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 $\Rightarrow$ Imagination

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

$\Downarrow$

Breaks established modules

Fiction $\Rightarrow$ Myths $\Rightarrow$ **New Concepts (not physical)**
$\Rightarrow$ Abstract thought $\Rightarrow$ **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
<table>
<thead>
<tr>
<th>Year</th>
<th>Population</th>
<th>Production</th>
<th>Energy Consumption</th>
</tr>
</thead>
<tbody>
<tr>
<td>1500</td>
<td>500,000,000</td>
<td>$250 Billion</td>
<td>13 Trillion calories/day</td>
</tr>
<tr>
<td>2016</td>
<td>7.4 Billion</td>
<td>$60 Trillion</td>
<td>1,500 Trillion</td>
</tr>
</tbody>
</table>

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 $\Rightarrow$ doubling will take 200 yrs.

2050 - Expected world population = 9 billion
<table>
<thead>
<tr>
<th>Country</th>
<th>Population (in millions)</th>
</tr>
</thead>
<tbody>
<tr>
<td>China</td>
<td>1,383</td>
</tr>
<tr>
<td>India</td>
<td>1,317</td>
</tr>
<tr>
<td>USA</td>
<td>325</td>
</tr>
<tr>
<td>Indonesia</td>
<td>261</td>
</tr>
<tr>
<td>Brazil</td>
<td>207</td>
</tr>
<tr>
<td>Pakistan</td>
<td>197</td>
</tr>
<tr>
<td>Nigeria</td>
<td>188</td>
</tr>
<tr>
<td>Bangladesh</td>
<td>162</td>
</tr>
<tr>
<td>Russia</td>
<td>146</td>
</tr>
<tr>
<td>Mexico</td>
<td>129</td>
</tr>
<tr>
<td>Japan</td>
<td>126</td>
</tr>
<tr>
<td>Philippines</td>
<td>103</td>
</tr>
<tr>
<td>Ethiopia</td>
<td>101</td>
</tr>
<tr>
<td>Vietnam</td>
<td>94</td>
</tr>
<tr>
<td>Egypt</td>
<td>86</td>
</tr>
<tr>
<td>Germany</td>
<td>82</td>
</tr>
<tr>
<td>Iran</td>
<td>80</td>
</tr>
<tr>
<td>Turkey</td>
<td>77</td>
</tr>
<tr>
<td>Congo</td>
<td>73</td>
</tr>
<tr>
<td>Thailand</td>
<td>67</td>
</tr>
</tbody>
</table>

2017 World Population = 7,500,000,000

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 $\Rightarrow$ **temperature buffer** (greenhouse effect)
CARDIO-VASCULAR CIRCULATION

HEART

Arteries

Arterioles

Capillaries

Single-cell wall – blood - tissue exchanges of O₂, CO₂, nutrients, and waste

Venules

Veins

HEART
THE HEART - Chambers, Valves, and Circulation
BLOOD-GAS EXCHANGES

Heart

(Right) Atrium

(Right) Ventricle

Pulmonary artery

Lungs

Release carbon dioxide

Get oxygen

Left atrium

Left ventricle

(To the Periphery)

(From 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 $\Rightarrow$ sulfuric dioxide in air + water + oxygen $\Rightarrow$ sulfuric acid $\Rightarrow$ acid rain

Effects of Acid Rain on a Forest in the Czech Republic
Ozone Layer

1. Oxygen molecules are photolysed, yielding 2 oxygen atoms (SLOW)

2. Ozone and oxygen atoms are continuously being interconverted as solar UV breaks ozone and the oxygen atom reacts with another oxygen molecule (FAST)

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 $\Rightarrow$

2 oxygen atoms ($O\cdot$)

Each oxygen atom quickly combines with an oxygen molecule ($O_2$) $\Rightarrow O_3$

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

COMBUSTION OF FOSSIL FUELS

- Industry, motor vehicle traffic
- 50% increase in lung cancer
- Si and C particles
  - Inflammatory response
  - Cytokines + free radicals
  - Mutagenic effects
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

The World

Place, History, Economy, Politics, Diseases

Resources WATER

Humankind
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 m³ = x 264 gal/m³ = 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
- Precipitation
- Snowmelt runoff to streams
- Infiltration
- Streamflow
- Ground-water discharge
- Ground-water storage
- Surface runoff
- Evapotranspiration
- Evaporation
- Condensation
- Water storage in the atmosphere
- Sublimation
- Evaporation
- Water storage in oceans

USGS

http://water.usgs.gov/watercycle.htm
Atmospheric River

An average of about 30% to 50% of annual precipitation on the West Coast comes from atmospheric rivers.

As water vapor lifts over mountains, it cools and condenses, falling as rain or snow.

Atmospheric rivers can carry as much water as 15 Mississippi Rivers, and usually approach from the southwest.

About 250-375 miles wide, on average

1 mile above ocean

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

- **Fresh Water (3%)**
  - Saline (oceans) 97%
- **Surface water (1.2%)**
  - Icecaps and Glaciers 68.7%
  - Ground water 30.1%
  - Surface water 0.3%
- **Rivers (2%)**
- **Fresh surface water (liquid)**
  - Swamps 11%
  - Lakes 87%
OCEAN AND SEA WATER
Seawater - Salinity

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

Freezing point $= -2.0^\circ$C

The Red Sea – 5.0% salt. The Dead Sea – 34% salt $\Rightarrow$
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 $\Rightarrow$ 39% lethality

Body homeostasis by kidneys $\Rightarrow$ 0.9% salt in blood

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

Sea water desalination OK
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

<table>
<thead>
<tr>
<th>River</th>
<th>Length (Mi)</th>
<th>Ave. discharge (m³/sec)</th>
<th>Outflow</th>
</tr>
</thead>
<tbody>
<tr>
<td>Amazon</td>
<td>4,345</td>
<td>219,000</td>
<td>Atlantic</td>
</tr>
<tr>
<td>Nile</td>
<td>4,258</td>
<td>5100</td>
<td>Mediterranean</td>
</tr>
<tr>
<td>Yangtze</td>
<td>3,917</td>
<td>31,000</td>
<td>East China Sea</td>
</tr>
<tr>
<td>Mississippi-Missouri</td>
<td>3,902</td>
<td>16,200</td>
<td>Gulf of Mexico, Atlantic</td>
</tr>
<tr>
<td>Yenisei-Angara</td>
<td>3,445</td>
<td>19,600</td>
<td>Kara Sea, Siberia</td>
</tr>
<tr>
<td>Yellow River</td>
<td>3,395</td>
<td>2,110</td>
<td>Bohai Sea, China</td>
</tr>
<tr>
<td>Ob-Irtysh</td>
<td>3,364</td>
<td>12,800</td>
<td>Gulf of Ob, Russia</td>
</tr>
</tbody>
</table>
The Amazon River
The Nile
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

Flowing artesian well

Ground water table

Upper confining bed

Lower confining bed

Recharge area for artesian aquifer

Confined artesian aquifer

Stream
Aquifer
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

<table>
<thead>
<tr>
<th>City</th>
<th>Year BC</th>
<th>City</th>
<th>Year BC</th>
</tr>
</thead>
<tbody>
<tr>
<td>Jericho – West Bank</td>
<td>9,000 BC</td>
<td>Tyre, Lebanon</td>
<td>2,750 BC</td>
</tr>
<tr>
<td>Byblos, Lebanon</td>
<td>5,000 BC</td>
<td>Arabil, Iraq</td>
<td>2,300 BC</td>
</tr>
<tr>
<td>Aleppo, Syria</td>
<td>4,300 BC</td>
<td>Kirkuk, Iraq</td>
<td>2,200 BC</td>
</tr>
<tr>
<td>Damascus, Syria</td>
<td>4,300 BC</td>
<td>Balkh (Bactra), Afghanistan</td>
<td>1,500 BC</td>
</tr>
<tr>
<td>Susa (Shush), Iran</td>
<td>4,200 BC</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Faiyum, Egypt</td>
<td>4,000 BC</td>
<td>Athens, Greece</td>
<td>1,400 BC</td>
</tr>
<tr>
<td>Sidon, Lebanon</td>
<td>4,000 BC</td>
<td>Larnaca, Cyprus</td>
<td>1,400 BC</td>
</tr>
<tr>
<td>Plovdiv, Bulgaria</td>
<td>4,000 BC</td>
<td>Luxor (Thebes), Egypt</td>
<td>1,400 BC</td>
</tr>
<tr>
<td>Gaziantep, Turkey</td>
<td>3,650 BC</td>
<td>Cádiz, Spain</td>
<td>1,100 BC</td>
</tr>
<tr>
<td>Beirut, Lebanon</td>
<td>3,000 BC</td>
<td>Benares, India</td>
<td>1,000 BC</td>
</tr>
<tr>
<td>Jerusalem, Israel</td>
<td>2,800 BC</td>
<td></td>
<td></td>
</tr>
<tr>
<td>City</td>
<td>Body of Water</td>
<td></td>
<td></td>
</tr>
<tr>
<td>--------------</td>
<td>-----------------------------</td>
<td></td>
<td></td>
</tr>
<tr>
<td>New York</td>
<td>Hudson and Atlantic</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Los Angeles</td>
<td>The Pacific</td>
<td></td>
<td></td>
</tr>
<tr>
<td>San Francisco</td>
<td>The Pacific</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Chicago</td>
<td>Michigan Lake</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Montreal</td>
<td>St. Lawrence River</td>
<td></td>
<td></td>
</tr>
<tr>
<td>London</td>
<td>The Thames</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Hong Kong</td>
<td>The Pacific</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>
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”


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) = \( \frac{2}{3} \) of body water
Extracellular fluid (ECF) = \( \frac{1}{3} \) of body water

Plasma (90% of blood volume) = \( \frac{1}{5} \) 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)

<table>
<thead>
<tr>
<th>Gain (mL*)</th>
<th>Loss (mL*)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Fluid intake</td>
<td>Urine</td>
</tr>
<tr>
<td>800 - 1,500</td>
<td>800 - 1,500</td>
</tr>
<tr>
<td>Water in food</td>
<td>Feces</td>
</tr>
<tr>
<td>475 - 725</td>
<td>125</td>
</tr>
<tr>
<td>Tissues oxidation</td>
<td>Insensible loss:</td>
</tr>
<tr>
<td>250</td>
<td>Skin</td>
</tr>
<tr>
<td></td>
<td>250 - 375</td>
</tr>
<tr>
<td></td>
<td>Lungs</td>
</tr>
<tr>
<td></td>
<td>250 - 375</td>
</tr>
<tr>
<td></td>
<td>Sweat</td>
</tr>
<tr>
<td></td>
<td>100</td>
</tr>
</tbody>
</table>

**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

(m³)

2,500
2,000
1,500
1,000
500
0

245
519
478
1,280
713

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 left 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, 2\textsuperscript{nd} 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

Aquifers and wells

Artesian well
Flowing artesian well
Potentiometric surface
(in confined aquifer)

Confining layer (impermeable)
Unconfined aquifer
Confined aquifer
Water table well
(in unconfined aquifer)
Top of the confined aquifer

Source: Environment Canada, USGS
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
“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”
The Poisoning Of An American City

Toxic water. Sick kids. And the incompetent leaders who betrayed Flint.

By Josh Sanborn
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

- Chlorination of sewage to protect New York City drinking water
  - 1893
- Chlorination of drinking water to stop typhoid epidemic in Chicago
  - 1908
- California legislates control of public drinking water
  - 1913
- California adopts its own SDWA and establishes primacy
  - 1976
- Ongoing revisions of regulations
- 1974
- 1986
- SDWA amendments, mandated schedule for new regulations
- 2002

- Coliform bacteria
- Lead, copper, and zinc
- Fluoride, arsenic, selenium, and chromium
- Barium, cadmium, cyanide, silver, and radioactivity

- SDWA*, uniform national drinking-water regulations
- U.S. PHS regulates interstate drinking waters
The Effect of Water Chlorination

Death Rate for Typhoid Fever
United States, 1900-1960

Chlorination Begun

Sub-Saharan Africa – Only 61% of People Have Drinking Water
Share of People with Access to Drinking Water ~80%
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.
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

Sea salts

Chloride
55% (19.25 g)

Sodium
30.6% (10.7 g)

Sulfate
17% (2.7 g)

Calcium
12% (0.42 g)

Potassium
1.1% (0.29 g)

Magnesium
2.7% (1.3 g)

Minor constituents
0.7% (0.25 g)

Salt
2.5% (25 g)

Sea water

Water
96.5% (965 g)

Quantities in relation to 1 kg or 1 litre of sea water.
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/m³
2. Pollution caused by the energy used
   (Minimum energy consumption = 1 Kwh/m³)

**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

<table>
<thead>
<tr>
<th>Area</th>
<th>Consumption US gal/person/day</th>
<th>Desalinated Water Cost US$/person/day</th>
</tr>
</thead>
<tbody>
<tr>
<td>USA</td>
<td>100</td>
<td>0.29</td>
</tr>
<tr>
<td>Europe</td>
<td>50</td>
<td>0.14</td>
</tr>
<tr>
<td>Africa</td>
<td>15</td>
<td>0.05</td>
</tr>
<tr>
<td>UN recommended minimum</td>
<td>13</td>
<td>0.04</td>
</tr>
</tbody>
</table>
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
- Monterey
- Marina
- Sand City
- Cambria
- Long Beach
- Huntington Beach
- South Orange
- Doheny
- Camp Pendleton
- 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. Desalinate 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