LECTURE # 2

Homo Sapiens Sapiens
The Only Survivor From *Homo Erectus*

Presumed Characteristics

- Adaptability
- Perseverance
- Endurance
- Curiosity
- Inquisitiveness
- Observation
- Instinctive
- Imagination
- Inventiveness
- Dexterity
- Constructiveness
- Pragmatism
- Artistic imagination

Homo Sapiens vs. Mankind

Helpful to his mates but also ignoring the needs of his neighbors

Envious, greedy, and violent

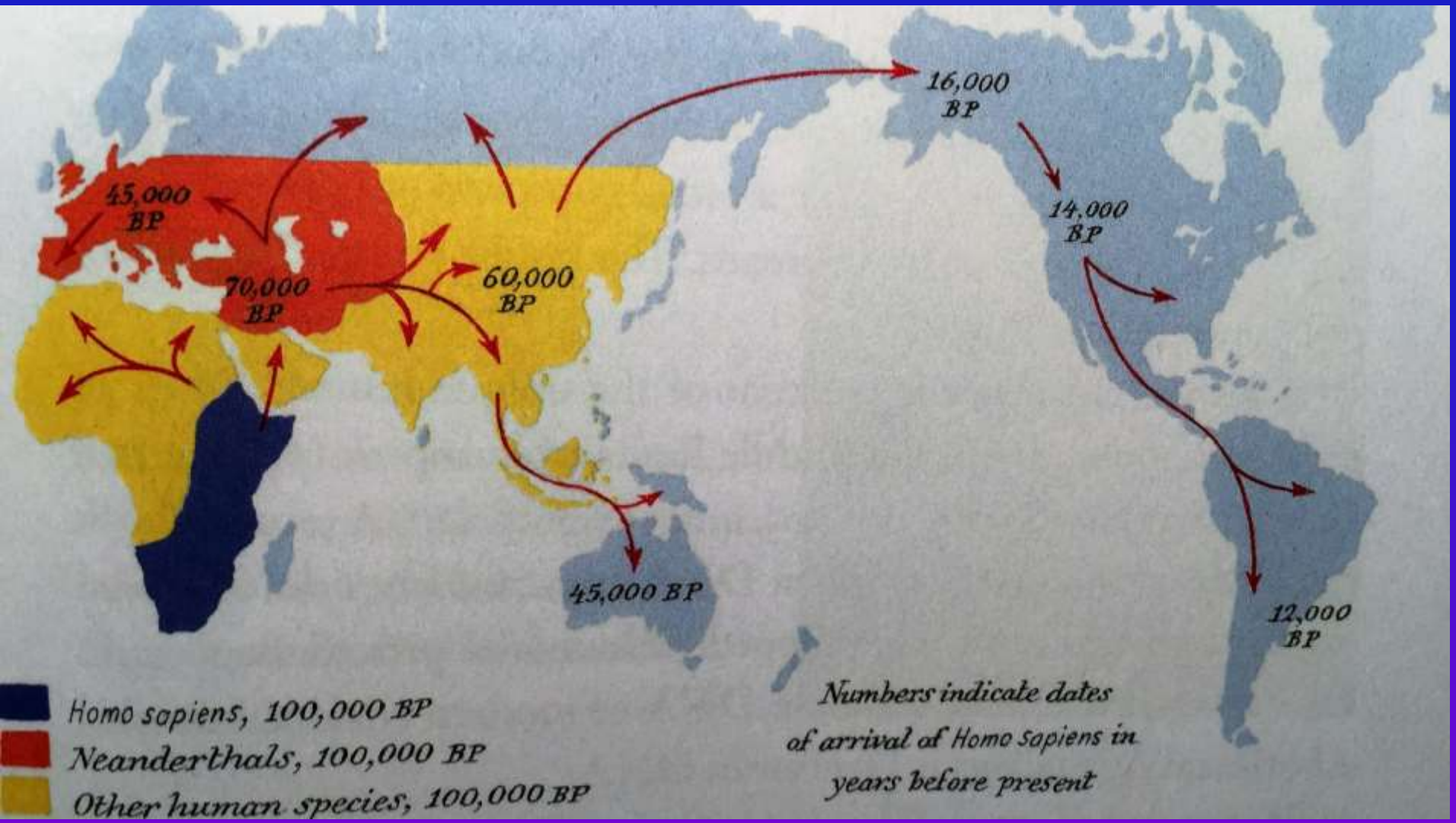
Evolving and reinventing self to master new conditions of life

Ancient foragers were the most knowledgeable and skillful people in history

Physically limber, energetic

Self-reliant

Homo sapiens Conquers the World



FROM Y. N. HARARI "*SAPIENS, A BRIEF HISTORY OF HUMANKIND*"

The Cognitive Revolution
~ 70,000 years ago

Observation ⇨ Imagination

Self-questions: “What if?” “Why not?” “Let’s try it”

Thinks outside the box

⬇

Breaks established modules

Fiction ⇨ Myths ⇨ **New Concepts (not physical)**
⇨ Abstract thought ⇨ **Societal Evolution**

(customs, religions, languages, manufacturing, finances, human rights, political ideology, etc.)

Major Formative Events in the Neolithic Era (Mesopotamia, Nile's banks, Indus River valley, and major rivers of China)

By 10,000 BC humans colonized all ice-free parts of the globe.

Future of humankind was molded by:

- **Domestication of animals and plants**
- **Agriculture - developed c. 8000 - 5000 BC**. ⇨ Man settled becoming a farmer
- The **wheel** - invented - 6500 - 4500 BC in Mesopotamia ⇨ facilitated transportation
- **Navigation –** from rivers to the sea.

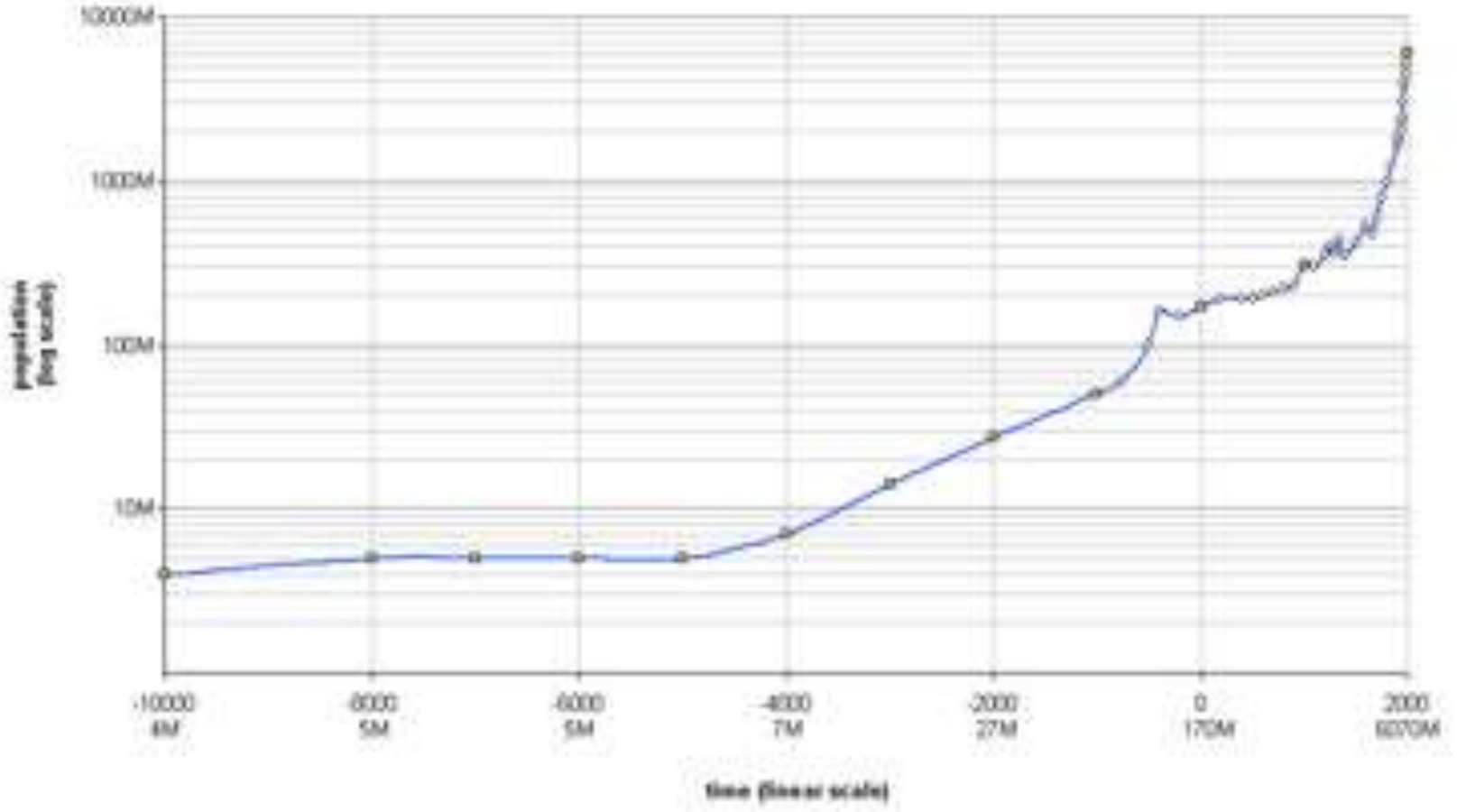
Major Formative Events in the Neolithic Era (cont'd)

- **Agriculture** and the **wheel** make the greatest human progress
- Accounting became necessary
- **Writing invented -** 3500 BC ⇨ Accounting
  ⇨ Communication

- Grains in excess of the need
- Social classes ensued ⇨ **"Haves"** and **"have-nots"**
- Creation of **city-states** and military for defense
- **"Have nots"** revolts *or* **Outsiders'** invasions

- Destruction and rebuilding was the norm

World Population - 10,000 BC – 2000 CE



World Population
Production, and Energy Consumption

1500	2016	
Population	**Population**	
500,000,000	7.4 Billion	= 14-fold
Production	**Production**	
$250 Billion	$60 Trillion	= 240-fold
Energy Consumption	**Energy Consumption**	
13 Trillion calories/day	1,500 Trillion	= 115-fold

FROM Y. N. HARARI “SAPIENS”

Major Formative Events in the Neolithic Era
The NAVIGATION

On rivers and on seas

Exchange of goods, ideas, inventions

↓

Development of new civilizations and conquest

Resources ⇨ Trade ⇨ Dominance ⇨ Conflicts

Industrial Revolution and World Population

By 1800 – 1 Billion people on Earth

1930 – Second billion (in 130 years)

1959 – Third billion (in 29 years)

1974 – Fourth billion (in 15 years)

1987 – Fifth billion (in 13 years)

Declining growth rates ⇨ doubling will take 200 yrs.

2050 - Expected world population = 9 billion

2017 World Population = 7,500,000,000

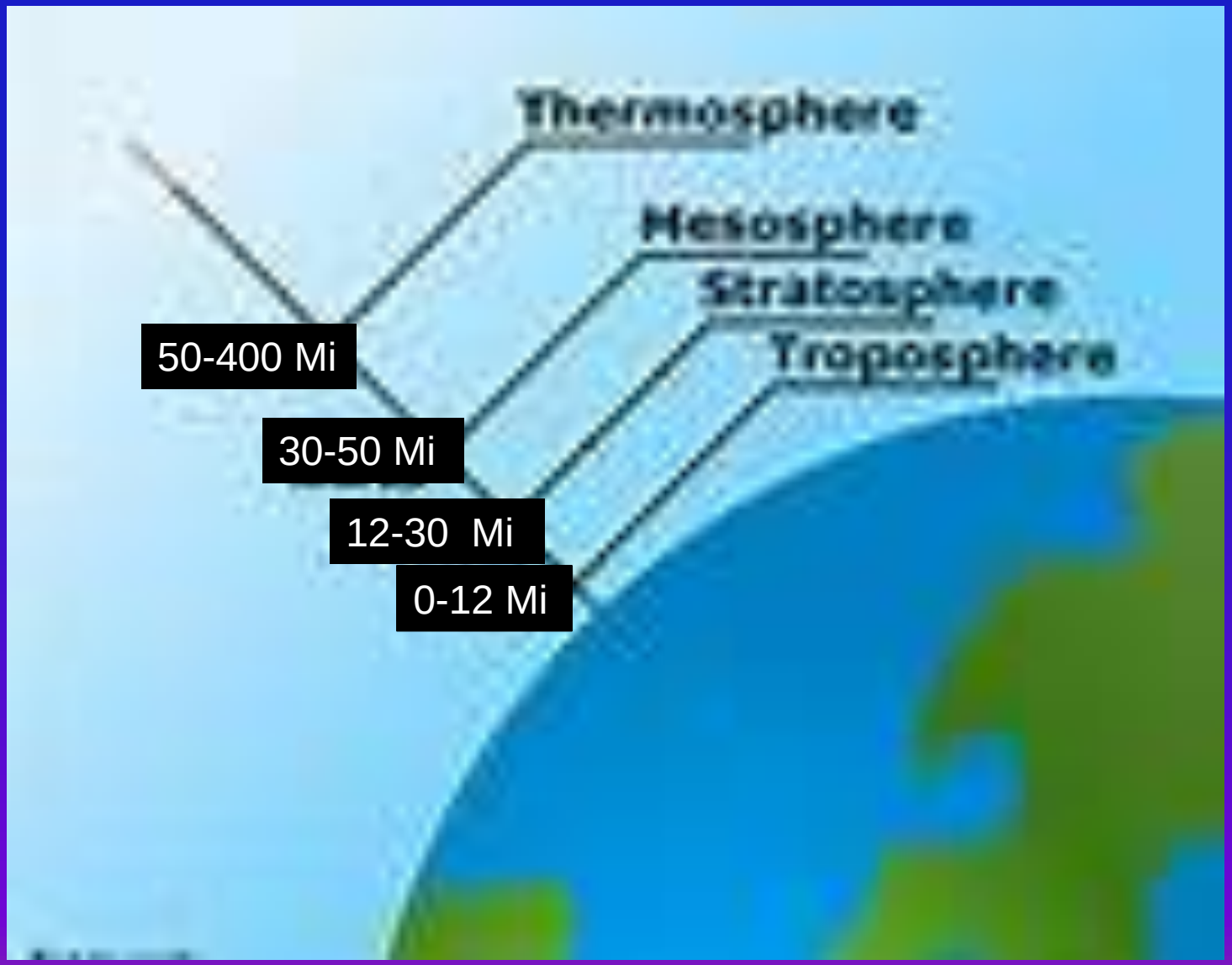
	In millions
China	1,383
India	1,317
USA	325
Indonesia	261
Brazil	207
Pakistan	197
Nigeria	188
Bangladesh	162
Russia	146
Mexico	129

	In millions
Japan	126
Philippines	103
Ethiopia	101
Vietnam	94
Egypt	86
Germany	82
Iran	80
Turkey	77
Congo	73
Thailand	67

70,000 BC – 15,000 – 2017 – 7,500,000

The World, its Resources, and Humankind. Topics of Study

Structure of the Atmosphere



ATMOSPHERIC AIR

Earth's gravity force allows to hold an atmosphere

Atmosphere: 78.09% Nitrogen
20.95% Oxygen
0.93% Argon
0.039% Carbon dioxide (CO_2) and
Small amounts of other gases

Air also contains a variable amount of **water vapor**

"Atmosphere river"

Water vapor and CO_2 in the atmosphere ⇨ temperature buffer (greenhouse effect)

CARDIO-VASCULAR CIRCULATION

HEART ➘

Arteries ➘

Arterioles ➘

Capillaries

Single-cell wall – blood - tissue exchanges of O_2, CO_2, nutrients, and waste

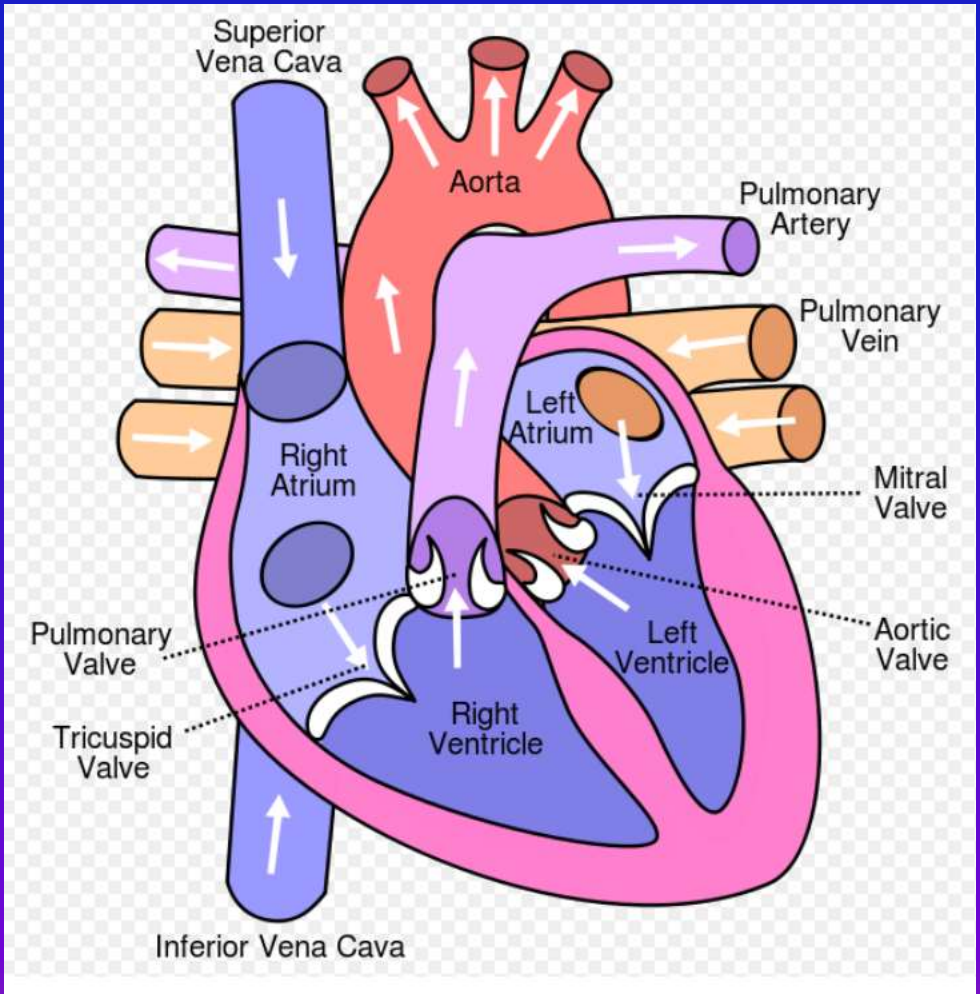
➘

Venules ➘

Veins ➘

HEART

THE HEART - Chambers, Valves, and Circulation



BLOOD-GAS EXCHANGES

Heart

(*From Periphery*)

Rt. Atrium

⮟

Rt. Ventricle

⮟

Pulmonary artery ➢

Lungs

Release carbon dioxide

Get oxygen ➢ Lt. atrium

⮟

Lt. ventricle

(To the Periphery)

Main Air Pollutants (1)

Harmful substances and particulate matter in the air

Primary and secondary pollutants

Carbon dioxide - Essential for plant life and harmful to animals (“greenhouse gas”)

Sulfur dioxide - Volcanoes and industry ⇨ Acid rain

Nitrogen dioxide - High temp. combustion, electrical discharges. Brown haze

Carbon monoxide - Incomplete combustion, vehicular exhaust

Chlorofluorocarbons (CFCs) - From ACs, refrigerators, aerosols,

halons

Ammonia - Agricultural processes

Main Air Pollutants (2)

Secondary pollutants:

Smog - Mixture of smoke and SO_2, from coal burning

Ozone (O_3) - "good" - in stratosphere; filters sun UV-B radiation (97-99%)

- "bad" - in troposphere – Combustion of fossil fuels. Toxic to animals and plants

Methane - Cattle digestion

Radon gas - Decay of radium from the Earth's crust

Smoke and CO - Wildfires

Smog in Beijing, 2005

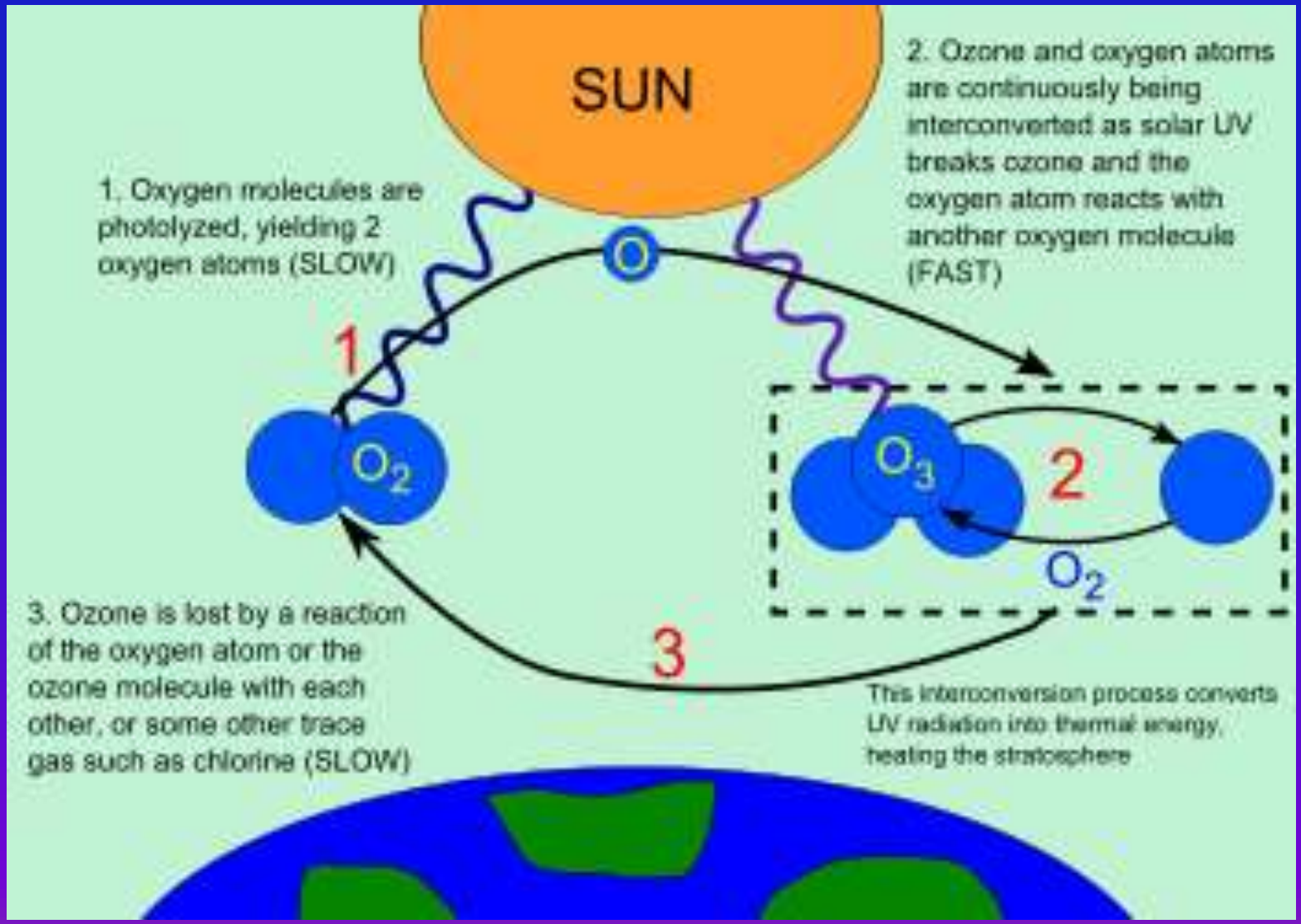
After rain **Smoggy day**

Smog in Cairo, Egypt

Burning of coal in industry ⇨ sulfuric dioxide in air + water + oxygen ⇨ sulfuric acid ⇨ acid rain

Effects of Acid Rain on a Forest in the Czech Republic

Ozone Layer


SUN
2. Ozone and oxygen atoms are continuously being interconverted as solar UV breaks ozone and the oxygen atom reacts with another oxygen molecule (FAST)
1. Oxygen molecules are photolyzed, yielding 2 oxygen atoms (SLOW)
O
1
O_2
O_3
2
O_2
3
3. Ozone is lost by a reaction of the oxygen atom or the ozone molecule with each other, or some other trace gas such as chlorine (SLOW)
This interconversion process converts UV radiation into thermal energy, heating the stratosphere

Creation of Ozone (O_3)

An oxygen molecule (O_2) is split by UV-B radiation ⇨

2 oxygen atoms (**O•)**

Each oxygen atom quickly combines with an oxygen

molecule (O_2) ⇨ **O_3**

1986-1995 Montreal Protocol limiting use of CFCs

Back to normal concentrations in 50 years

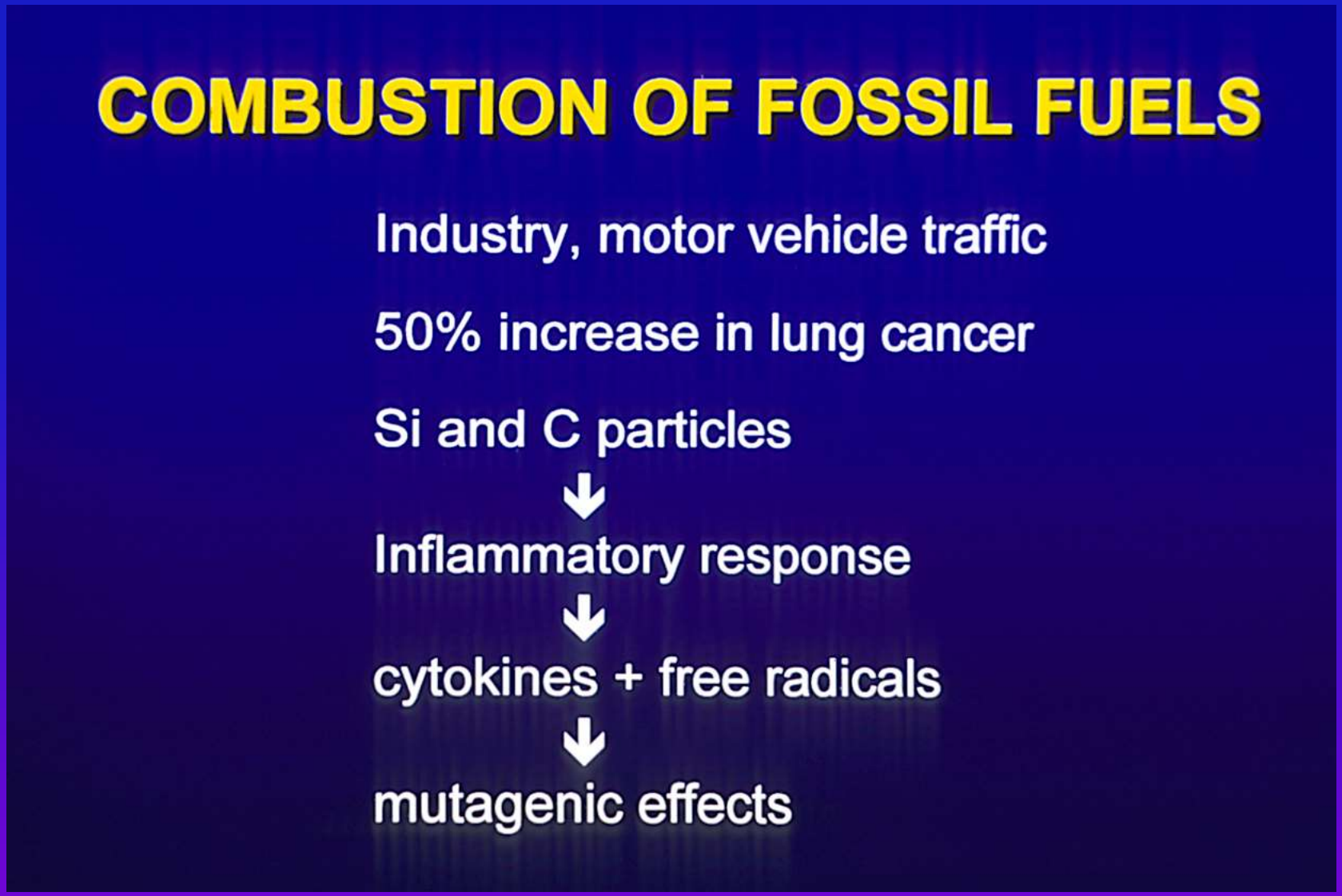
Air Pollution Effects

Morbidity: Respiratory diseases, lung cancer, cardiovascular diseases, stroke.

Mortality: WHO 2014: ~7 million people died worldwide.

Urban outdoor air pollution ⇨ 1.3 million deaths/year worldwide

CANCER CAUSES



CANCER CAUSES

AIR POLLUTION BY COMBUSTION

Epidemiologic Studies

Silesia (Poland) → PAH → genotoxic effects

Yunan (China) - lung cancer in women

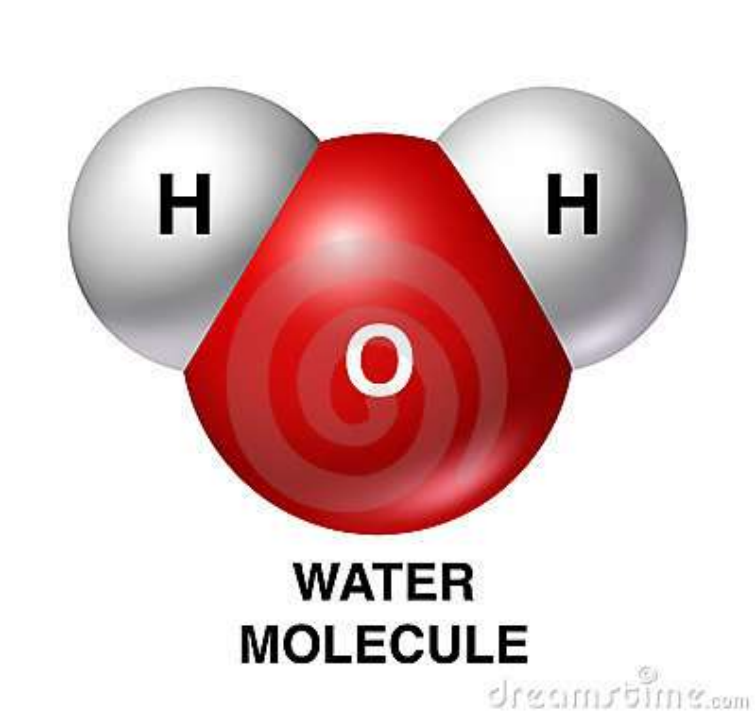
Shanghai - lung cancer in non-smoking women

The World, its Resources, and Humankind. Topics of Study

Topics of this Lecture

- Water in the Universe
- Water on Earth
- Properties
- Water Cycle
- Natural Sites of Water
- Ocean and Sea Water
- Rivers
- Underground Water
- Water and Humankind
- Water in the Organism
- Water Use
- Drinking Water
- Water Supply and Transport
- Wells
- Water Pollution
- Waterborne Diseases
- Water Chlorination
- Water Desalination
- Water Recycling
- Water and Politics

WATER
Hydrogen + Oxygen
H_2O



WATER IN THE UNIVERSE

Unique substance in the universe: **liquid, vapor, ice**

A by-product of star formation

2011 - Discovery of a gigantic cloud of vapor = “140 Trillion times more water than all the water of the Earth” = “Water prevalent in the universe for its entire existence”

Where? **In a quasar 12 Billion years from Earth**

As **vapor,** water is present in the atmosphere of all planets of our solar system

As **ice,** water is present in most planets of our solar system

WATER ON EARTH

Hydrosphere

Volume is FIXED and STABLE - 321,000,000 m^3 = x 264 gal/m^3 = **84.7 Trillion gallons of water**

Only substance existing in three states: liquid, solid, and gas (vapor)

NOT RENEWABLE and VITAL FOR LIFE

Essential for living organisms

Important for the physical and chemical reactions

Weather changes

Important in geological processes (restructuring)

Physical States

Liquid at standard temperature:

Oceans, seas, lakes, rivers, streams, rain, dew

Fluids of organisms

Solid below freezing point:

Icebergs, glaciers, snow

Vapor at higher than standard temperature:

Steam, vapor, clouds, fog

Water in its Three States: Liquid, Solid, and Gas

PROPERTIES

PHYSICAL PROPERTIES

Pure water is colorless, tasteless, and transparent

Density of pure water at 4°C = 1.

Lower density when frozen (ice is floating)

Larger volume when frozen (+9% - expanding)

Universal solvent for hydrophilic substances:

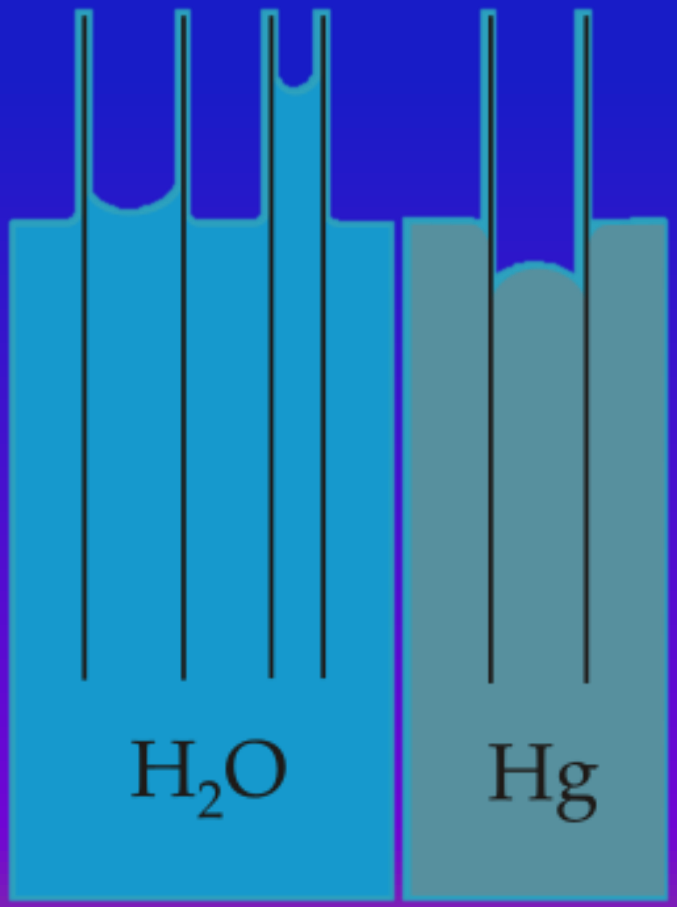
Crystals, salts, sugars, proteins, some gases

Low electrical conductivity. Increases when NaCl added.

High surface tension and capillary forces – Moves up in narrow tubes against gravity – Vascular plants, trees.

If molecule is broken by high heat, the hydrogen may explode (Firefighters are aware of such danger)

Capillary Action of Water and of Mercury: Water Has a Meniscus. Mercury Does Not



Surface tension – Water drops (dew) on a spider web

Water's turquoise-color in Sun-light reflects the Sky

WATER CYCLE

WATER CYCLE

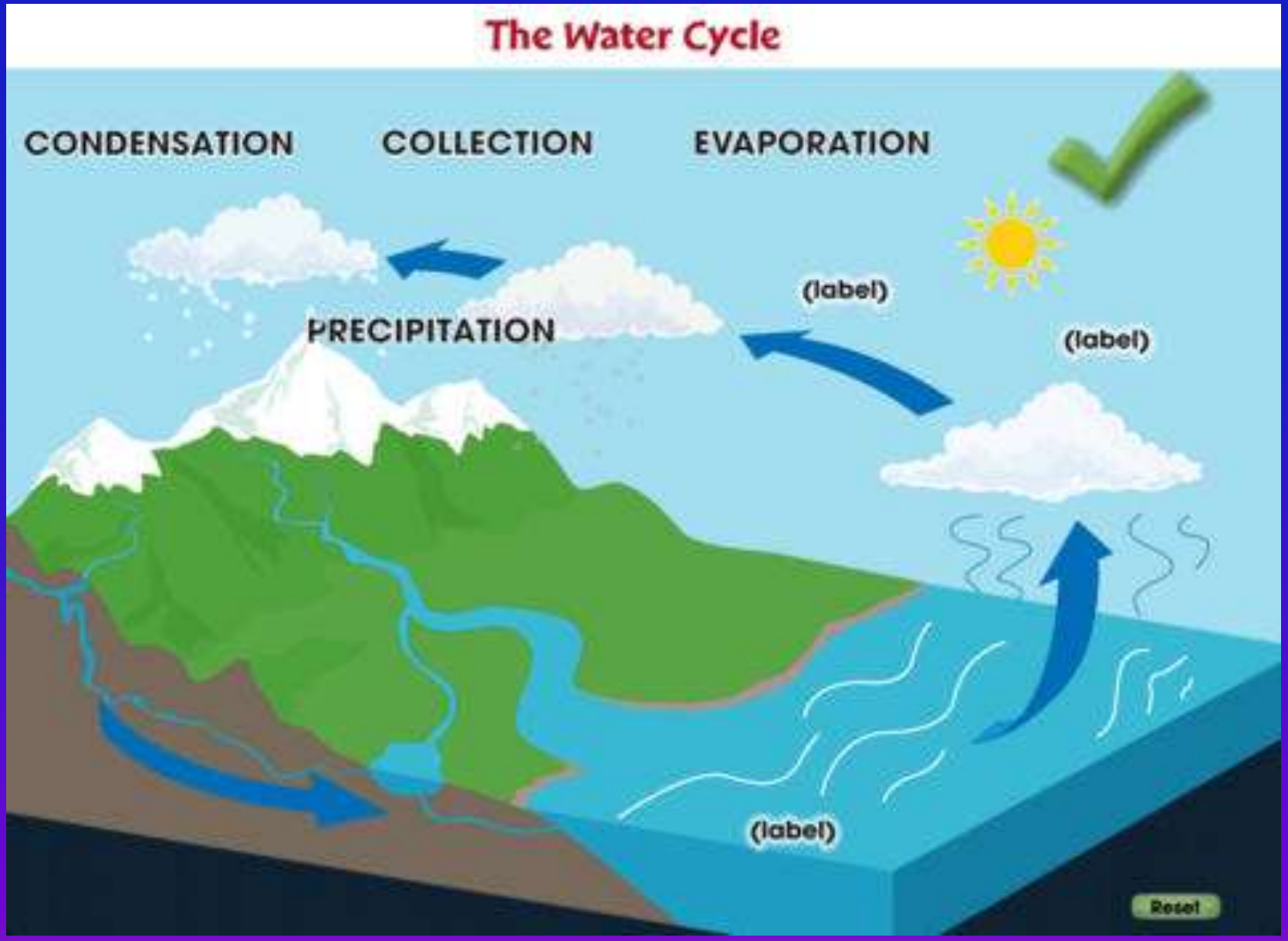
First description in 1580 by Bernard Palissy (1519-1590)

Written in French instead of Latin ⇨ ignored

“Underground veins” = aquifers

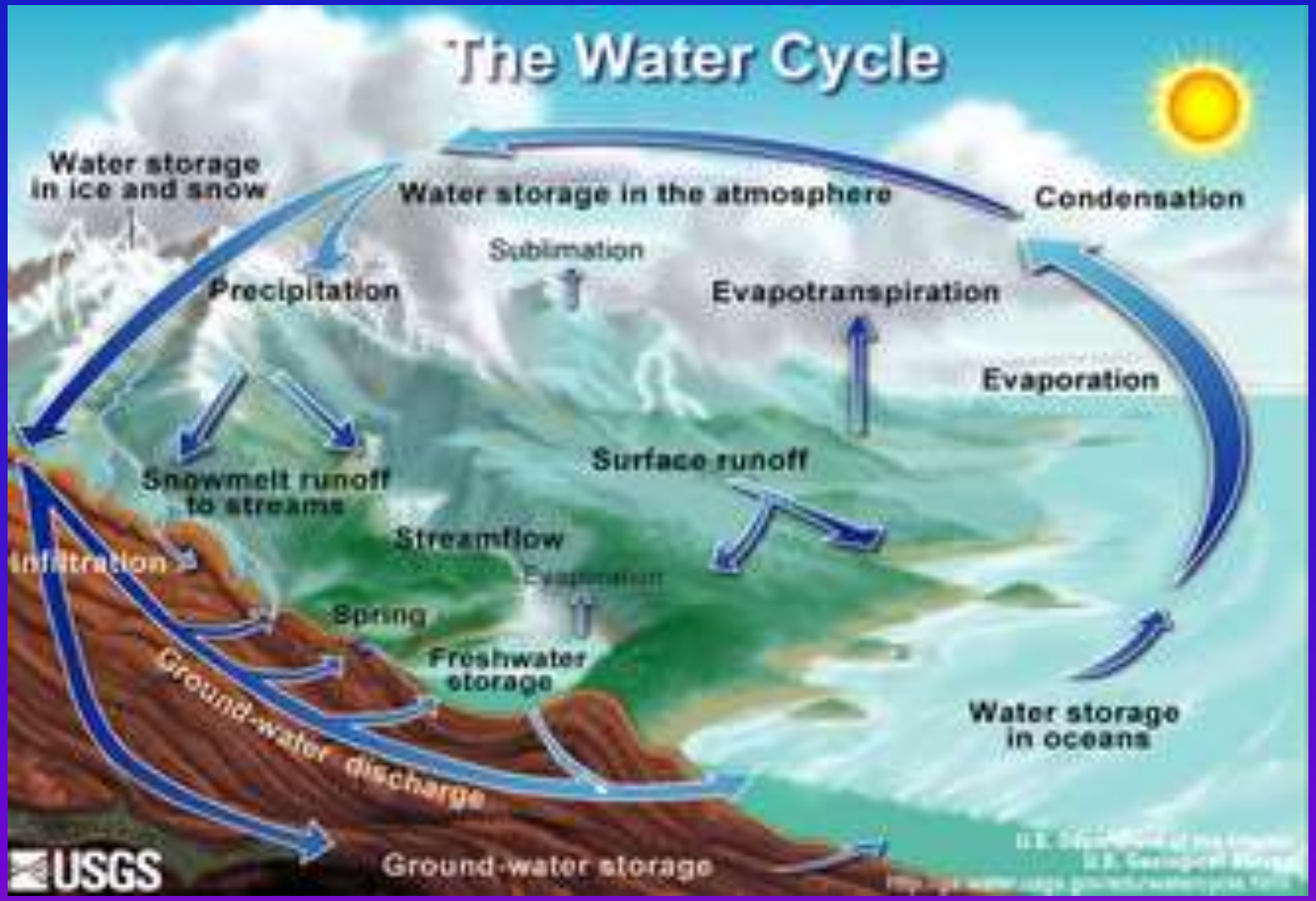
Water storage:

- Oceans, Rivers, Lakes
- Evaporation
- Condensation
- Precipitation
- Rain, Snow, and Ice
- Ground Water runoff

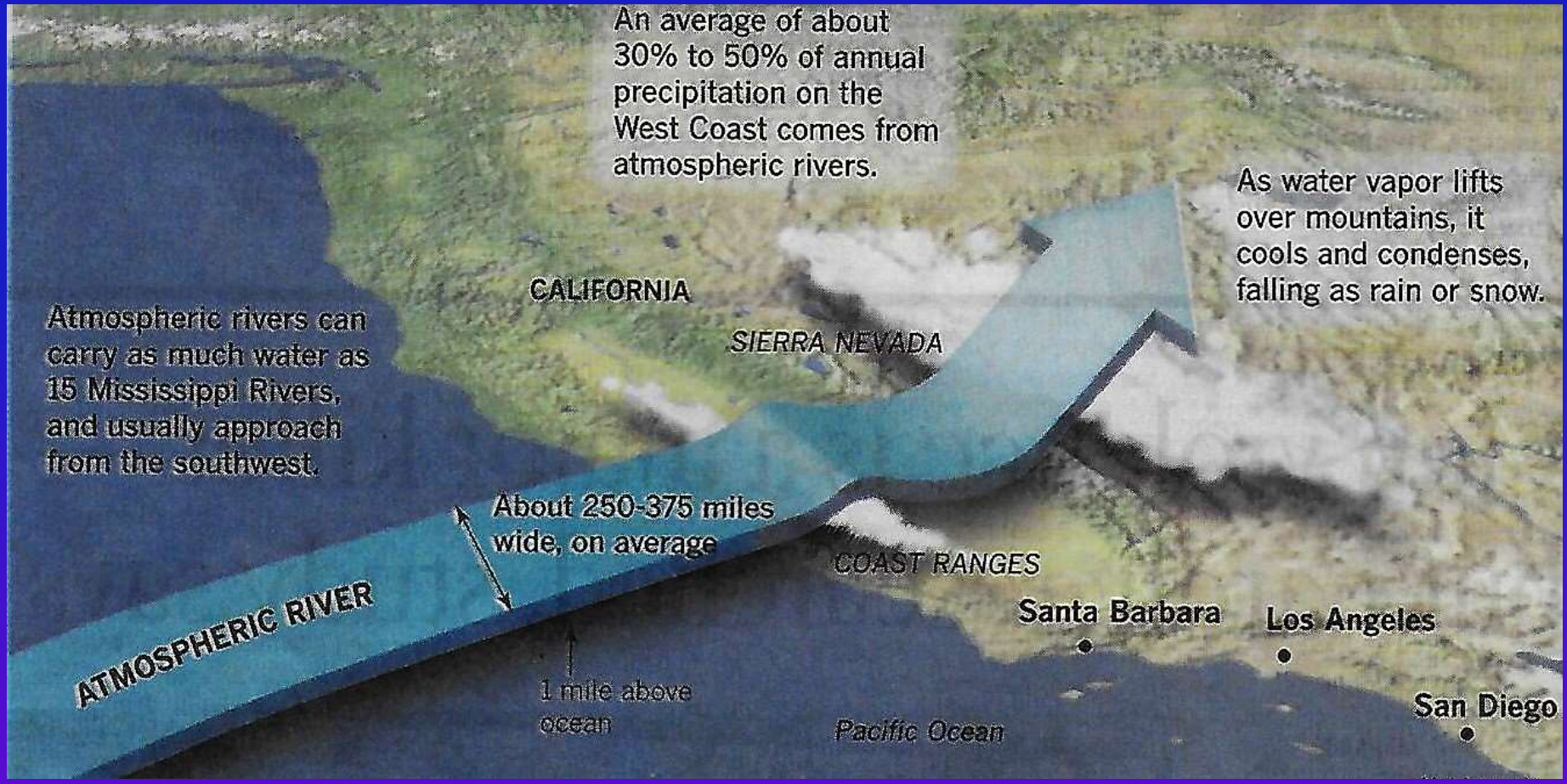


WATER NEVER GETS LOST!

WATER CYCLE


The Water Cycle
Water storage in ice and snow
Water storage in the atmosphere
Condensation
Sublimation
Precipitation
Evapotranspiration
Evaporation
Surface runoff
Snowmelt runoff to streams
Streamflow
Infiltration
Spring
Freshwater storage
Ground-water discharge
Water storage in oceans
Ground-water storage
USGS

Atmospheric River



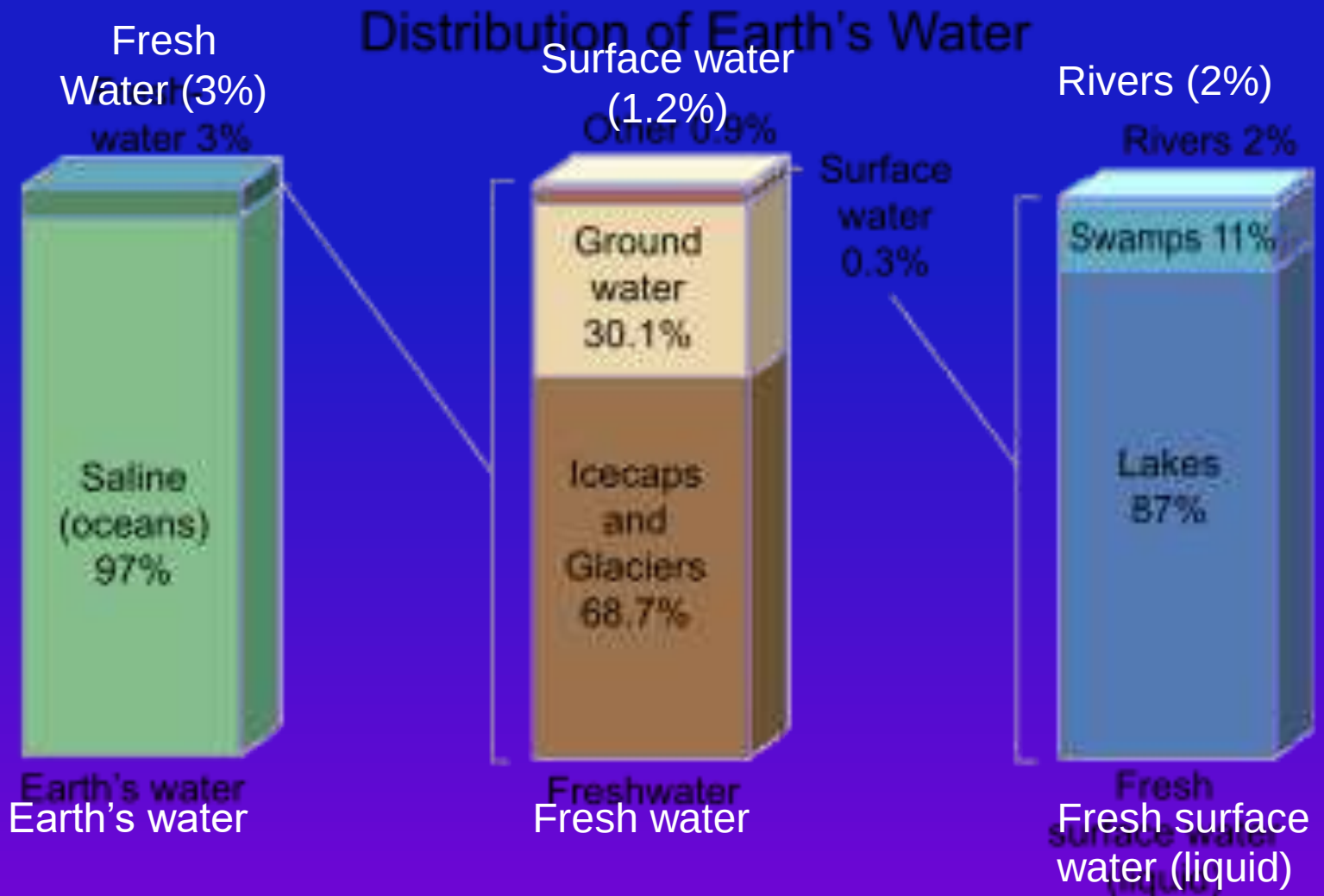
250-375 MILES WIDE RIVER OF WATER =
15-FOLD MISSISSIPPI RIVER
LA TIMES JANUARY 6, 2017

NATURAL SITES OF LIQUID WATER

Natural Sites of Liquid Water

- Oceans and seas
- Rivers, lakes, marshes
- Underground aquifers

Distribution of Earth's Water



Earth's water

Fresh water

Fresh surface water (liquid)

OCEAN AND SEA WATER

Seawater - Salinity

Contains salts 3.5% on average, dissolved sodium chloride ⇨ 35 gm/Liter of sea water with density = 1.025kg/L

Freezing point = -2.0°C

The Red Sea – 5.0% salt. The Dead Sea – 34% salt ⇨ Human body floats

The Caspian Sea - 35% salt

The most abundant, dissolved ions in seawater are: sodium, chloride, magnesium, sulfate, and calcium

Human Consumption of Sea Water

Accidental consumption is not harmful if potable water is added

Use of sea water for hydration ⇨ 39% lethality

Body homeostasis by kidneys ⇨ 0.9% salt in blood

Use of sea water + potable water at 2:3 ratio possibly OK

Sea water desalination OK

RIVERS

Water and Human Settlements

Many cities developed on the banks of lakes and rivers as early as 3000 BC.

Some of the first prominent, well-developed settlements had arisen in Mesopotamia, on the banks of Egypt's Nile, Indus river valley, and major rivers of China.

Major Formative Events in the Neolithic Era
The NAVIGATION

On rivers and on seas

Exchange of goods, ideas, inventions

↓

Development of new civilizations and conquest

Resources ⇨ Trade ⇨ Dominance ⇨ Conflicts

Longest Rivers

River	Length (Mi)	Ave. discharge (m^3/sec)	Outflow
Amazon	4,345	219,000	Atlantic
Nile	4,258	5100	Mediterranean
Yangtze	3,917	31,000	East China Sea
Mississippi -Missouri	3,902	16,200	Gulf of Mexico, Atlantic
Yenisei-Angara	3,445	19,600	Kara Sea, Siberia
Yellow River	3,395	2,110	Bohai Sea, China
Ob-Irtysh	3,364	12,800	Gulf of Ob, Russia

The Amazon River

The Nile


Mediterranean Sea
Alexandria
Cairo
Nile
LIBYA
EGYPT
Luxor
Aswan
Lake Nasser
Red Sea
CHAD
Khartoum
ERITREA
SUDAN
Blue Nile
Lake Tana
ETHIOPIA
CENTRAL AFRICAN REPUBLIC
SOUTH SUDAN
White Nile
Juba
Lake Albert
UGANDA
Lake Kyoga
DEMOCRATIC REPUBLIC OF THE CONGO
Jinja
KENYA
RWANDA
Lake Victoria
BURUNDI
TANZANIA

The Yellow River, China

Xia Dynasty in China
c. 2,070 – c.1,600 BC

First dynasty in the traditional Chinese history

Yu – First emperor of this dynasty

Stopped the Yellow river floods by building **canals for drainage and irrigation of fields**

Vast agricultural progress

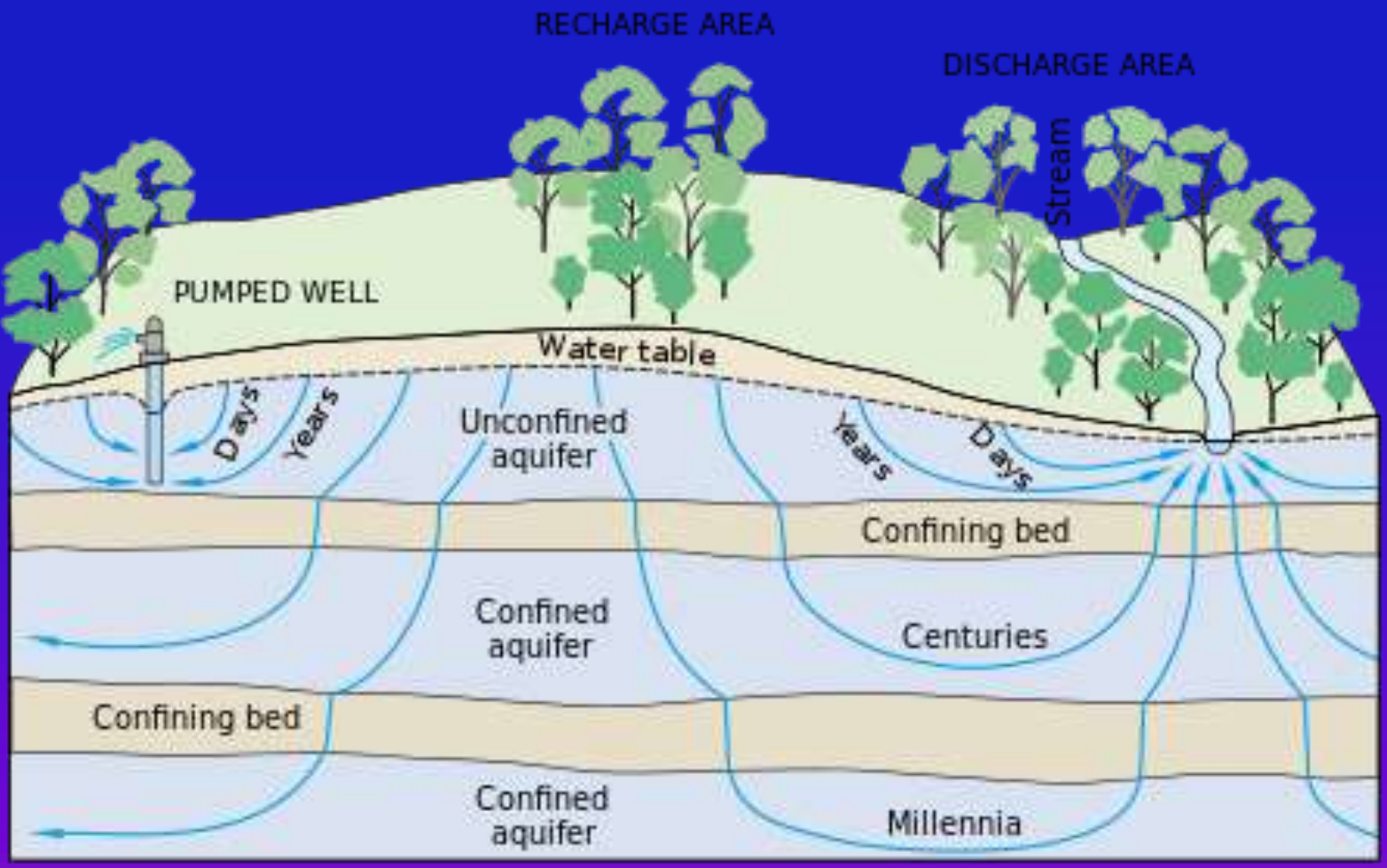
Early **medicine**

The Yangtze River, China

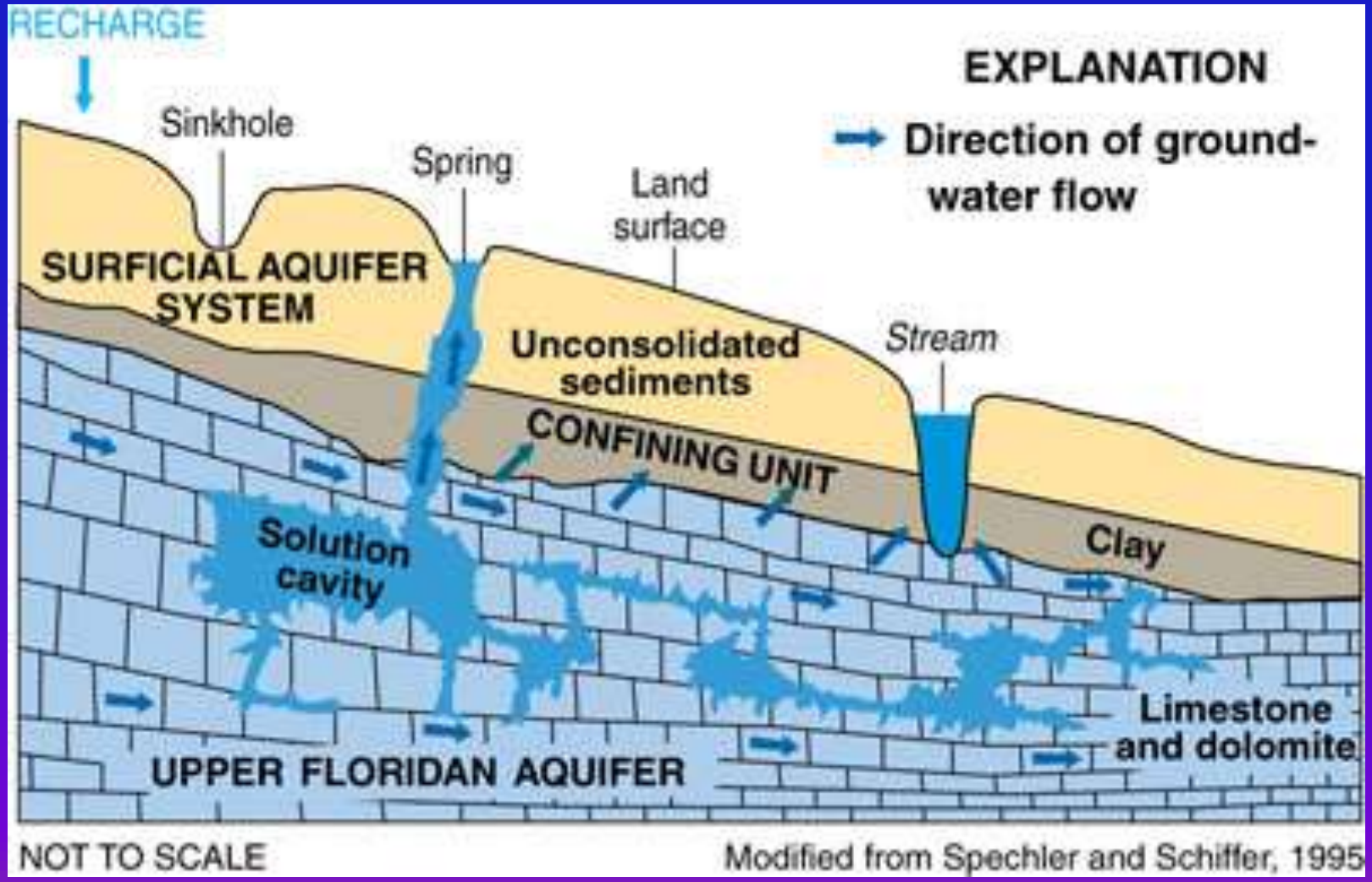
Mississippi River

UNDERGROUND WATER

Water Travels under the Surface



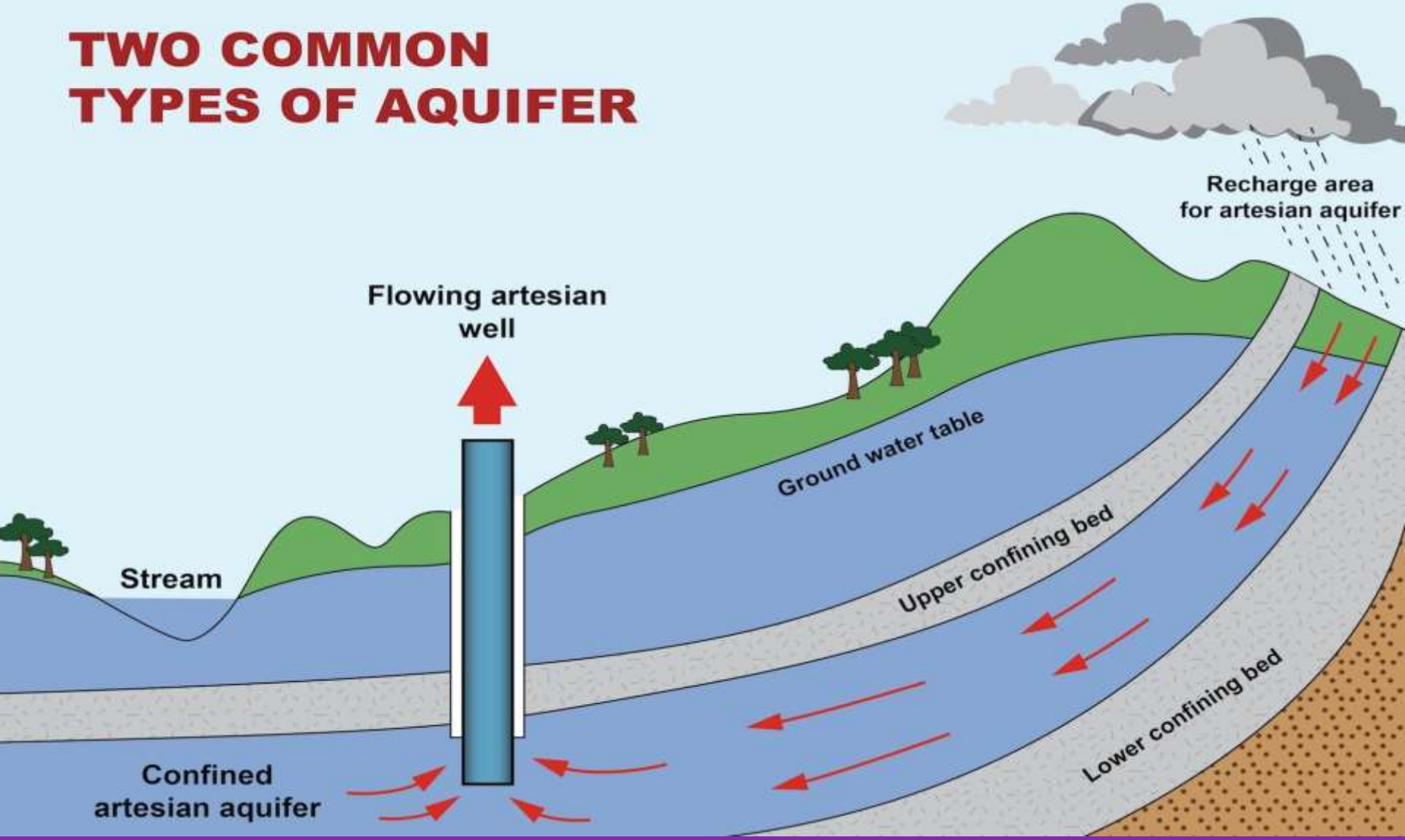
Formation of Caves



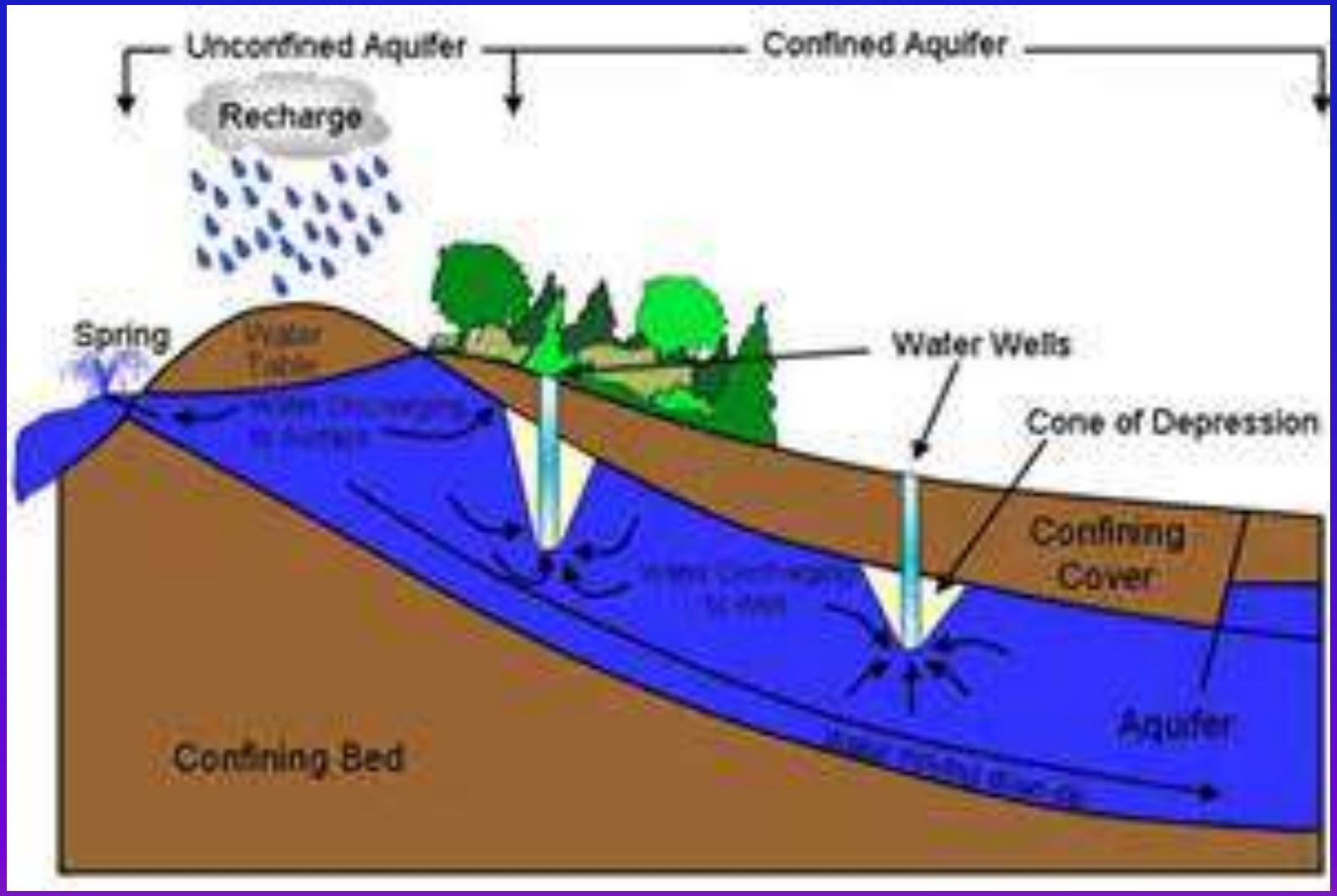
Carlsbad Caverns, NM

Carlsbad Caverns – “Rock of Ages” Photo Ansel Adams - 1941

Aquifers


TWO COMMON
TYPES OF AQUIFER
Recharge area
for artesian aquifer
Flowing artesian
well
Ground water table
Upper confining bed
Stream
Lower confining bed
Confined
artesian aquifer

Aquifer


Unconfined Aquifer
Confined Aquifer
Recharge
Spring
Water Wells
Cone of Depression
Confining Cover
Aquifer
Confining Bed

WATER AND HUMANKIND

Water and Man's Philosophy

Ancient Greeks:

- Water is one of the 4 classical elements of the world: Fire, Earth, and Air
- Water is one of the 4 body humors

Ancient Chinese:

- Water is one of the 5 elements of the world: Fire, Earth, Wood, and Metal

Water and Man's Culture

Most religions require ***ritual washing*** as a **sign of purification** before praying

Judaism – *Mikvah*

Christianity – *Baptism*

Islam – *Ghusl*

Sikhism – *Amrit Sanskar*

Shinto - *Misogi*

The Oldest Cities in the World

Jericho – West Bank	9,000 BC
Byblos, Lebanon	5,000 BC
Aleppo, Syria	4,300 BC
Damascus, Syria	4,300 BC
Susa (Shush), Iran	4,200 BC
Faiyum, Egypt	4,000 BC
Sidon, Lebanon	4,000 BC
Plovdiv, Bulgaria	4,000 BC
Gaziantep, Turkey	3,650 BC
Beirut, Lebanon	3,000 BC
Jerusalem, Israel	2,800 BC
Tyre, Lebanon	2,750 BC
Arabil, Iraq	2,300 BC
Kirkuk, Iraq	2,200 BC
Balkh (Bactra), Afghanistan	1,500 BC
Athens, Greece	1,400 BC
Larnaca, Cyprus	1,400 BC
Luxor (Thebes), Egypt	1,400 BC
Cádiz, Spain	1,100 BC
Benares, India	1,000 BC

Modern Human Settlements and Water

City	Body of Water
New York	Hudson and Atlantic
Los Angeles	The Pacific
San Francisco	The Pacific
Chicago	Michigan Lake
Montreal	St. Lawrence River
London	The Thames
Hong Kong	The Pacific

Water and Humankind in Modern Times

1.8 Bil. people lack access to safe water

2.5 Bil. lack access to adequate sanitation

2003 – G-8 Evian Summit: “By 2015, reduce to half the number of people who do not have access to safe water and sanitation”

2015 - California Water Crisis – Gov. Brown – 25% reduction in water usage

2025 - Half of world population will face water shortages

2030 - Water demand in developing countries will exceed supply by 50%

Water and Human Life

BIOLOGIC PROCESSES:

Body Metabolism: Anabolism and Catabolism

Photosynthesis and Respiration

Maintains acid-base neutrality

WATER IS USED:

AGRICULTURE - 70% - 90% of freshwater

DOMESTIC USE: Cooking, Cleaning, Washing, Recreation

INDUSTRIES - Solvent, Reactant, Catalyst, Power ⇨ **Pollution**

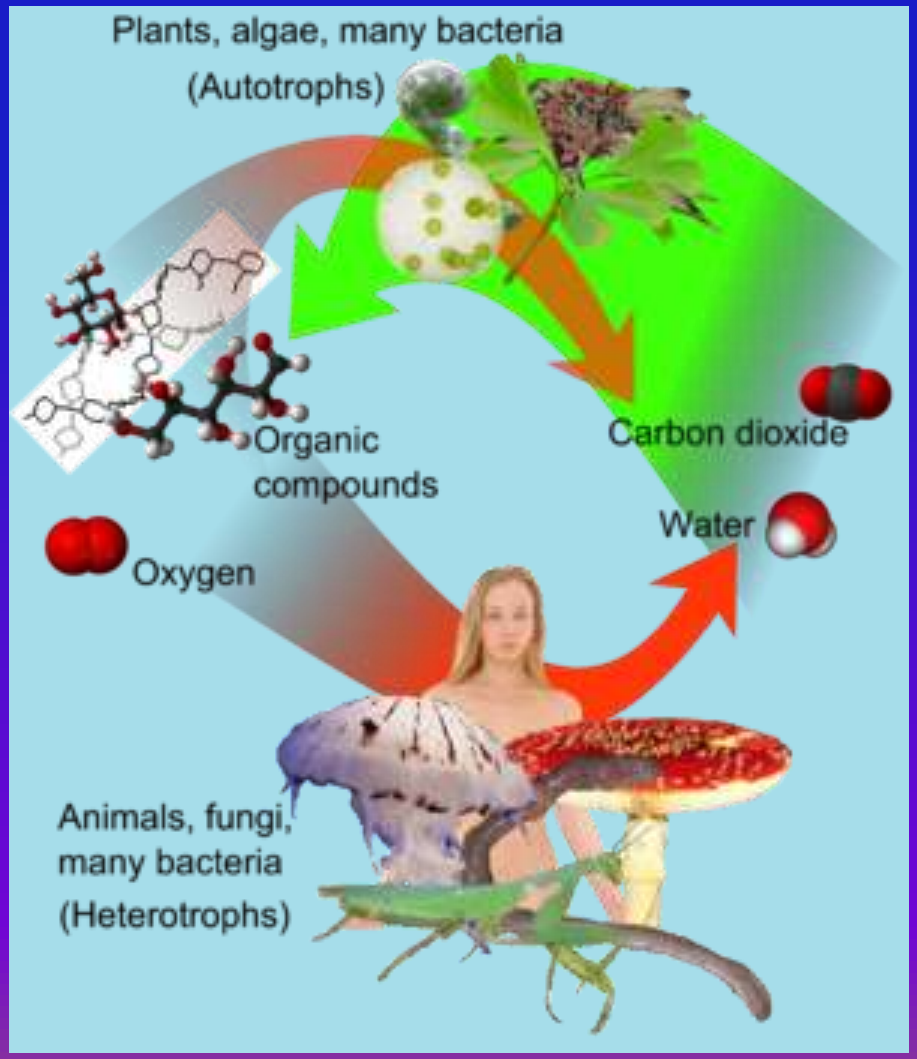
NUCLEAR REACTORS –

HYDROELECTRIC POWER -

FIRE CONTROL - Danger of steam explosion !

TRANSPORTATION – People and Merchandise

Photosynthesis and Respiration
Algae and bacteria produce organic compounds and oxygen



Water in the Organism

About 69% of human body weight is water

Intracellular fluid (ICF) = 2/3 of body water
Extracellular fluid (ECF) = 1/3 of body water

Plasma (90% of blood volume) = 1/5 of ECF

Transcellular fluid (“third space”) = fluid contained inside organs (GI, kidneys, CSF, eyes)

Body Water
Adult 70 kg = ~154 lbs.

Body water content varies with age, gender, amount of fat (adiposity), and physical activity

Body fat has 10% water. Muscles have 5% water

Obese persons have 45% water

Infants have 73%

Basic Metabolism
Gain and Loss of Water (mL* in 24 hours)

Gain (mL*)		Loss (mL*)	
Fluid intake	800 - 1,500	Urine	800 - 1,500
Water in food	475 - 725	Feces	125
Tissues oxidation	250	Insensible loss:	
		Skin	250 - 375
		Lungs	250 - 375
		Sweat	100
TOTAL GAIN	**1,525 - 2,475**	**TOTAL LOSS**	**1,525 - 2,475**

* 1 ML ~ 1/30 OF 1 FL. OZ; 1/16 OF 1 FL. PT

Regulation of Water in the Organism

Hormones acting on kidney tubules:

- Antidiuretic hormone (pituitary gland)
- Aldosterone (adrenal cortex)
- Atrial natriuretic peptide (heart muscle)

Dehydration = Loss of water by:

- Excessive sweating
- Diarrhea
- Vomiting

Optimal Water Intake

Controls dehydration

Quenches thirst

Improves digestion

Prevents constipation

Prevents kidney stones

Combats muscle cramps

Helps losing weight

Thirst = Is not a good indicator for drinking water.
It's a late indicator

The Organism Need of Water

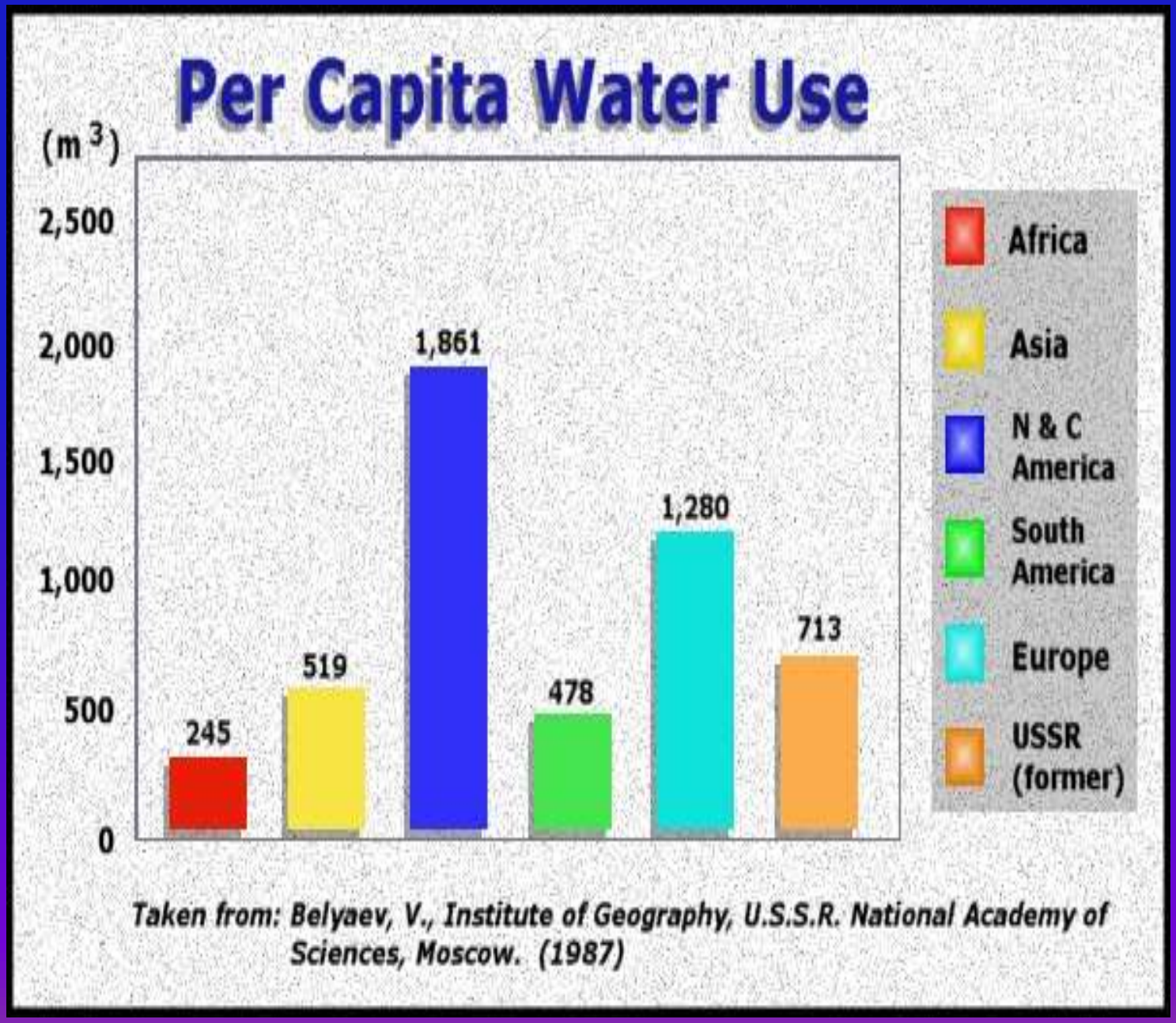
Without food we may live 4-6 weeks

Without water we may live 7-10 days

Daily need of water intake: 1.5 – 2.0 qts.

INTERMISSION

WATER USE


Per Capita Water Use
(m 3)
2,500
2,000
1,500
1,000
500
0
245
519
1,861
478
1,280
713
Africa
Asia
N & C America
South America
Europe
USSR (former)
Taken from: Belyaev, V., Institute of Geography, U.S.S.R. National Academy of Sciences, Moscow. (1987)

Our Use of Water

One washing machine load = 40 gallons

Shower (without singing) = 50 gallons

Teeth brushing (with water let running) = 4 gallons

American water use per person 160 gal./day

Millions live with 3 gal./day

1/5 of world is without potable water

One child dies every 15 min. because of waterborne diseases

How much water does it take to make?

1 cup of tea: 30 liters
1 slice of bread: 40 liters
1 apple: 70 liters
1 glass of beer: 75 liters
1 liter of milk: 1,000 liters

1 T-shirt: 2,700 liters
1 kg of rice: 3,400 liters
1 pair of jeans: 4,100 liters
1 kg of beef: 15,000 liters

1 gallon = ~4 liters

DRINKING WATER

What Did Men Drink? (1)

Late Paleolithic Era: Alcohol from berries or honey (mead)

Neolithic Era: Alcoholic beverages. Beer jugs found

Beer preceded bread making

Agriculture (8,000 BC) - Northern China pottery:

Wine from rice, honey, grapes, and berries

5,400-5,000 BC – First wine residue found in a jar in Iran

~4,000 BC – Oldest winery in Armenia

3,400 BC – Egyptian city Hierakonpolis – Oldest brewery

What Did Men Drink? (2)

3,500 - 2,900 BC – Alcoholic barley brew found in 3,500 BC – Egyptians made wine and beer. Osiris was the god of wine. Beer was “a necessity of life.” Moderation stressed

~ 3,100 – Beer for workers. Wine for the elite.

2,500 BC - Babylonians had wine deities.

- Sumerians had the goddess *Ninkasi* to rule over the production and distribution of beer. Regulated drinking places (bars?)

2,600-2,500 BC – The pyramid builders were given a daily ration of beer (5% alcohol)

2,799 - 600 BC – Epic of Gilgamesh – Wine making in Mesopotamia

What Did Men Drink? (3)

~ 2,000 - Wine making reached the Greek and Italian peninsulas.

~ 2,000 - Alcohol in China = spiritual food used in rituals.

1,800 BC - Land of Israel “blessed vineyards”

1,750 BC - Code of Hamurabi - Concern about alcohol commerce

1,700 BC - Greece winemaking for rituals, hospitality, medicine, meals

1,450 - 1,410 BC - Noah’s drunkenness - Ararat, Turkey

~ 1,100 - Vines first planted around Cadiz, Spain by Phoenicians

1,000 BC - Maya culture - Mead

700 BC - Greek culture: Wine offering to gods, currency, medicine, civic duty, and base of democracy

Daily Water Intake

To avoid dehydration, the amount of water/day depends on body size, activity, ambient temperature, humidity, lactating

~ 2 liters of water/day

US National Research Council: **"One mL of water for each calorie of food"**

~ 20% of needed water comes from food

Definition of Potable Water

"Water that meets the standards for drinking purposes of the State or local authority having jurisdiction, or water that meets the standards prescribed by the U.S. Environmental Protection Agency's National Primary Water Regulations."

WATER SUPPLY AND TRANSPORT

Man and Water Supply
A timeline

Each settlement of men depends on sufficient water supply

Since the beginning of recorded times:

- Natural water resources
- Saving water: from flooding and rain
- Digging wells (Jericho, Byblos)

Gihon Spring and the Siloah Pool Jerusalem, Israel, 700 BC

Eupalinos Tunnel
Island of Samos (Greece) - 550 BC

Manhole above the Eupalinos tunnel

Water Pipes - Madradag Aqueduct Pergamum (Bergama), Turkey, 2nd c. BC

Pont du Gard, near Nîmes, France
Roman, 60 AD

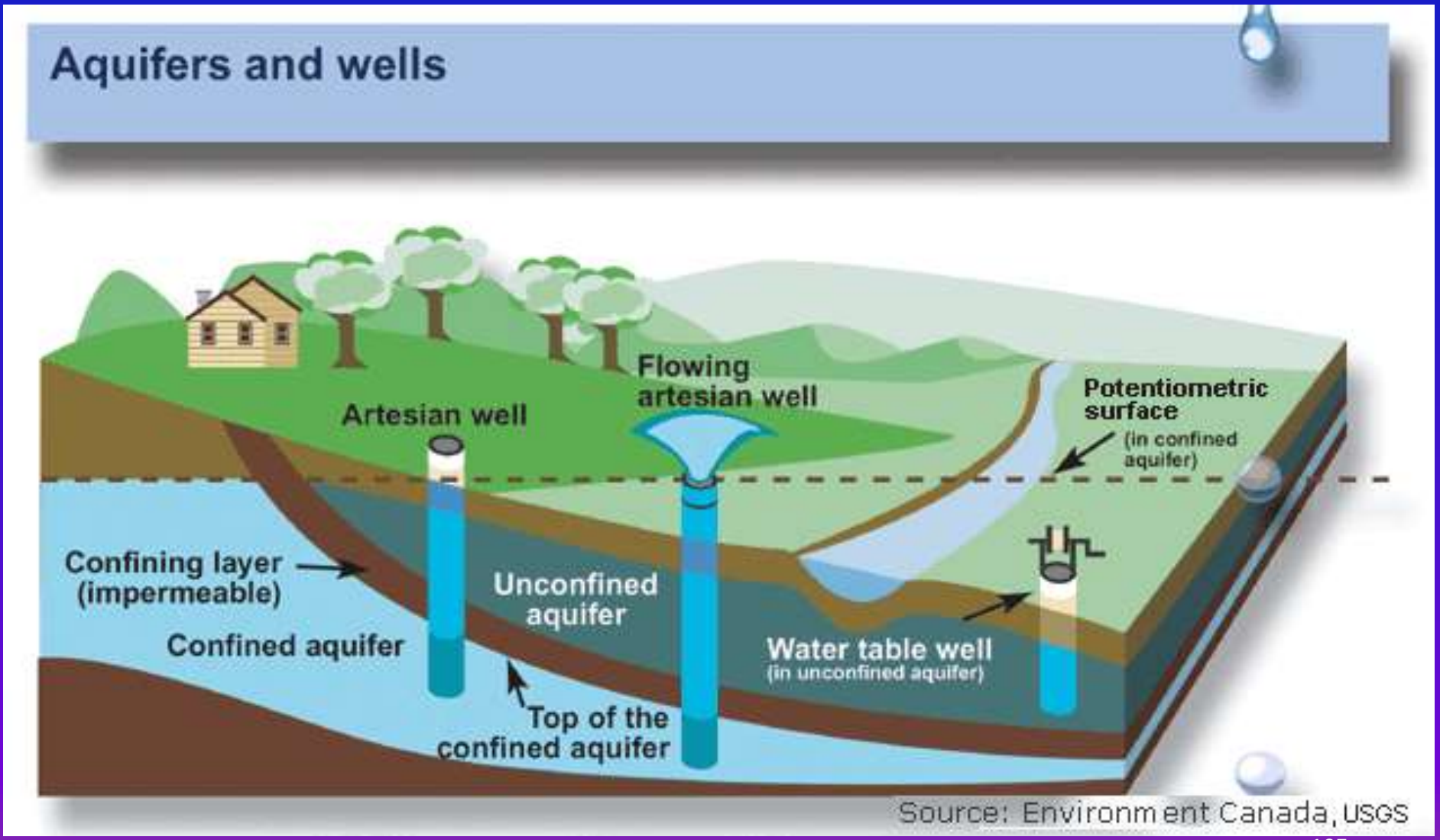
Length 902 ft., Gradient 1”, Height 160 ft.

Water carrier – India, 1882

Water Canalization

WELLS CONSTRUCTION

Aquifers and Wells



History of Well Construction (1)

Earliest wells dug in the Neolithic era

Wood-lined wells in the early Neolithic Age in Germany and Austria

Agriculture and farming, use of metal (copper) tools

Later, iron tools made possible effective digging

Atlit Yam, Israel, is the oldest well (8,100 – 7,500 BC)

Chinese – 4,000 years ago - percussion method with bamboo frameworks. Took generations for completion

Oldest Man-made Well
Atlit Yam, Israel 8,100 - 7,500 BC

An agro-pastoral-marine settlement found under the sea bed

Destroyed by Mt. Etna collapse and giant tsunami

Well was built in stone

Human skeletons 8,000 years old. Oldest cases of tuberculosis of bones

Many stone tools

History of Well Construction (2)

"Persian Works" – 2,000 BC made irrigation tunnels and collector wells called "ganats" honeycombing 100,000 miles

The method spread to western China, N. Africa, Sicily, Spain = *One World*

Jacob's Well in Samaria, c. 2040 BC
Nablus, West Bank

Greek Orthodox St. Photini's Church Nablus, West Bank

Jesus and the Samaritan Woman at Jacob's Well ("the Living Water")

"Everyone who drinks of this water will be thirsty again, but those who drink of the water that I will give them will never be thirsty"

St. Patrick's well
Antonio da Sangallo the Younger
Orvieto, Umbria, Italy, 1527

Fountain of Diana, Villa d'Este, Tivoli, Italy (1550 – 1573)

Versailles, France, 1662

Versailles, France, 1662

Fontana di Trevi (Rome, 1762)

Manual water pump in China

David and Joseph Ruffner's First Well on the Banks of Kanawha River, Charleston, WVA, 1808

From Wells to Everywhere

- Springs and Lakes ⇨ Wells ⇨ Basins

Solon, Athens legislator (638-558 BC):

"**Public wells for each radius of 740m"** (~2200 ft.)

- Tunnels
- Pipes
- Aqueducts
- Canals

Water and Civilizations Destroyed by Lack of Water

3300-1300 BC - **Harappan civilization** on Indus Valley had efficient management of water resources

2334-2083 BC - **Akkadian civilization** had a massive agricultural system with the highest recorded population density

2700-2200 BC – **Old Kingdom of Egypt** – devastating drought that lasted ~1000 years

WATER POLLUTION

Hazard symbol for non-potable water

Water Pollution Causes

Improperly disposed chemicals

Animal wastes

Pesticides

Human threats

Wastes injected underground

Naturally-occurring substances

Improperly maintained distribution systems

Improper disinfection of sources

Water Pollution - Causes

Greywater = 50-80% of residential waste water

Blackwater from sewage and toilets

Industries: Discharged solutes (chemical)

Discharged coolant water (thermal)

Food Industries

Pharmaceuticals

Runoffs must be subject to treatment plants

Protective Actions

Preventative – Safe Drinking Water Act and EPA

Reactive – Treating the polluted water

States have delegated authority for protecting the quality of drinking water

States have Water Programs

Homes built before 1986 may have corroded water pipes.

Advice: Flush old water pipes before drinking

Drink cold water from the tap

Lead Intoxication (Plumbism, Saturnism)

Lead intoxication ⇨⇑ in the Industrial Revolution

Causes: Ingestion or contact with paints

Children more exposed than adults because of rate of absorption. 12 Mil. children are affected annually

Lead in Drinking Water: Old houses

Corroded water pipes

Water acidity

The Safe Drinking Water Act (SDWA)

Issued 1974; amended in 1986 and in 1996.

Its instrumentality is EPA

Standards for safe drinking water. Protection and Prevention

Applies to every public water system

Sets the Maximum Contaminant Level Goals (MCLGs).

For lead – maximum 0.25%

Lead in drinking water because of corroded water pipes and water acidity

The Timeline of Flint Water Crisis
"A man-made disaster" 2014 - 2016

July 2011 - Analysis of Flint River for water supply of Flint: Most effective drinking water is to build a new pipeline to Lake Huron - Karegnondi Water Authority (KWA).

Feb.-Mar.2013 - Dept. of Environmental Quality (DEQ) knew of high levels of total trihalomethanes (TTHM)

March 25, 2013 - Flint City Council Votes 7-1 to join KWA

March-April 2013 - Gov. Snyder fails to negotiate a deal btw. Detroit and Flint

April 25, 2014 - Water supply switched from Detroit to Flint River

Locals noted brown color and abnormal taste and smell

Authorities added more chlorine.

The Timeline of Flint Water Crisis "A man-made disaster" 2014 – 2016

PROBLEMS: >75 y.o. cast-iron pipes. Iron released into water.

Authorities added more chlorination + organic matter ➢TTHM

Feb. 2015 - Oct. 2015 – **high levels of lead: 104 ppb** (threshold is 15 ppb)

Oct. 2, 2015 - State officials publicly announce **high lead content in drinking water of Flint**

Dec. 14, 2015 - Flint Mayor Karen Weaver declares state of emergency

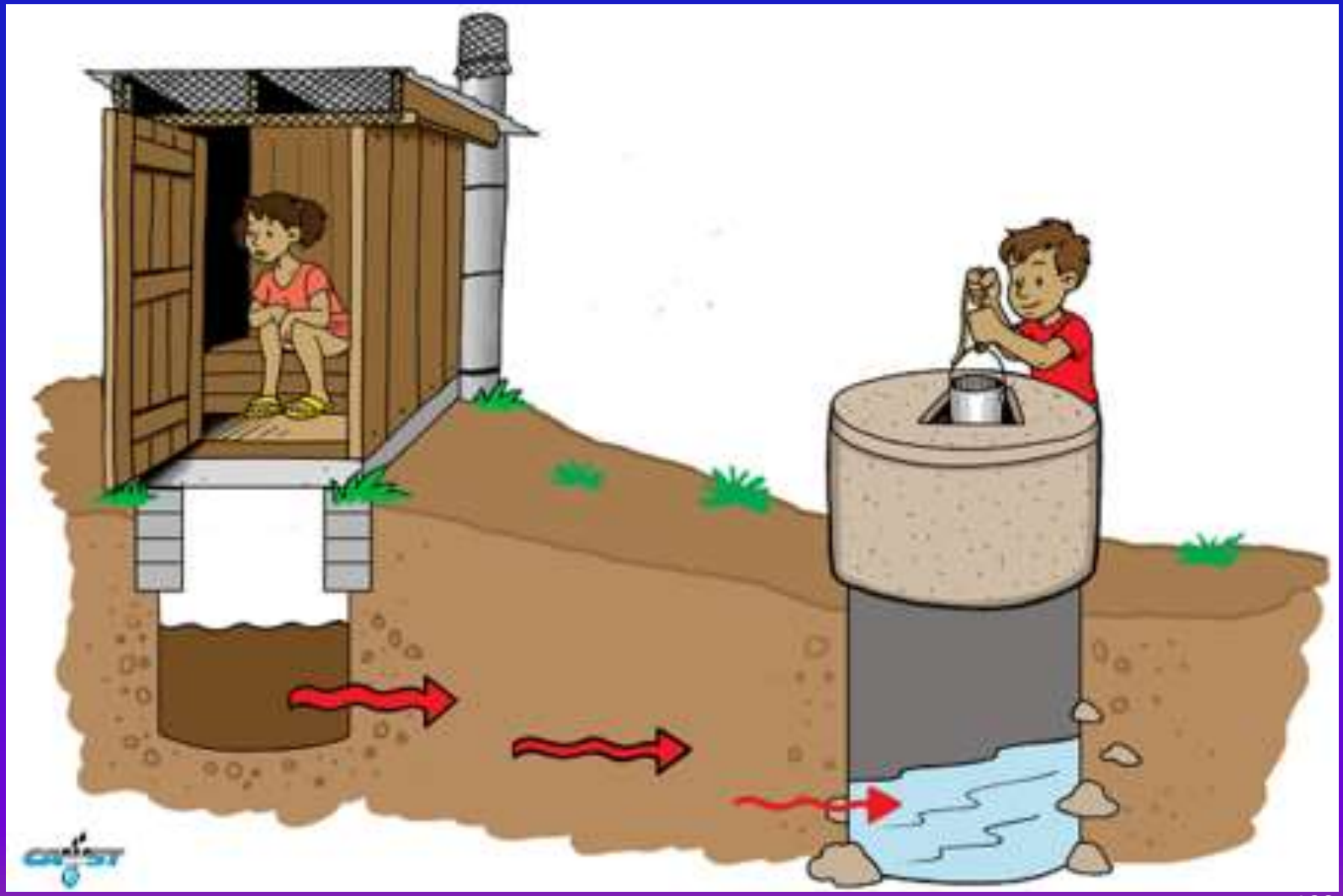
Feb. 5, 2016 – Head of Municipal Drinking Water for the state is fired

Apr. 20, 2016 – Michigan Attorney General announces charges against DEQ employees. **Jun. 2, 2016** - DEQ Chief Deputy Director Jim Sygo stated that Flint water crisis "was overplayed"


TIME
The Poisoning Of An American City
Toxic water. Sick kids. And the incompetent leaders who betrayed Flint
By Josh Sanburn

WATERBORNE DISEASES

Waterborne Diseases



Waterborne Diseases

Diseases transmitted through contact with or consumption of infected water.

Waterborne diseases can have a significant impact on the economy, locally as well as internationally.

Devastating effects on the population infected.

Major cost in eradicating = 10% of GDP.

Most Frequent Water-borne Diseases

Bacterial: Cholera, *E. coli* infection, dysentery, botulism, salmonellosis, typhoid fever

Viruses: SARS (Severe acute respiratory syndrome), hepatitis A, polio, influenza

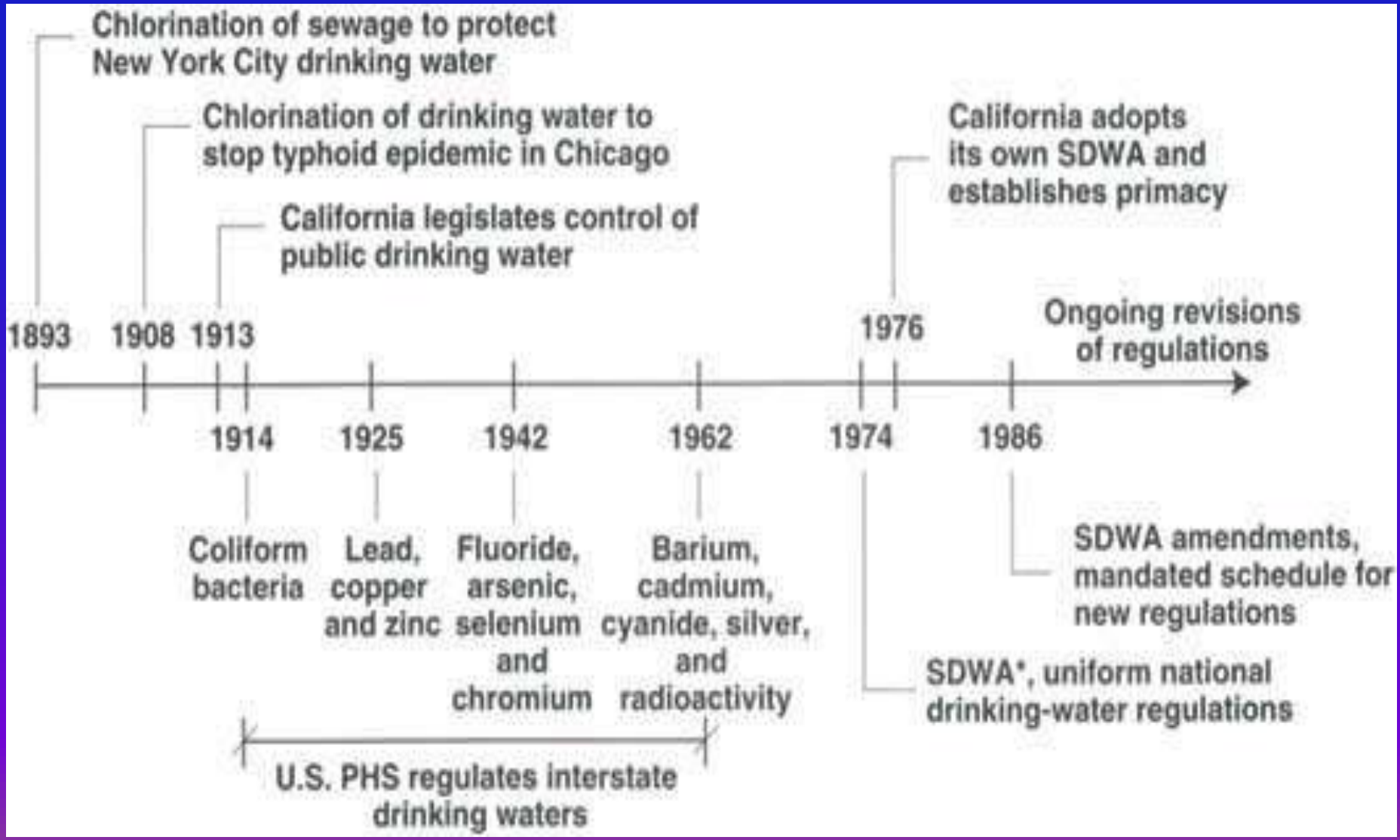
(1852 - Russia flu epidemic ⇨ 1 Mil. dead)

Protozoa: Amoebiasis

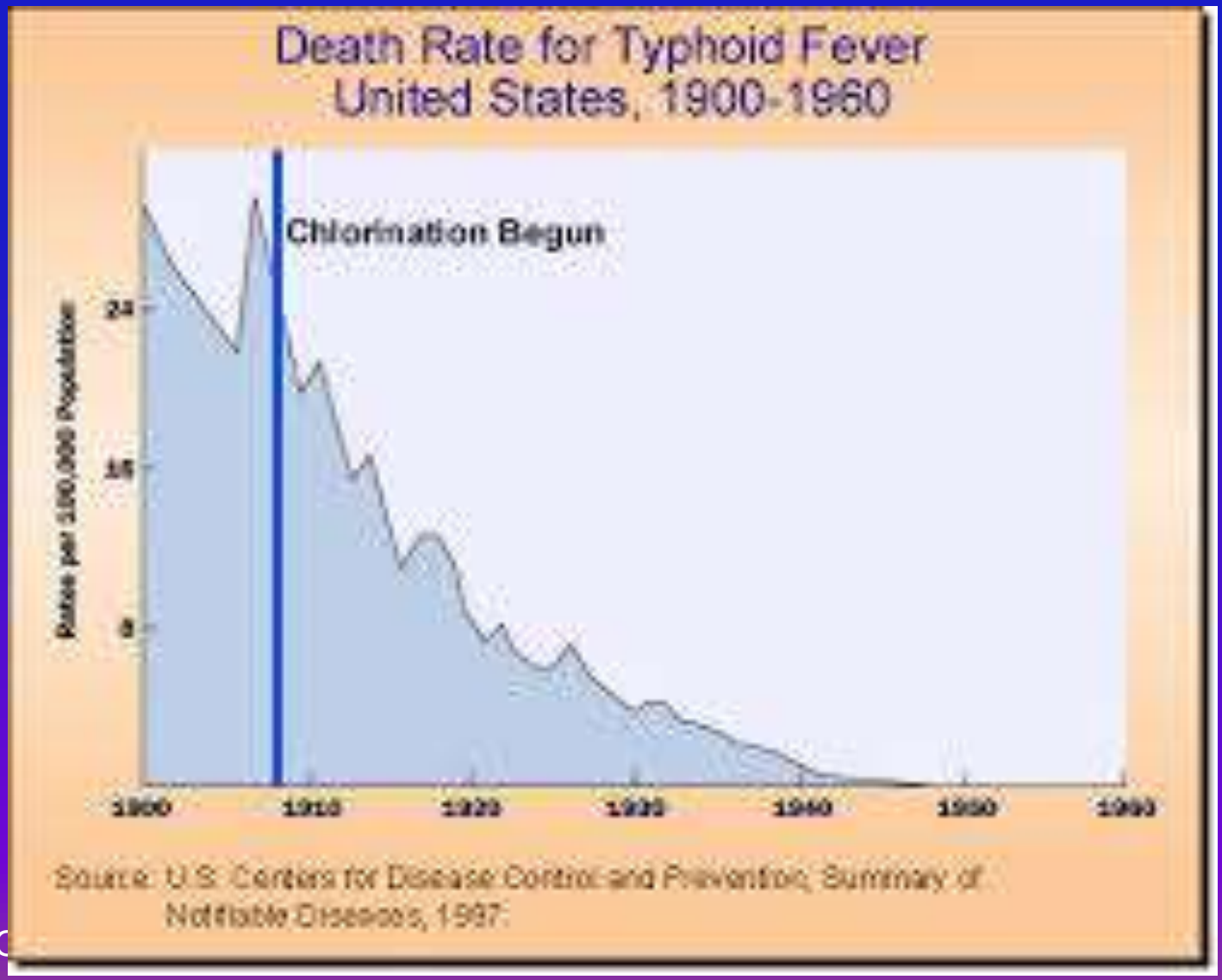
Protozoa: Echinococcosis, Taeniasis, (Tapeworm), schistosomiasis

WATER CHLORINATION

Water Chlorination in USA

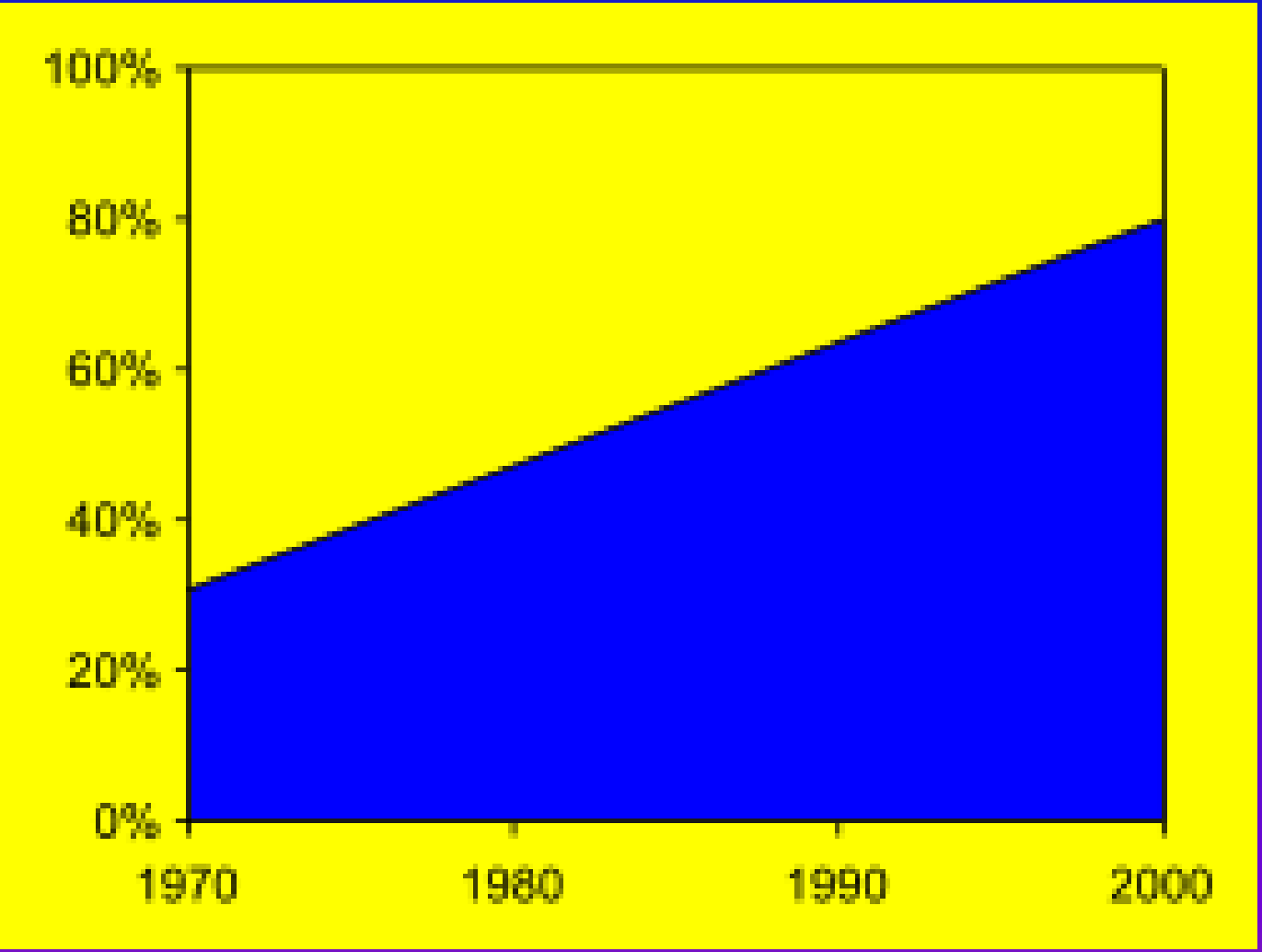


The Effect of Water Chlorination



Sub-Saharan Africa – Only 61% of People Have Drinking Water

Developing Countries, 1970-2000.
Share of People with Access to Drinking Water ~80%



WATER DESALINATION

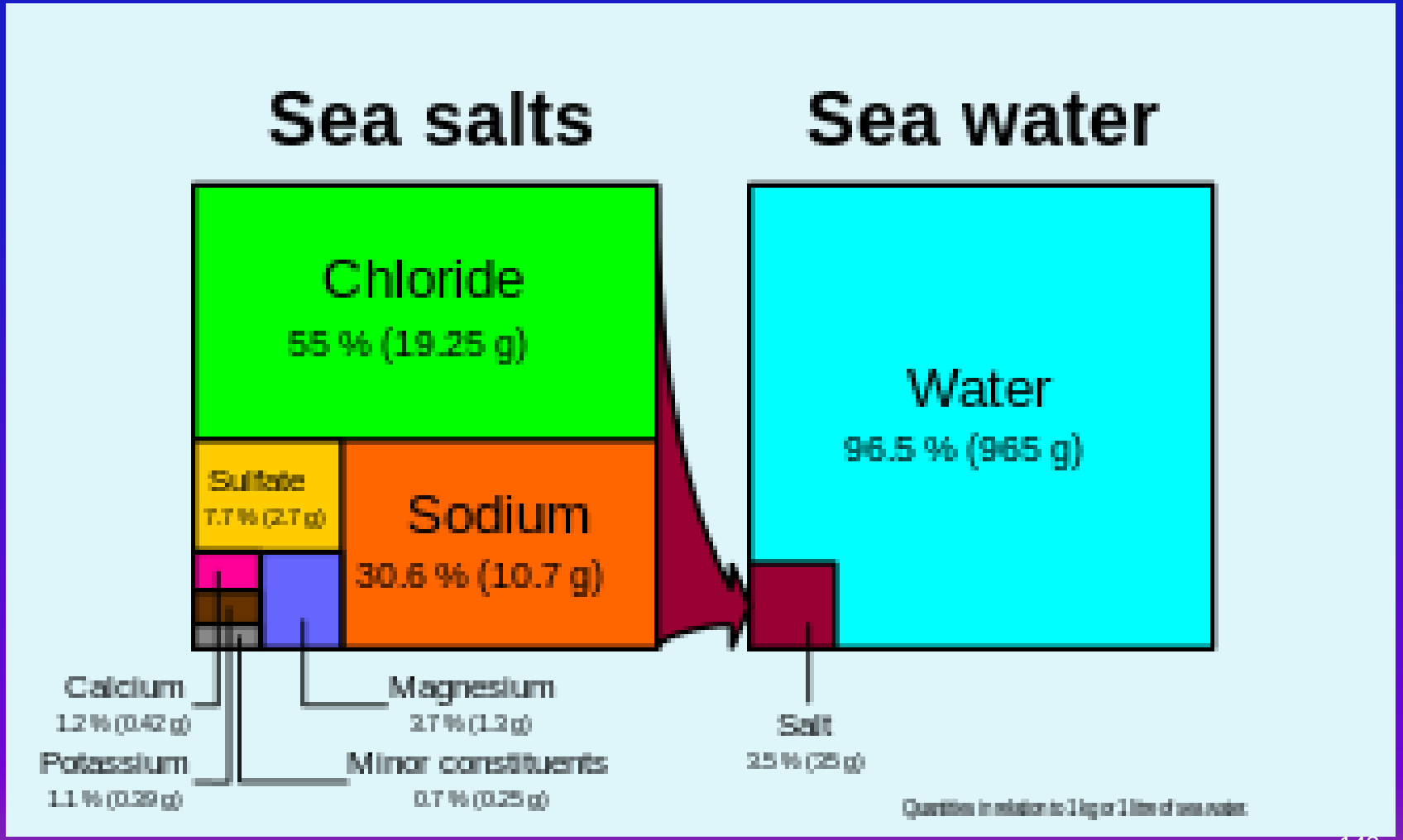
DESALINATION
General

- By 2025, the UN expects 14% of the world's population to be encountering water scarcity
- Developing cost-effective ways of providing fresh water for human use
- Cost of desalination is higher than groundwater, water recycling, and water conservation
- In 2013 - 15,988 desalination plants operated worldwide, producing 78.4 million cubic meters per day, providing water for 300 million people

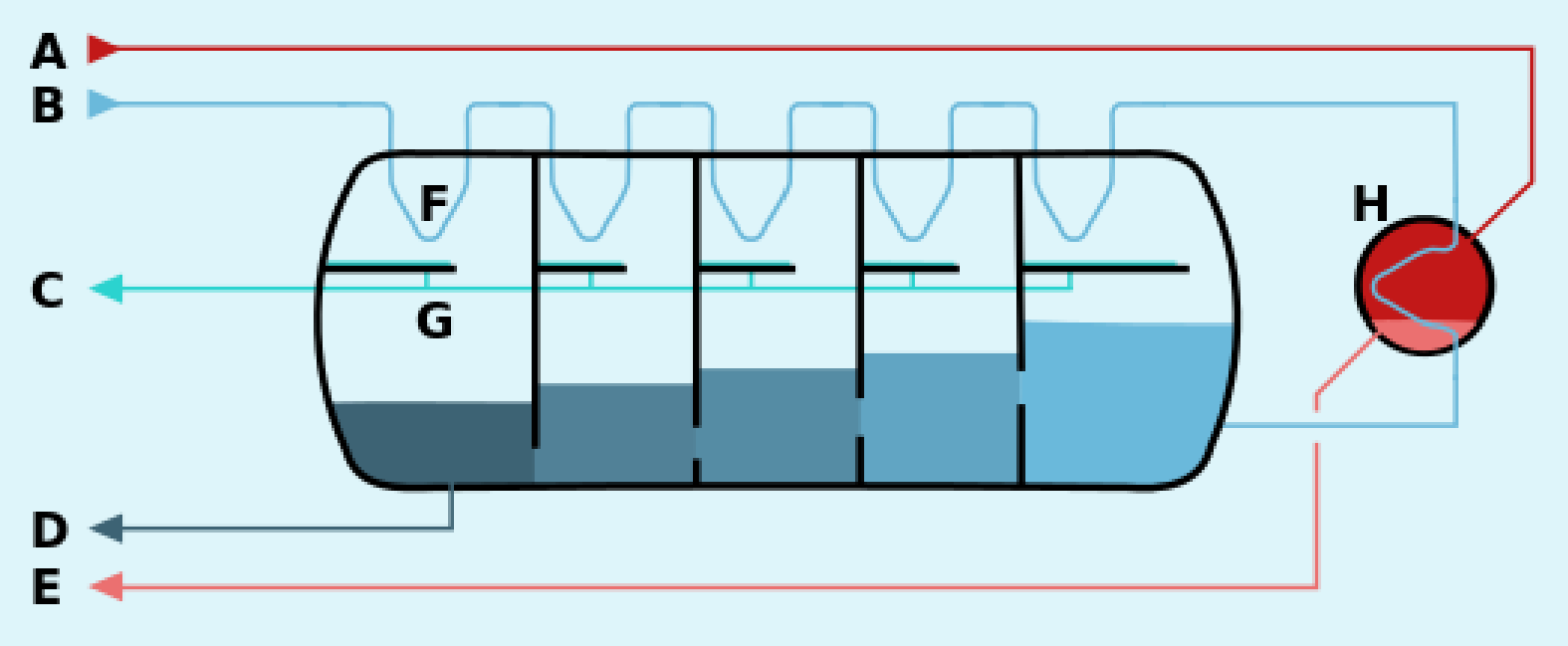
DESALINATION
General (2)

- Most countries have active desalination facilities
- The largest percent of desalinated water used in any country is in Israel, which produces 40% of its domestic water use from seawater desalination.

Sea Water Salinity



Principle of Desalination



A – steam in
B – seawater in
C – potable water out
D – waste out
E – steam out
F – heat exchange
G – condensation collection
H – brine heater

Desalination - Methods

- Sea water vacuum distillation
- Reverse osmosis – semipermeable membranes (kidney physiology)
- Hybrid methodology

Problems: 1. Expensive processes US$/0.40/$m^3$

2. Pollution caused by the energy used

(Minimum energy consumption = 1 Kwh/$m^{3)}$

Future developments: Evaporation ponds

Solar stills

Condensation traps (solar desalination)

2017 – Israel introduces desalination using solar energy – cost reduced by 90%

Average Water Consumption and Cost of Supply by Sea Water Desalination

Area	Consumption US gal/person/day	Desalinated Water Cost US$/person/day
USA	100	0.29
Europe	50	0.14
Africa	15	0.05
UN recommended minimum	13	0.04

Desalination Plants

World's largest: Ras Al-Kahir (Saudi Arabia) – 1,025,000 cubic meter/day

Carlsbad, CA – Projected plant = the largest in USA


Desalination in California
The nation's largest ocean desalination plant is under construction in Carlsbad and set to open in 2016. Only three small plants are open now, and about 15 others are proposed.
Desalination plants
Existing
Proposed
Santa Cruz
Moss Landing
Marina
Monterey
Sand City
Cambria
Long Beach
Huntington Beach
South Orange
West Basin (2)
Doheny
Santa Catalina Island
Camp Pendleton
San Nicolas Island
Carlsbad
Oceanside
Source: California Department of Water Resources
BAY AREA NEWS GROUP

A Project for a Better World

"Three Countries Project" studied by the IMF ($1 Bil.):

1. Desalinize Mediterranean water at Ashdot, Israel
2. Move the water across the Judean Hills –
3. Irrigate the West Bank and the Negev
4. Water falls to Dead Sea 429 m (1,407 ft.) below sea level
5. Create a major hydroelectric plant

Reduce Dead Sea salinity (from 34.2%)

Project declined by the West Bank (Palestine)

ISRAEL and a Failed 3-Nations Water Project

RECYCLED WATER

Reclaimed (Recycled) Water

Reclaimed (Recycled) Water

Definition: Wastewater sent from home or business through a pipeline system to a treatment facility, where it is treated to a level consistent with its intended use.

Reclaimed Water facilities in California:

- San Francisco Golden Gate Park (1932)
- Irvine Ranch Water District

End products:

Potable water: Drinking water

Potable reuse: Reused water one can drink

Reused water: Water used more than once (recycled)

Non-potable reuse: Not for drinking. OK for irrigation and industry

Renewed water: Reclaimed water subjected to advanced treatment to make it potable.

Reclaimed (Recycled) Water
Reclamation Process

Bar screens – Removal of large solids

Primary Settling Tanks – Solids are skimmed from the top and bottom

Biological treatment – Bacteria digest the sludge

Secondary Settling tanks – Water gets clear

Tertiary treatment – Sand filters

Chlorine Contact tanks – Disinfection

Reclaimed water may be used for agriculture, irrigations, cooling towers, land fills, golf courses.

Quantitative Microbiological Risk Assessment (QMRA)

Quantitative microbiological risk assessment (QMRA) is the process of estimating the risk from exposure to microorganisms.

The process involves measuring known microbial pathogens or indicators and running a simulation test to estimate the risk of transfer. If a dose-response model is available for the microbe, it be used to estimate the probability of infection.

QMRA has expanded to be used to estimate microbial risk in many fields, but is particularly important in assessments of food water supply and human feces/wastewater safety.

Mobile Water Purifier made in Israel
8,000 cups of water per hour

WATER AND POLITICS

Law and Politics of Water

- Water is a strategic resource on the globe
- 70% of freshwater used by humans goes to agriculture
- 1.6 Bil. people have gained access to safe water since 1990
- Safe water for 30% in 1970
  71% in 1990
  79% in 2000
  84% in 2004
- 2003 - G8 Summit in Evian: By 2015 to reduce to half the number of people who do not have access to safe water and sanitation
- 2009 – Report stated that in 2010 water demand will exceed supply by 50%

HOW CAN WE SAVE WATER?

1. **Restrict our use**
2. **Limit garden use by planting drought resistant plants**
3. **Greywater** = water from bathroom sinks, showers tubs, and washing machines

   Israel recycles 90% of its gray water

   USA recycles 2% of its gray water
4. **Capture water from rain and snow**
5. **Desalination**

"People will make all the mistakes they can before doing the correct thing that was always apparent but ignored…"

John Maynard Keynes
(1883 - 1946)

Conclusions: Water and Civilizations

Civilizations had thrived when water supply was abundant

Civilizations have been destroyed by floods or droughts

Countries **without adequate water resources risk instability**

Political instability = greatest danger to civilization

END OF LECTURE # 2