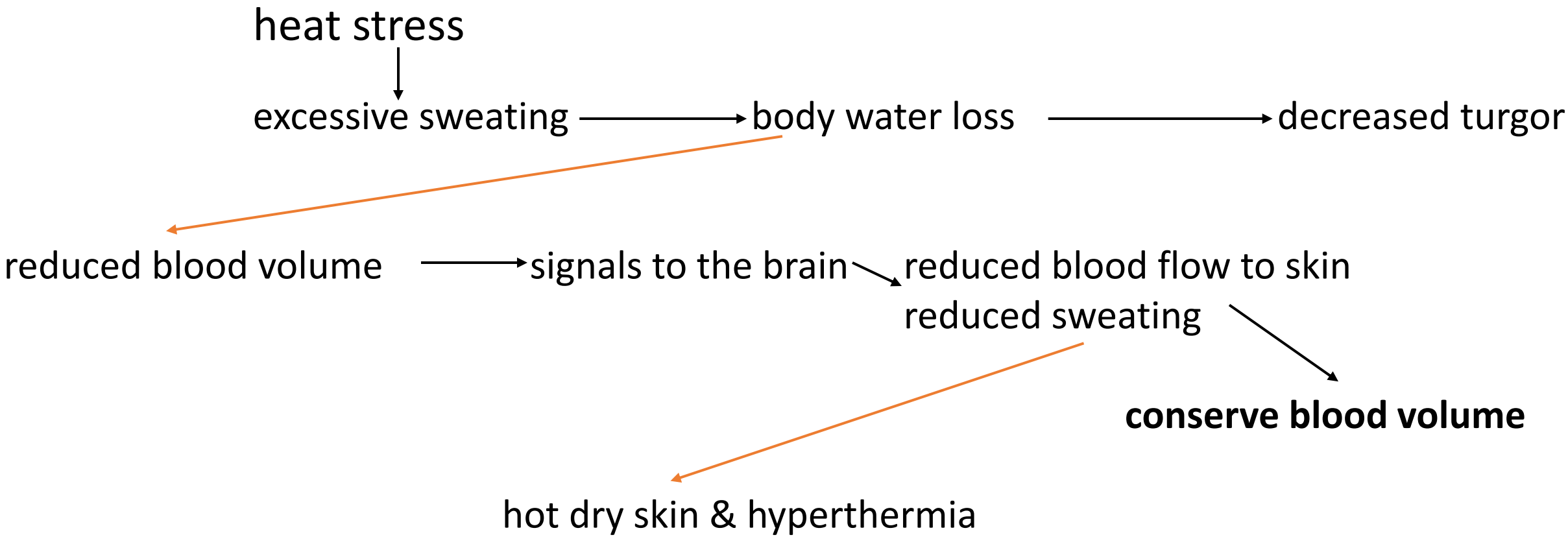


Heat caused = Hyperthermia (aka heat stroke)*

- high body temperature
- hot dry skin
- little or no sweating
- nausea
- decreased skin turgor

*a life threatening condition (call 911)

Scenario of heat stroke:



Review of body temperature regulation in response to heat:

Physiological

Maintains body temp in warm environments

Behavioral (dressing for hot weather) & Physiological

Maintains body temp in warm to hot environments

Two main physiological/physical mechanisms

Evaporation

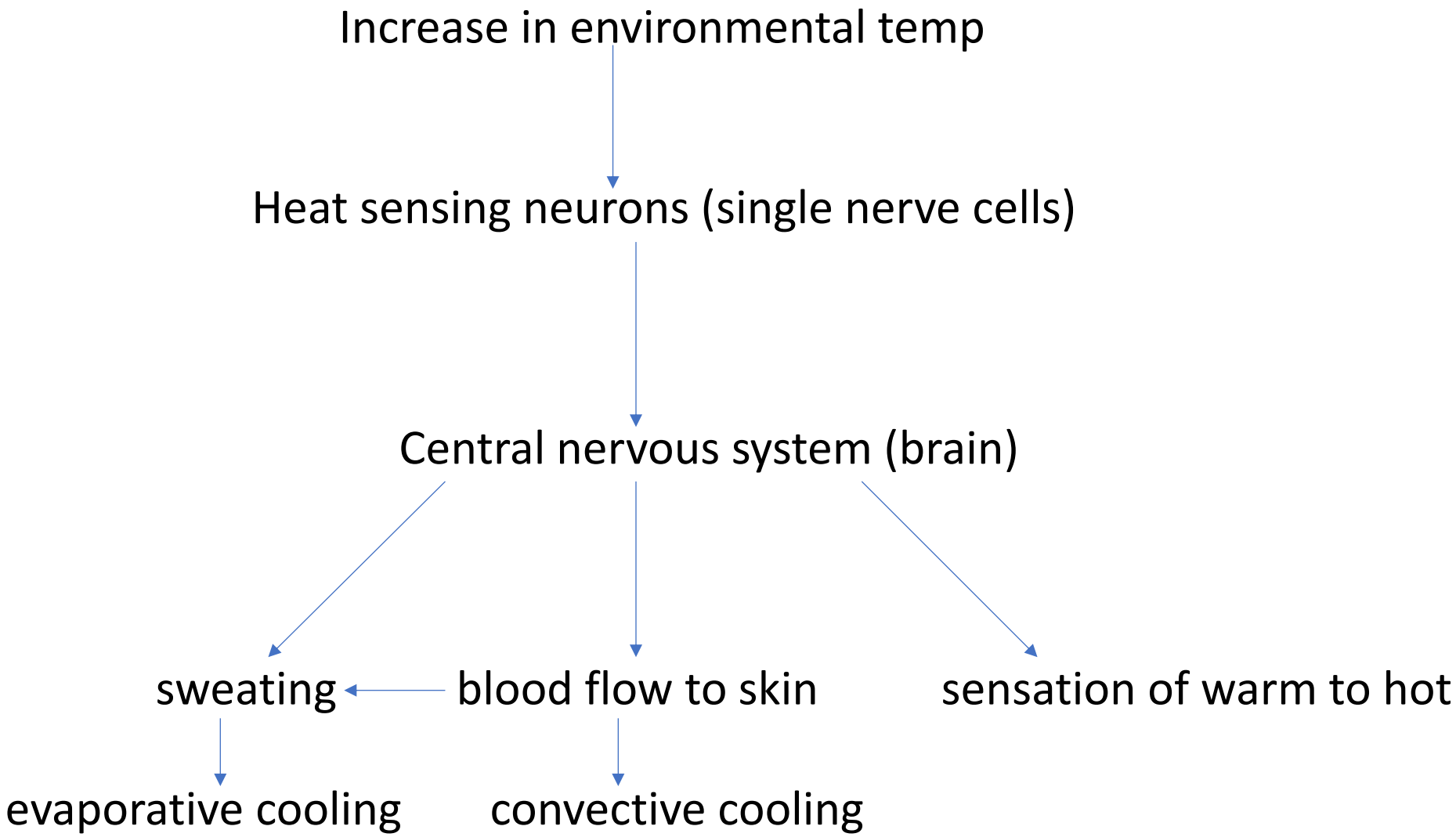
Body heat is carried away as water vapor.

Occurs mainly, *but not exclusively*, by sweating.

Convection

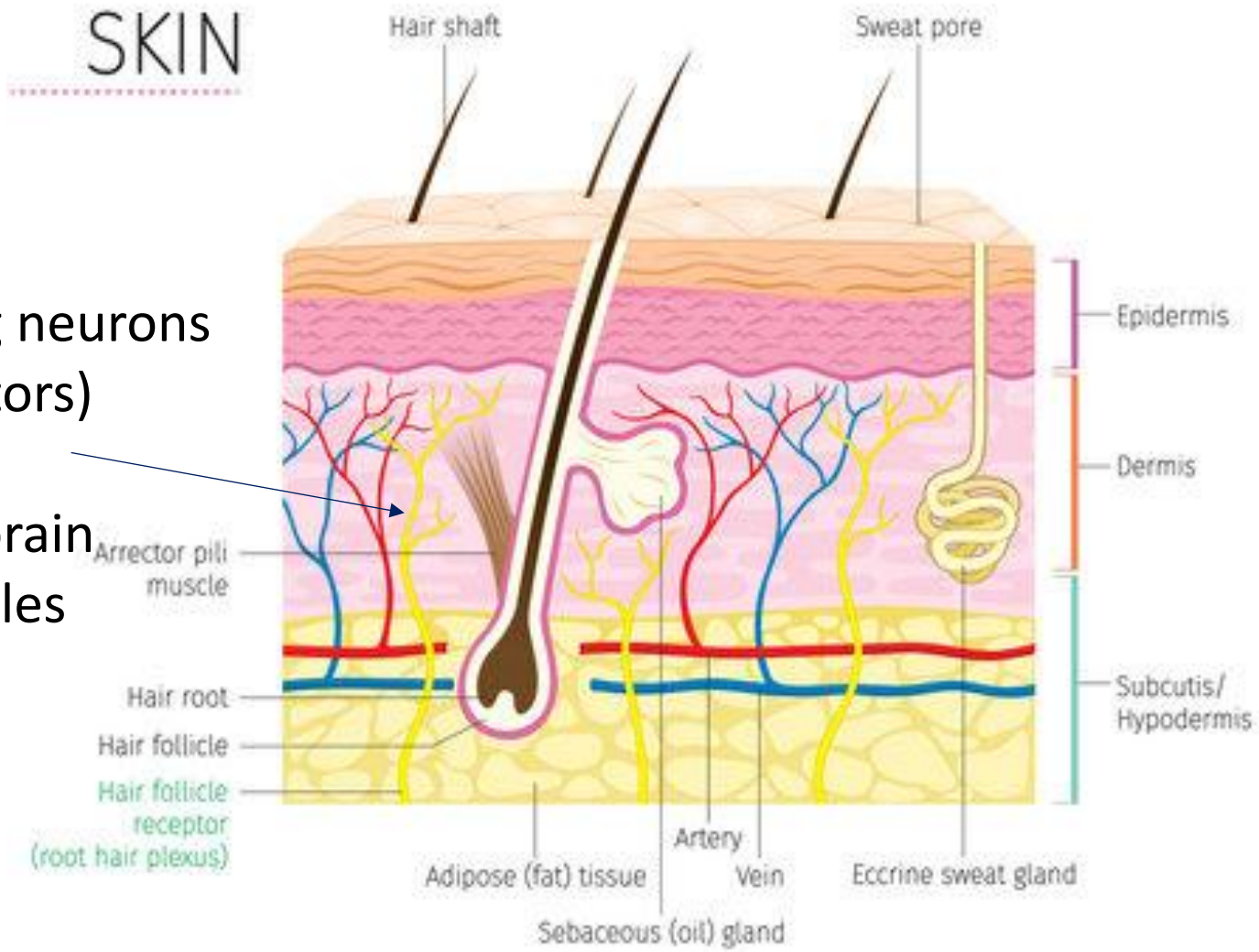
Air currents carry away heat from the surface(skin) of the body including the heat in water vapor produced by sweating.

General Scheme of Response to Heat



Detection of Environmental Temperature

Temperature sensing neurons
(aka thermoreceptors)
also exist in:
parts of the brain
skeletal muscles



Thermoreceptors

Two types of single neuron endings

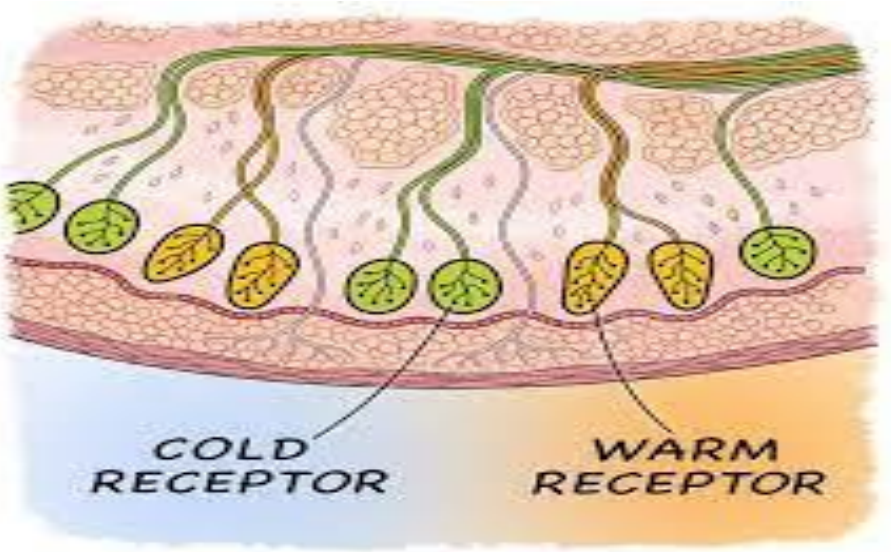
Those that respond to cooling temperatures

Range 23 to 82 deg F

reduce blood flow to skin

increase body metabolism

shivering



Those that respond to warming temperatures

Range 82 to 130 deg F

increase blood flow to skin

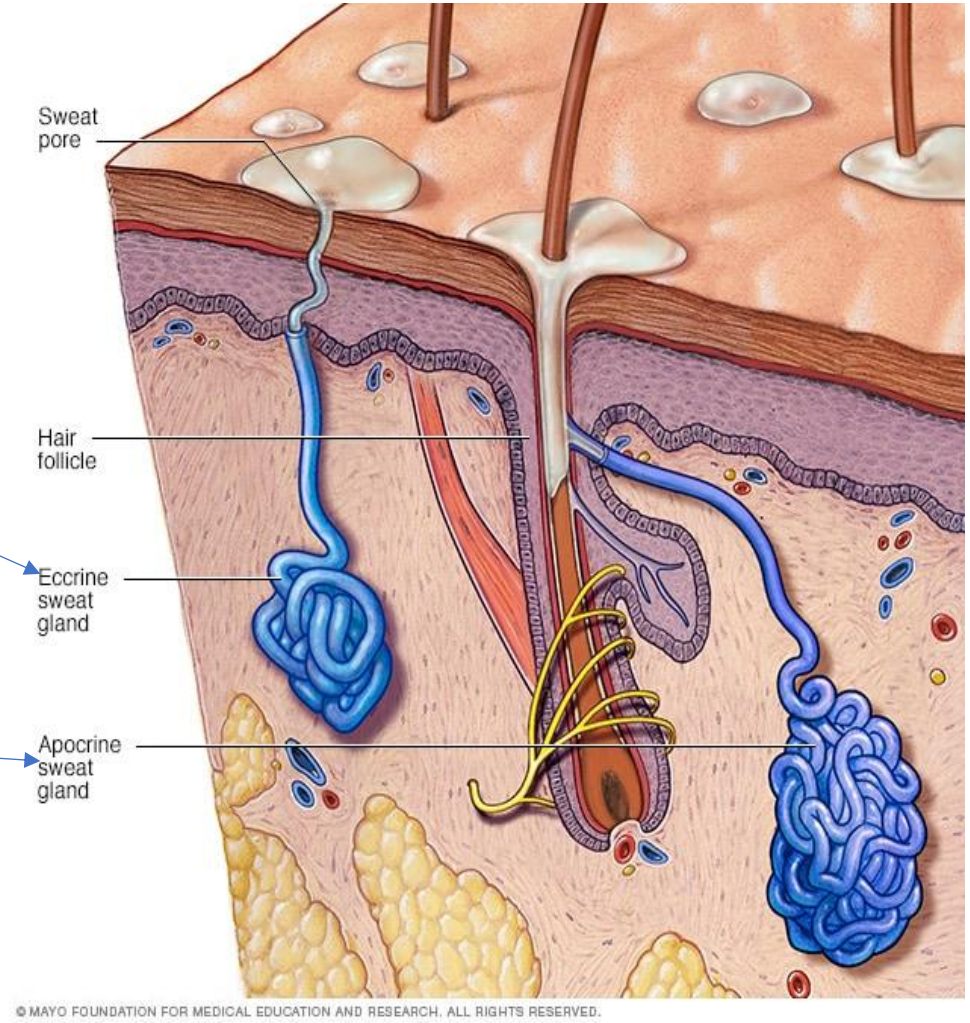
initiate sweating

Sweat glands

Humans have from 2 to 5 million sweat glands

Eccrine glands are the vast majority
- Occur throughout the skin
  - 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



Sweating initiated when:

Environmental temperature increases

Usually starts around 80 degrees F

Performing physical work (i.e., physical activity)

Yes, even in the cold

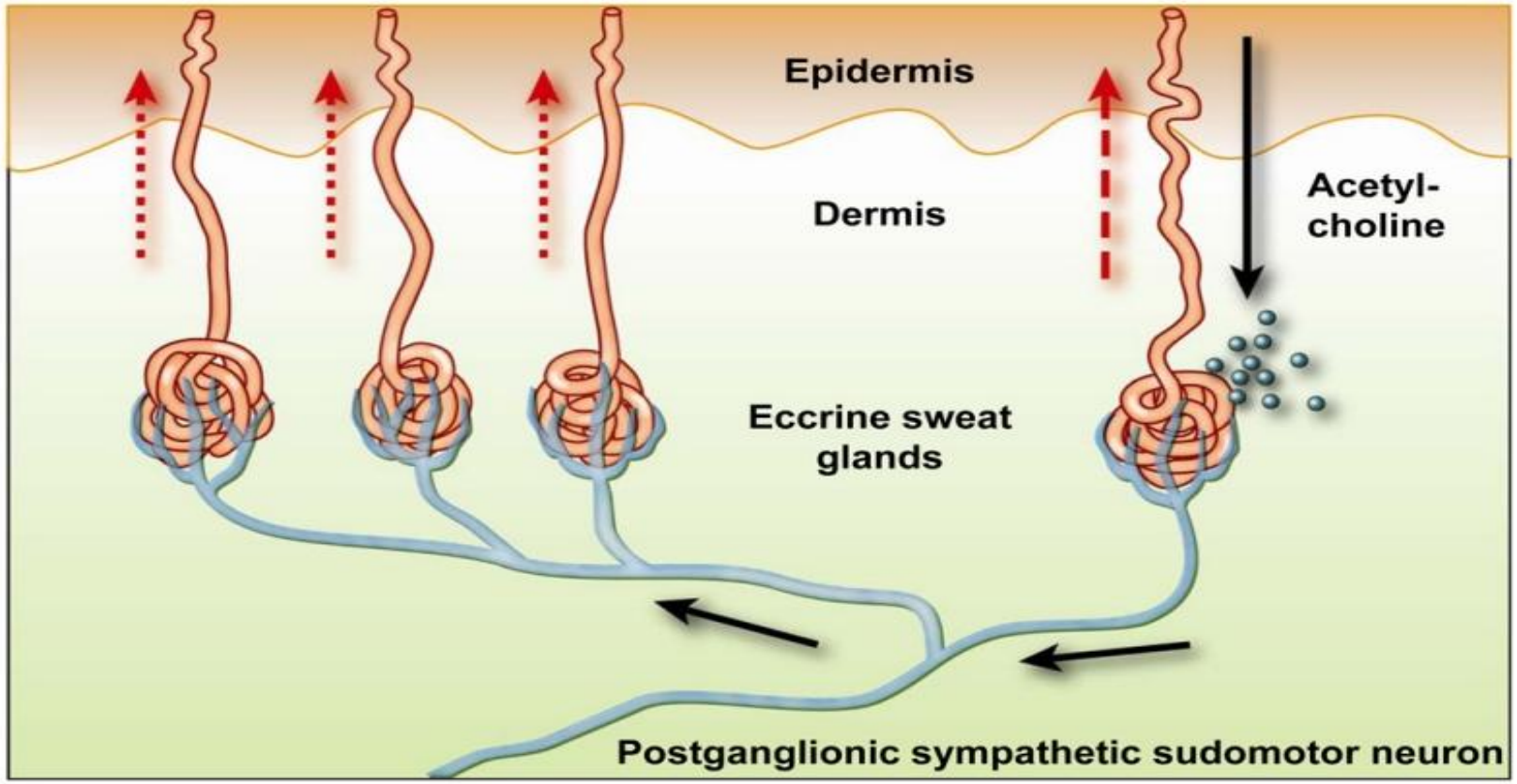
Experiencing nervous tension

Individual and highly variable

Sudomotor neurons elicit contraction of special muscle cells on sweat glands

physical activity emotional stress

heat stress → body temperature → brain → sudomotor neurons → Sweat glands contract!



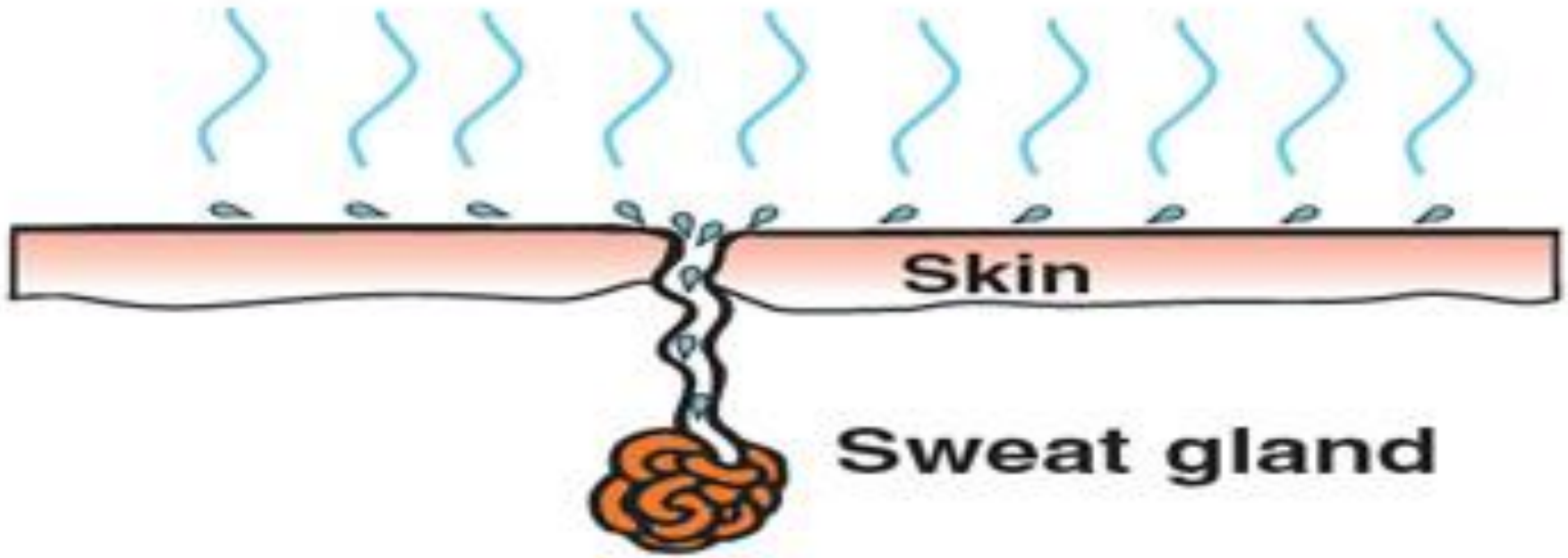
Sweating is maximal when physically active in hot weather!!!
(Combines effects of work and heat.)

In which environment is sweating most effective?
A dry environment (left), or a humid environment (right).

Answer: A dry environment

REMEMBER, sweat that drips off your body can't keep you cool. Sweat has to evaporate from your skin to cool you off.

The heat required to vaporize sweat is drawn from your body!!



Sweating is most effective in dry (low humidity) environment,

But it can also be dangerous because in such an environment:

Evaporative heat loss is imperceptible!

Such a situation can lead to:

Heat exhaustion, or more seriously

Heat stroke (aka hyperthermia)

Behaviors used to Beat the Heat

Stay hydrated
Dress for heat
Minimize midday sun exposure
Acclimate to warm weather

Stay hydrated

Dehydration triggers the sensation of thirst
If you're thirsty, your dehydrated

Sensation of thirst diminishes with age
If us senior citizens are thirsty,
we're really dehydrated.
Don't let yourself get thirsty!

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.

What to drink

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

To replace salt and water, drink a sports drink

Warning! Regular sports drinks contain large amounts of sugar.

However: Some sports drinks (eg, Gatorade Zero) are sugar free.

Dressing for heat

Ventilated hat

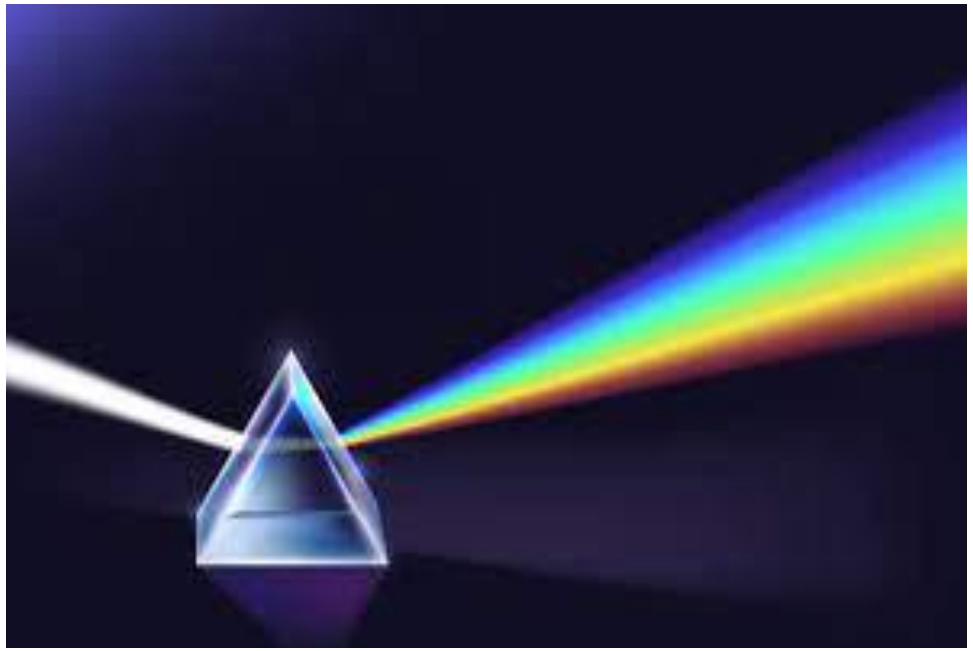
Clothing that satisfies the three L's

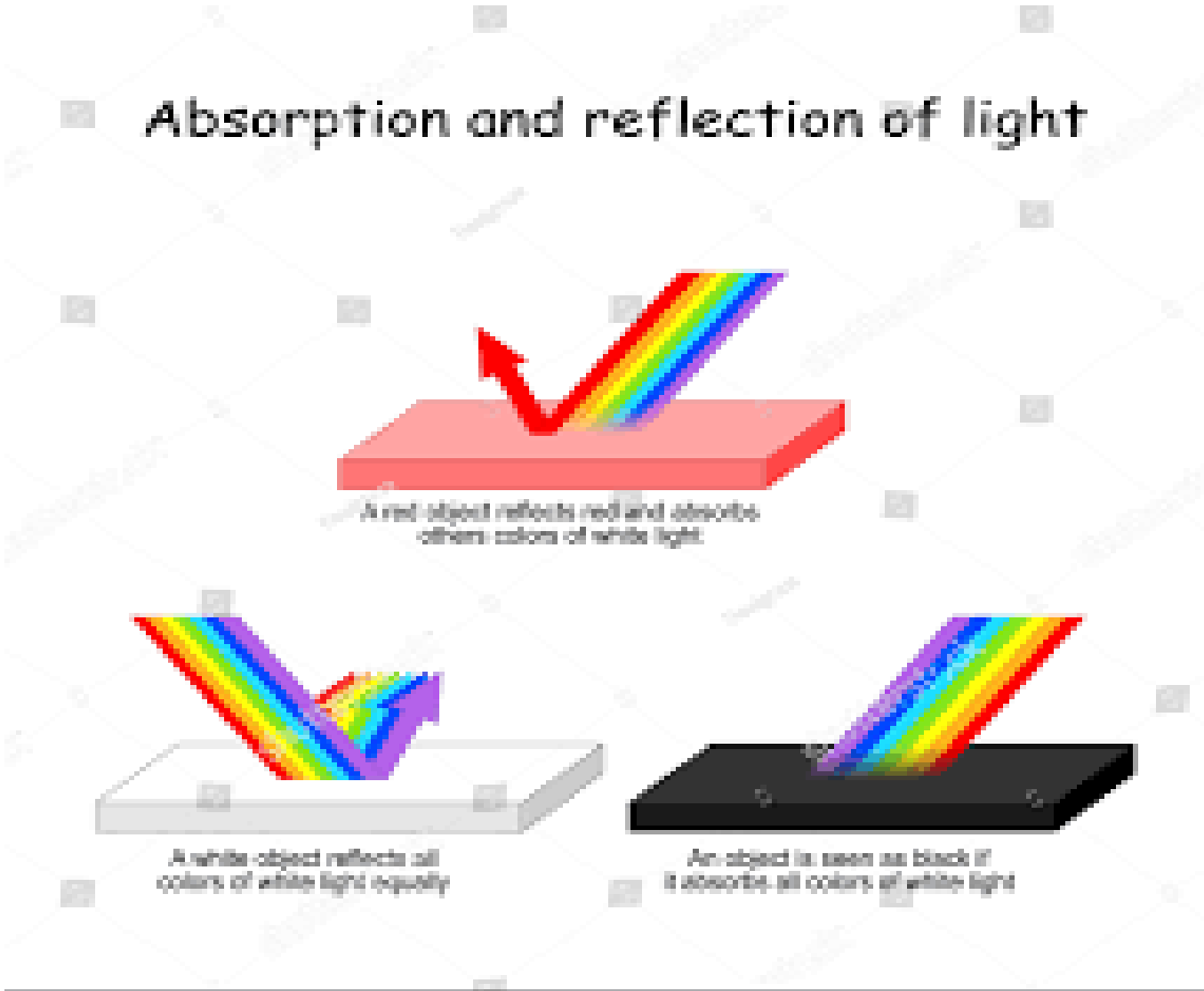
Light in weight.

Loose fitting.

Light in color.

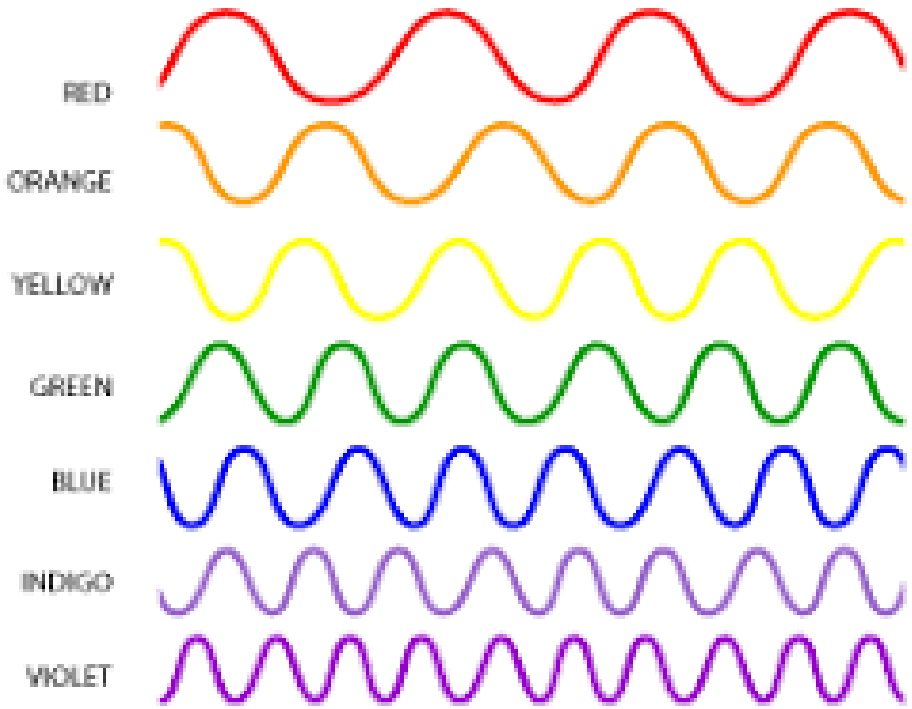
Why light in color.





The wave nature of light

The colors of light travel in discrete units of a given frequency, but all colors travel at the same speed, 300,000 km/sec.



Low energy

High energy

Best option:

White shirts with special weaving that blocks UV rays.

Columbia brand with a UPF* rating of 30 is about $45 at REI.

*UPF (ultraviolet protection factor)

1/UPF = fraction of UV rays that will pass through a fabric.

1/30 = 0.033 = 3.3% of UV rays will pass = 96.7% UV rays blocked.

While white clothing reflects all visible light thereby keeping you cool, dark blue, and other dark colors, will absorb UV rays keeping them from reaching your skin.

Thought to give good protection against UV rays. (Cancer Council of Australia, 2020)

Sunscreen: Protects skin from UV rays

"Slather" face and other exposed skin with SPF of 30 or higher about 30 min before going out.

SPF (Sun Protection Factor) essentially same as UPF except that SPF refers to cancer causing UVB rays

Minimize midday sun exposure:

Usually 10:00 AM to 3:00 or 4:00 PM

When sun is most direct and UV rays are high

Produces highest temp and
most high energy UV exposure

Web site to look up hourly UV index in your zip code
(https://chromedomecaps.com/uv-index-today/)

Caution: Heat and UV (ultraviolet) rays are not the same.

On October 31, 2023, 11:30 AM

In Tempe, AZ, elevation 1,180 ft

Air Temp – 76

UV index – 3.8

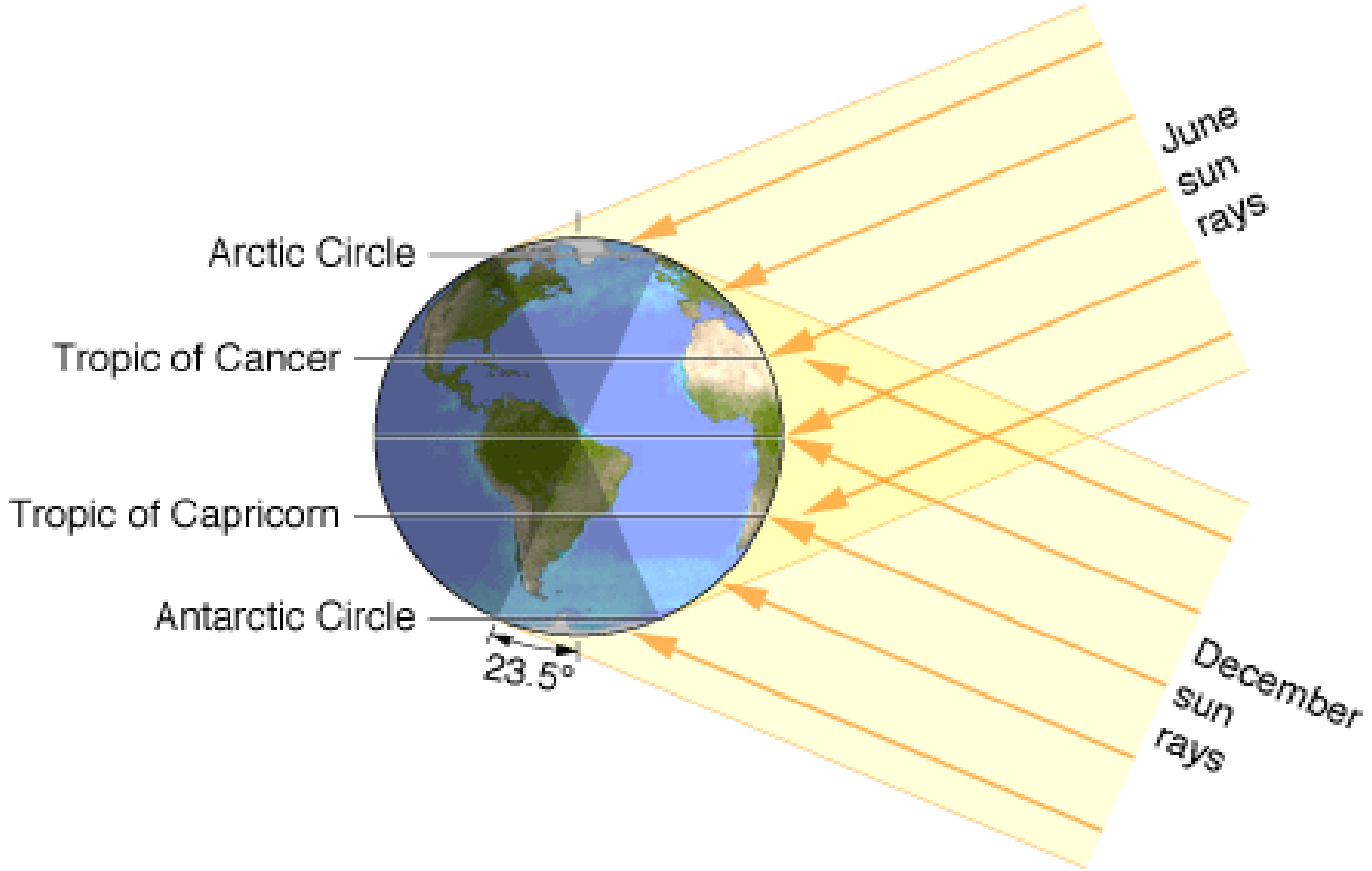
In Tonto Village, AZ, elevation 5,700 ft

Air Temp – 62

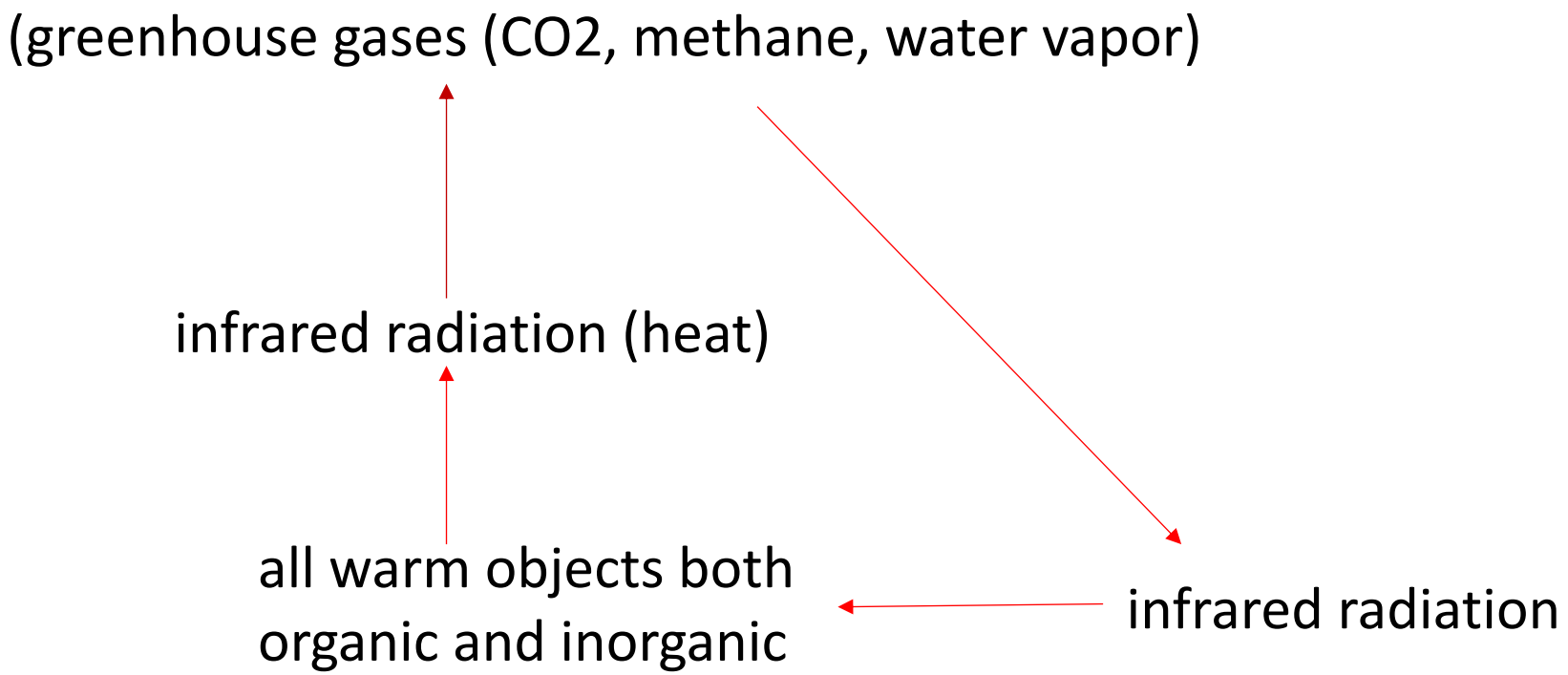
UV index - 4.0

(On average air temp decreases 3.5 F per 1,000 ft increase in elevation)

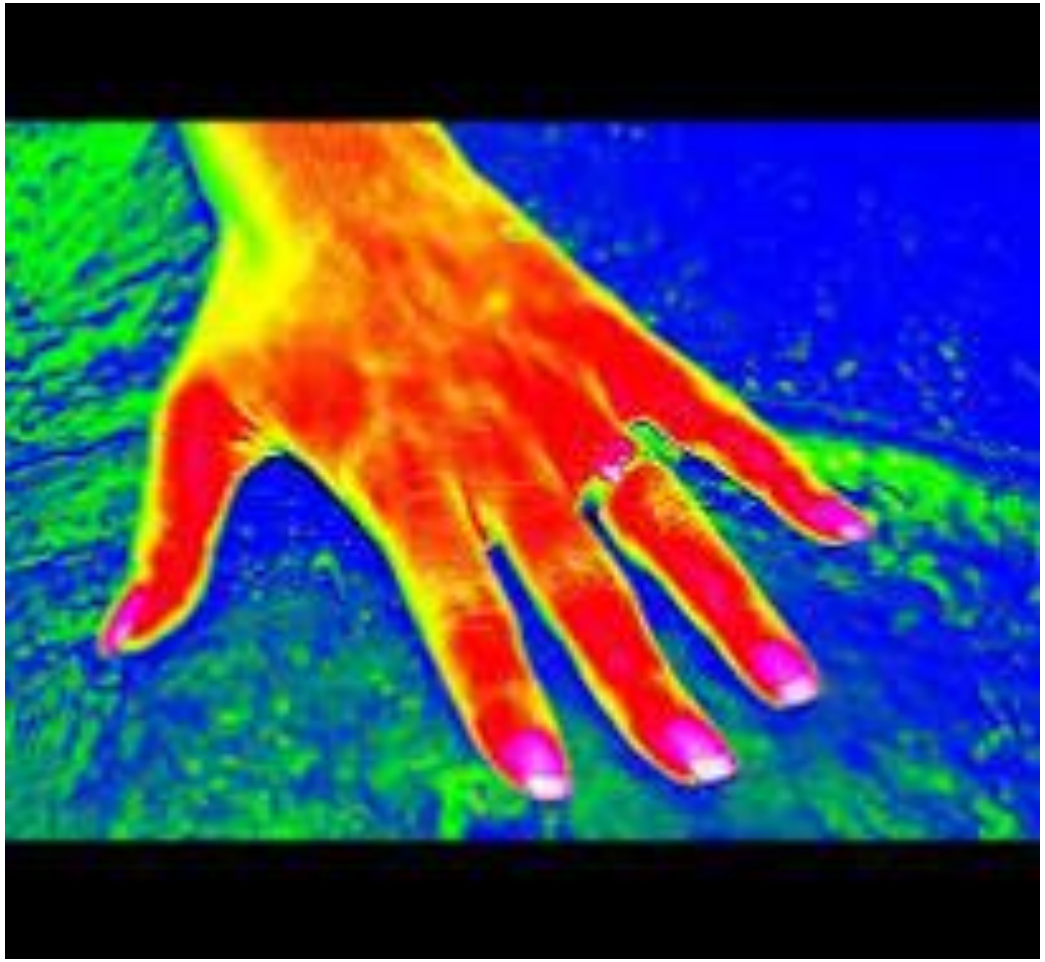
In northern hemisphere UV rays are higher and air temperature warmer in summer because the sun is more direct.



What we feel as heat is infrared radiation generated largely by the greenhouse effect.



Infrared radiation from a human hand



Infrared radiation is invisible to us, but not to rattle snakes

The Greenhouse Effect*

Energy from the sun's rays cause molecules within all matter on earth to vibrate.

This vibration causes these molecules to emit infrared radiation (what is felt as heat) which is projected in all directions including back up into the atmosphere.

Some of the projected radiation is absorbed by certain molecules in the atmosphere, such as carbon dioxide, methane and water vapor.

A portion of the absorbed infrared radiation is reemitted back toward earth where it is reabsorbed by earthly matter and reemitted.

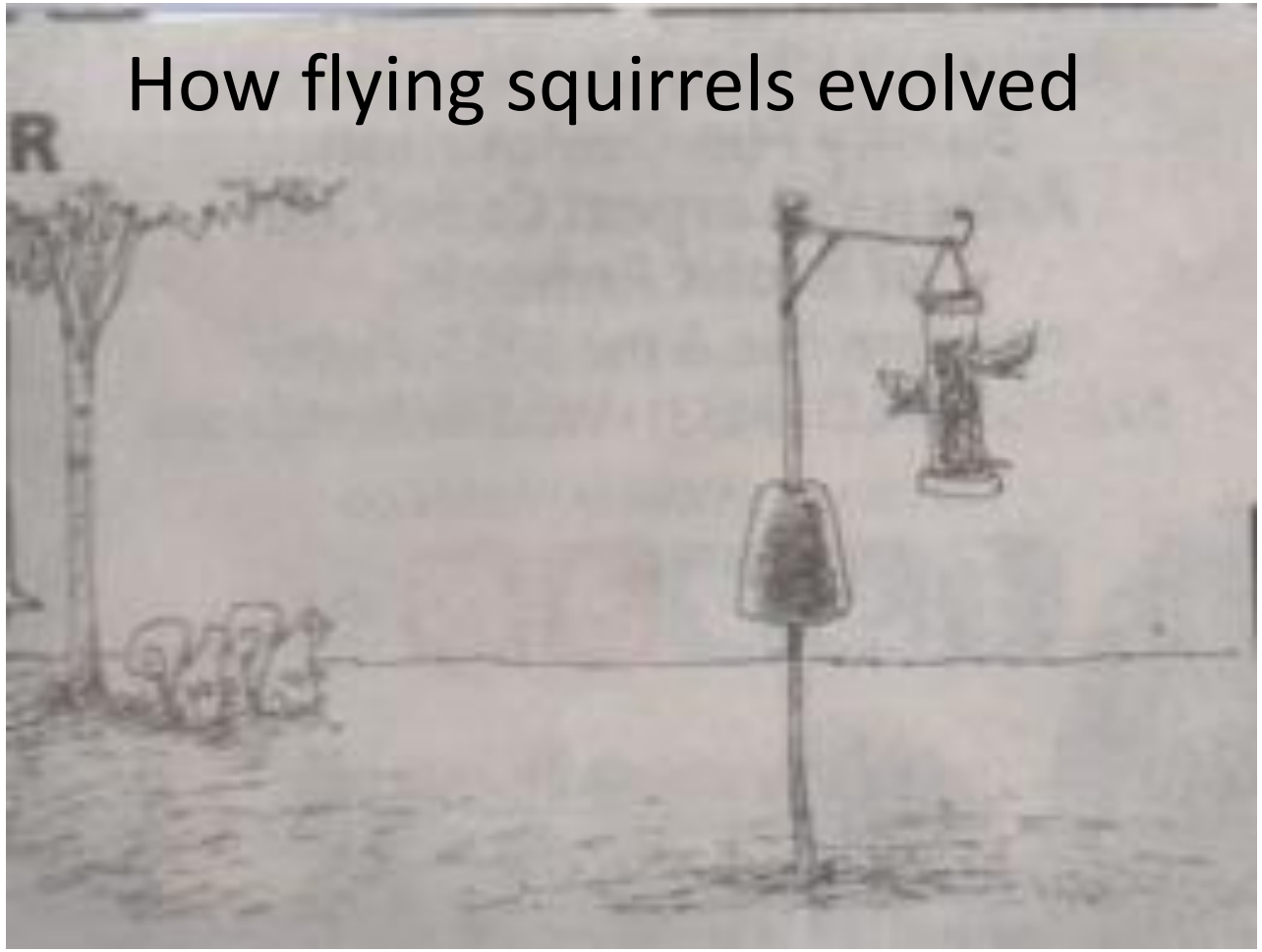
This back-and-forth is known as the greenhouse effect, and the participating atmospheric molecules are known as greenhouse gases.

The greenhouse effect continues throughout the day as the sun rises producing our steadily increasing temperature, then reverses as the sun goes down.

*From: Neil DeGrass Tyson & Lindsey Nyx Walker, "*To Infinity and Beyond*", 2023 pp 22-23.

Acclimating to a Warmer Environment

Acclimation: The Key Process in Evolution.



This may sound crazy, but I think I figured out a way to get up there!

Mechanism of Acclimation:

Involves environmental induced modification of genes.

Short term (seasonal):

genetically modified physiological adjustments.

Long term (several generations):

genetically modified anatomical and physiological adjustments.

Examples of evolutionary modification of body structure

Fennec (Desert) Fox

McFly and Noelle on display at Phoenix Zoo

Polar (Artic) Fox

Grand Canyon Squirrels

North Rim 8,000 ft ← 10 miles → South Rim 7,000 ft

Sensing the environment: The initial step in genetic mediated adaptation and evolution.

Darwin had it half right. Evolution occurs by genetic mutations, but they aren't random. Instead, living organisms sense the environment through signals coming from the environment that can directly affect a cell's genes. This often leads to mutations that enhance adaptation to a change in the environment.

But what are those signals?

Current Hypothesis

Living organisms communicate with the environment by way of *photons* emitted and received.

External environment ⇄ Photons ⇄ Organisms

people, animals, birds etc

So, what is a photon?

Single light waves of a given frequency are energy carrying components, called photons.

A blue photon

A red photon

Kirlian* photograph depicting an "aura” of violet** photons

** Invisible to most humans

* Seymon and Valentina Kirlian, 1939

Next step – activating specific genes.

What are genes:

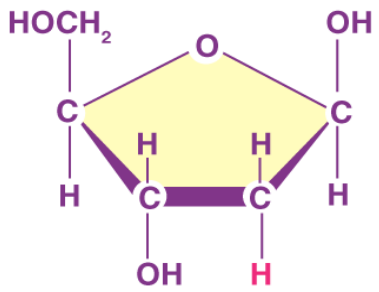
Sections of DNA (deoxyribonucleic acid) on chromosomes which are located in the nucleus of all cells.

What do genes do:

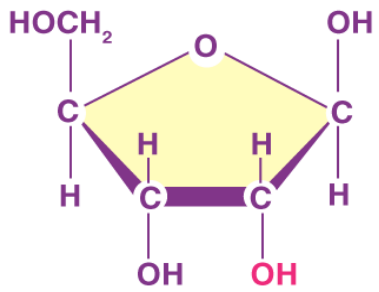
Code for the manufacture of proteins in a process termed *genetic expression*.

How do genes interact with the environment:

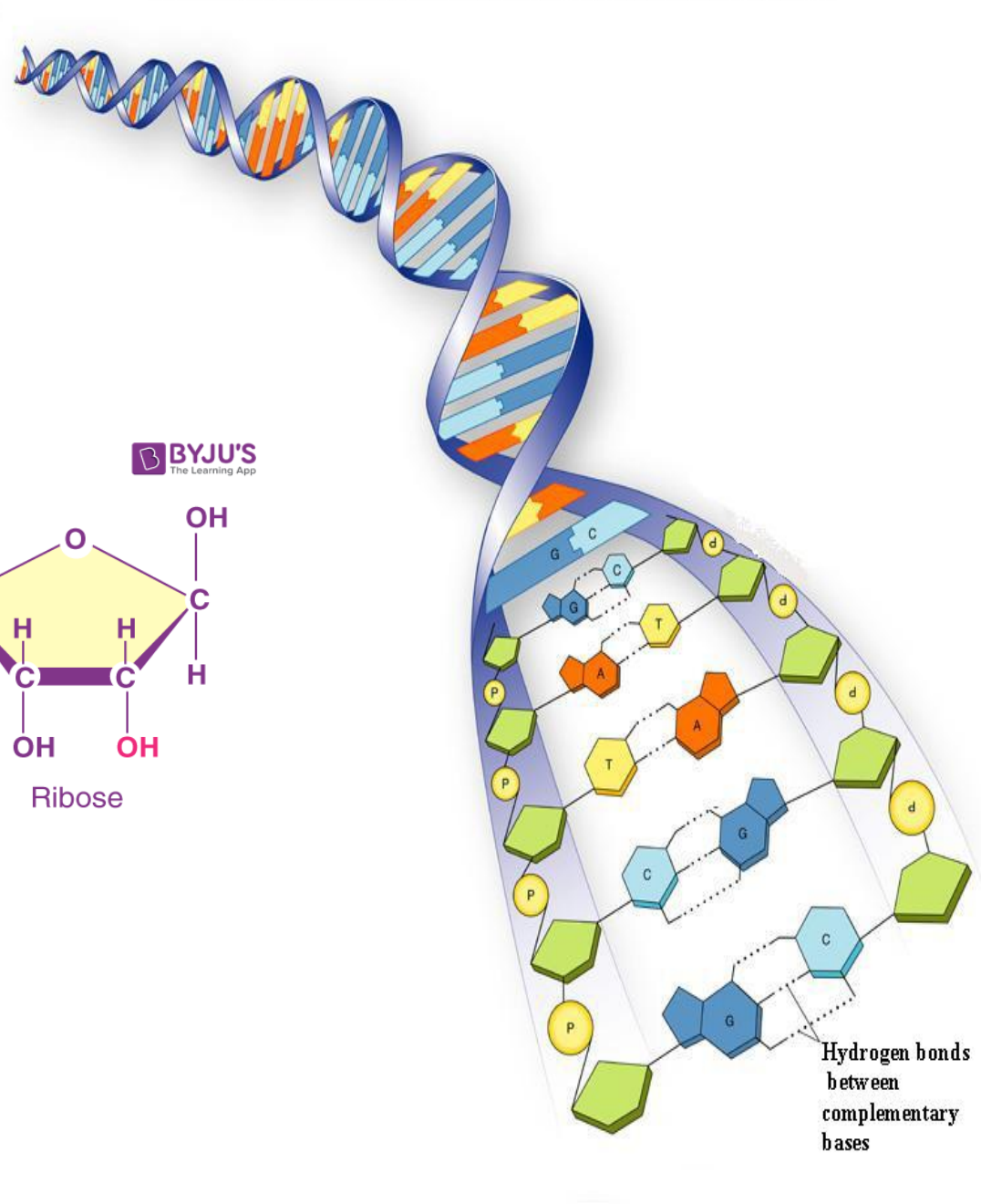
By way of *epigenetic* molecules, called *epigenomes*, on the surface of DNA which can receive signals from the environment.



2- Deoxyribose

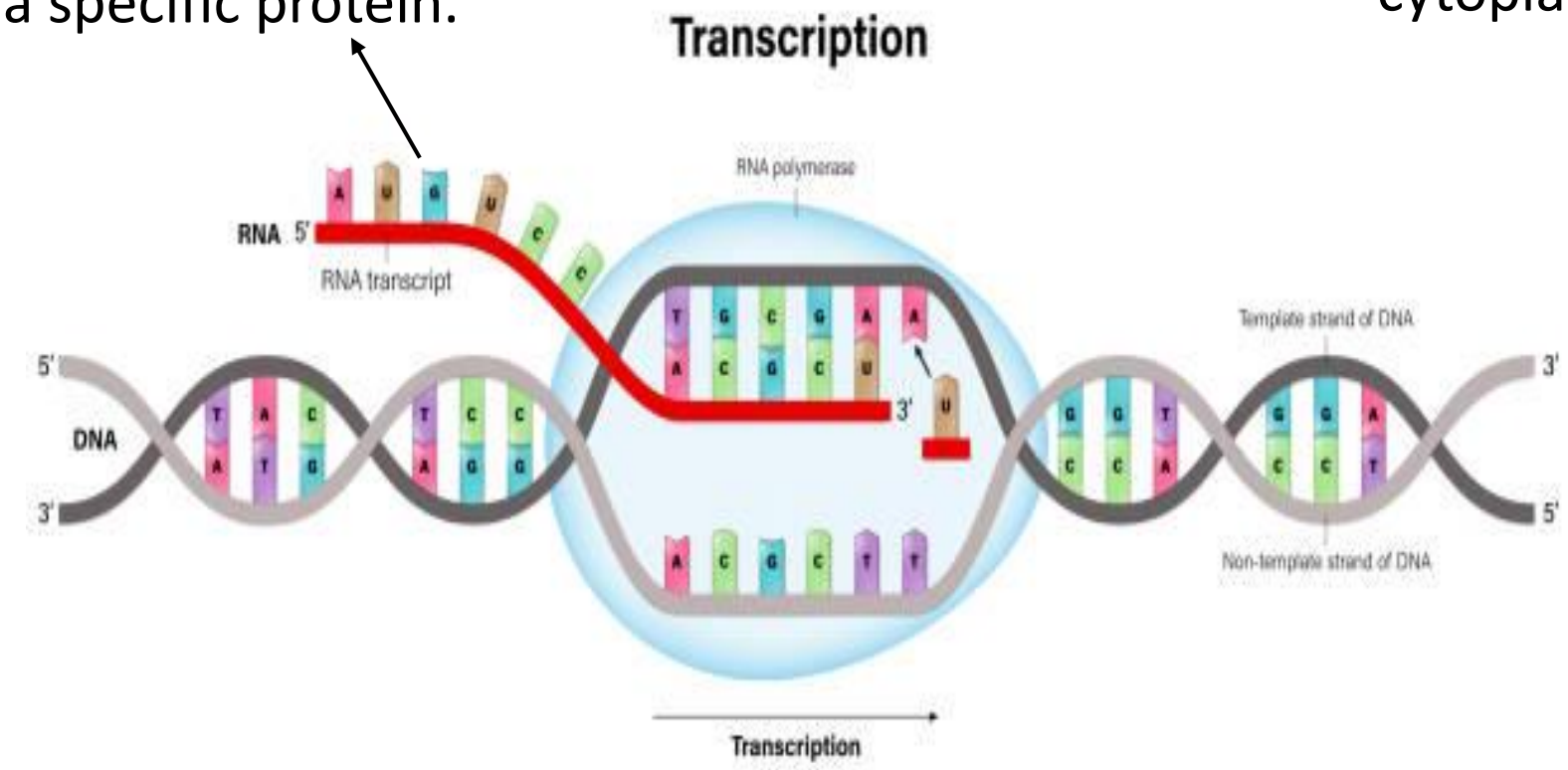


Ribose

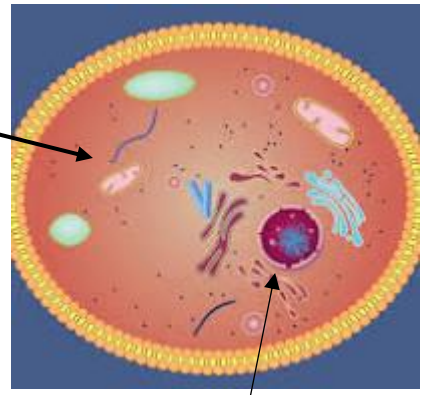


Deoxyribose

Migrates to a cell's cytoplasm to orchestrate manufacture of a specific protein.



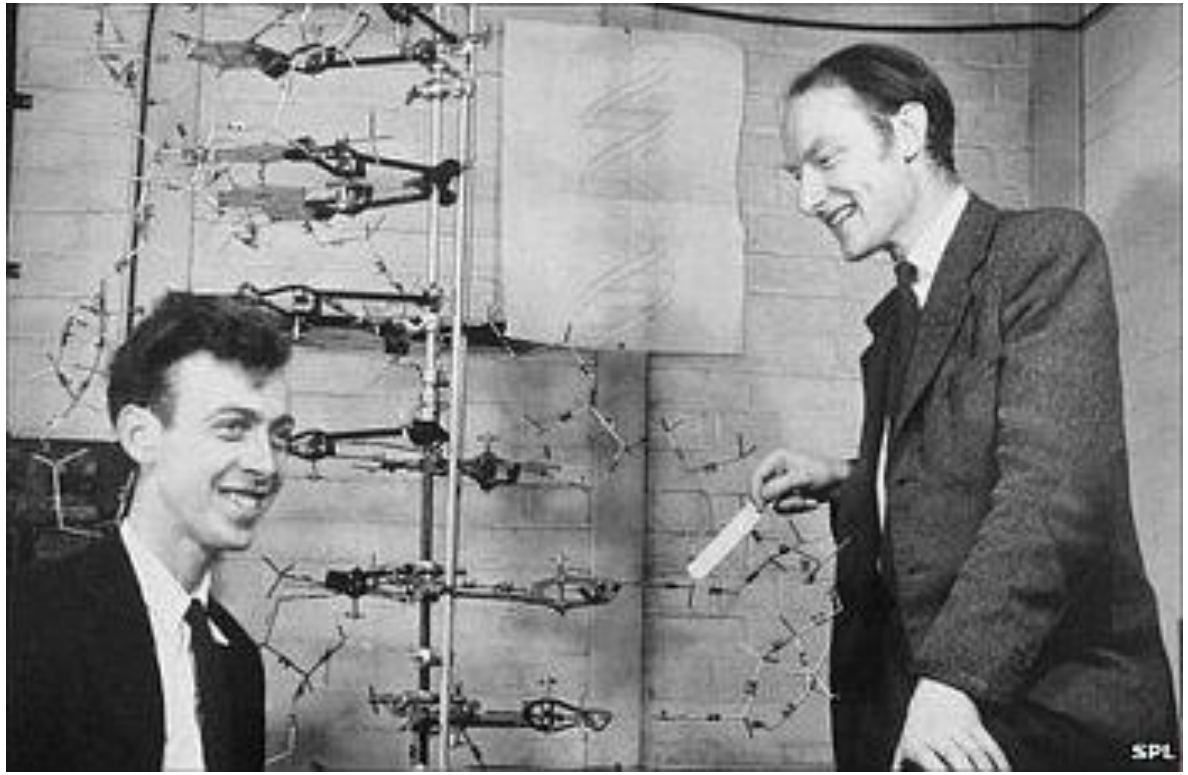
Cross section of a cell



Elucidation of Deoxyribonucleic acid (DNA), Cambridge circa 1953
(A necessary step in understanding how genes work.)

Rosalind Franklin, British Chemist.
Demonstrated double-helix structure of DNA in her famous X-ray crystallograph photo 51.

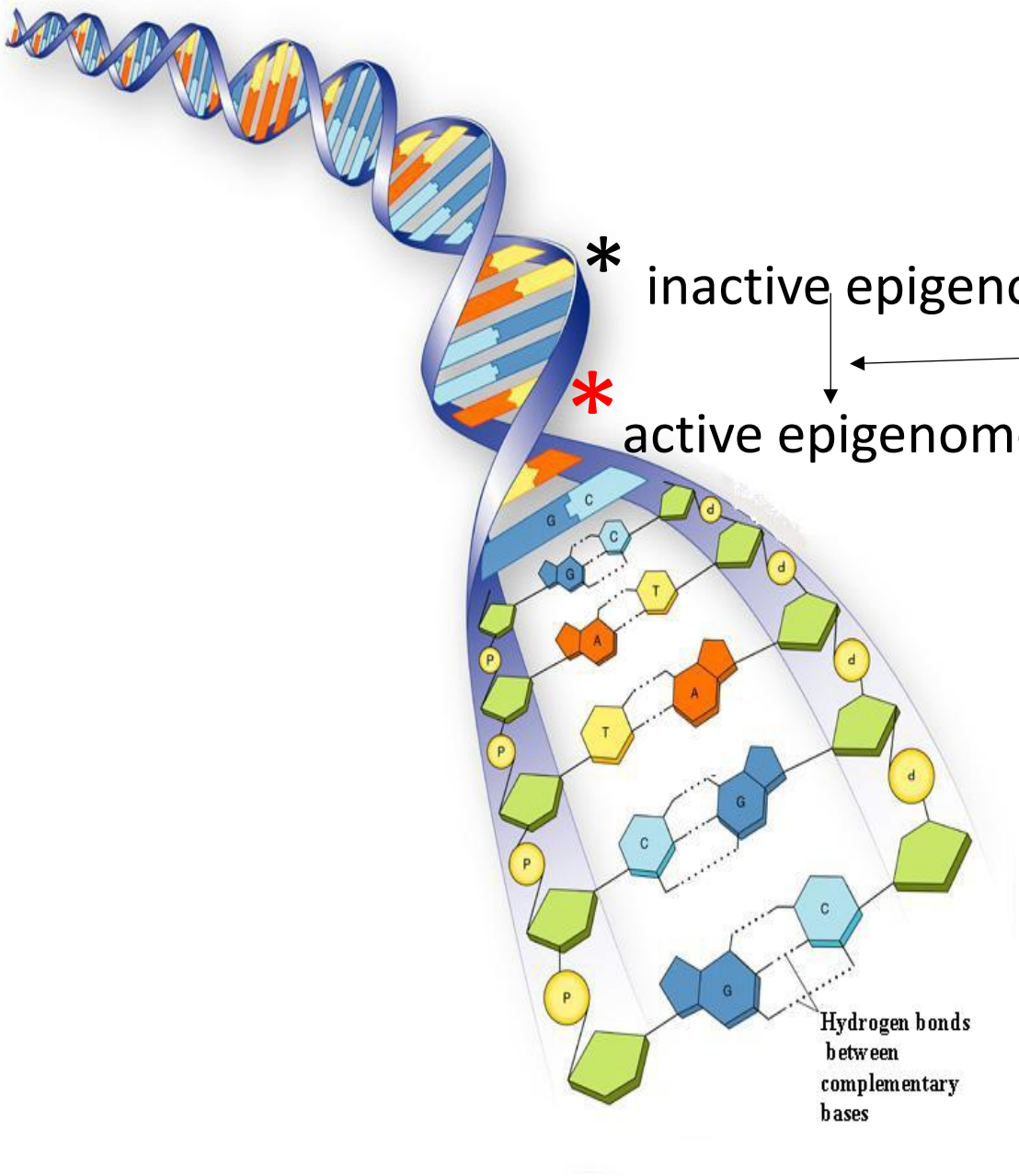
James Watson, American Biologist & Francis Crick, British physicist.
Worked out the details of the double-helix shown in Franklin's photo 51.



Role of Epigenomes in Acclimating to the Environment:

Epigenomes receive signals from the environment, and are the link by which environmental change induces adaptive responses of an organism.

Form a *"memory"* of an environmental change, which provides a more rapid adaptive response to subsequent exposures.

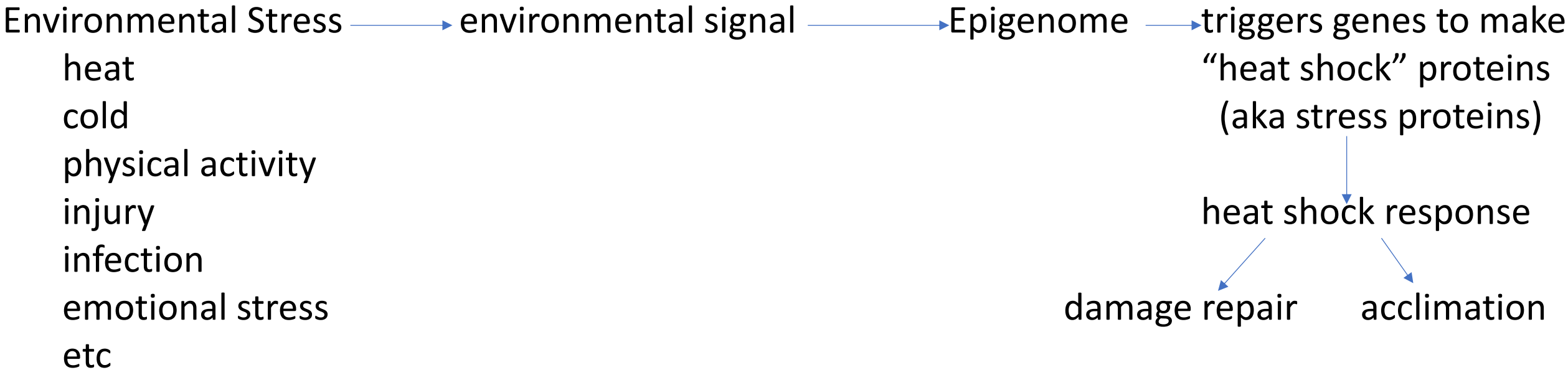


* inactive epigenome

* active epigenome

environmental signal

Epigenomes Initiate a Heat Shock (stress) Response*



* Discovered in 1962 in response to heat. Since shown to be a response to other stresses.

Effects of Heat-Shock Proteins

- Repair of damaged proteins and more
  - Restore damaged protein structure
  - Uncouple aggregated proteins
  - Stabilize and protect protein interactions
  - Repair damaged cell membranes
  - Etc

Effects of Heat-Shock Proteins: continued

Adaptive (acclimation) effects:

Increase in sweating efficiency.

earlier onset of sweating

increased sweat production

reduced loss of electrolytes in sweat

Increased blood flow to the skin.

more effective evaporative and convective cooling.

lower body temperature at a given environmental temp.

Adaptive (acclimation) effects: Continued

Reduced activation threshold for thermoreceptors.
More rapid response to heat exposure.

Improved coupling between body water and thirst.
Reduces risk of dehydration.

Facilitates manufacture of new-heat shock proteins
More effective acclimation.

Steps in Acclimating to a Warm Environment

Do outdoor summer activity before 10:00 AM or after 4:00 PM when UV rays are low (it will still be plenty hot enough in the valley). But dress properly, use sun screen and don't get thursty.

As for how to heat acclimate, there are no specific guidelines for elders. General guidelines can be found in the following Time magazine article: *How to Build Up Your Heat Tolerance to Prepare for a Hotter World* https://time.com/6207087/improve-heat-tolerance/

However, if you are accustomed to going outside year-round on a regular basis, even for a few minutes a day, you will naturally acclimate to whatever the weather may be. This is the best strategy to protect yourself from the whims of weather.

Guidelines for heat acclimation in the Time article recommend 15 min of mild* outside activity daily for 9 to 14 days. But use your best judgment as to both time* and frequency* depending on your experience with heat and exactly how hot it is. (*highly subjective)

As our world gets warmer, you can still safely get out and enjoy!
Whatever your pleasure may be. *Do, but don't overdo!*