Energy Balance

Basic Energy Needs

- The body uses most of the daily energy supply for constant use in voluntary and involuntary activity
- Voluntary work and exercise
  - The body uses most of its energy supply for basal metabolic needs
    - Includes all physical actions related to usual activities and additional physical exercise
  - Seems to require most of the energy output, but is usually not the case

Basic Energy Needs, cont'd

- Involuntary work: includes all activities of the body that are not consciously performed
  - Circulation, respiration, digestion, absorption
  - Requirements include:
    - **Chemical energy**: in many metabolic products
    - **Electrical energy**: in brain and nerve activities
    - **Mechanical energy**: in muscle contraction
    - **Thermal energy**: to maintain body temperature

Basic Energy Needs, cont'd

- Fuel is provided in the form of nutrients and changed to ATP
- Only three energy-containing nutrients:
  - **Carbohydrate** is primary fuel
  - **Fat** assists as storage fuel
  - **Protein** is a back-up fuel source
- **Alcohol** also provides energy but its detrimental in many ways

Measurement of Energy

- **Calorie**: Amount of energy in food or expended in physical actions
- **Kilocalorie** (1000 calories or 1 **Calorie**): Amount of heat necessary to raise 1 kg of water 1° C
  - Large Calorie unit used in nutrition science to avoid dealing with large numbers
  - Abbreviation: kcalorie or kcal or Cal

Fuel Factors

- **Carbohydrate: 4 kcal/g**
- **Fat: 9 kcal/g**
- **Protein: 4 kcal/g**
- **Alcohol: 7 kcal/g**

Caloric (energy) and Nutrient Density

- Density: The degree of concentration of material in a given substance
- **Caloric (energy) density**: Concentration of energy in a given amount of food (think of the bakery!)
  - Foods high in fat have the highest caloric density
- **Nutrient density**: Concentration of all nutrients including vitamins and minerals in a given amount of food (Think of an apple)
  - Foods that are referred to as empty calories are the direct opposite of a nutrient dense food.
- Food guides recommend foods that are nutrient- dense.

Energy Intake

- The body's energy balance depends on energy intake in relation to energy output
- Energy intake
  - Three macronutrients are **stored** as:
    - **Glycogen**
    - **Adipose tissue**
    - **Muscle mass**
  - Energy intake is the calculated energy value of actual food consumption

Sources of Food Energy

- Estimating Dietary Energy Intake
  - Energy intake can be estimated by tracking intake and calculating its energy value.
  - Nutritrac on Evolve is an excellent tool for calculating energy intake.
  - Cronometer (https://cronometer.com) is another free software tool for calculating energy intake:
    - Can also estimate energy output through physical activity and **basal energy expenditure (BEE)**

Energy Output

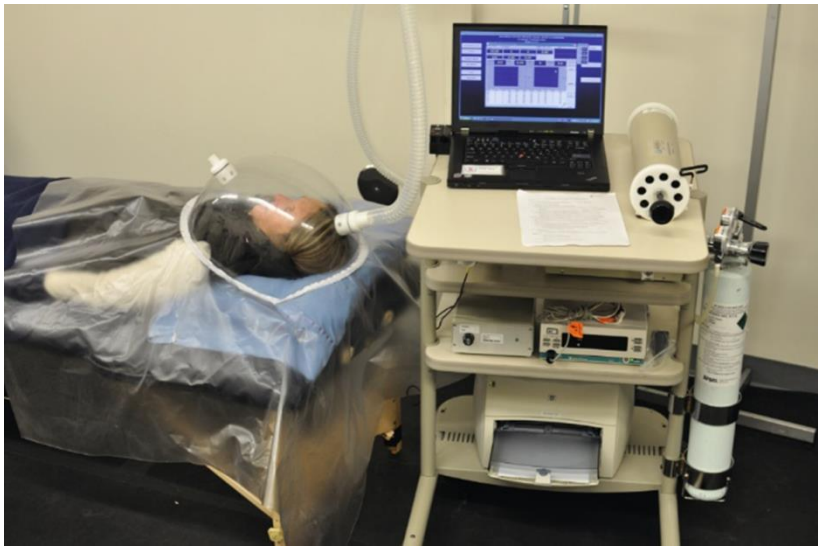
- Metabolism: chemical changes that occur during:
  - Normal body functions
  - Regulation of body temperature
  - Tissue growth and repair
- Activities to sustain life require energy from food and body reserves
- Three demands for energy determine the body's total energy requirements
  - **Basal energy expenditure**
  - **Resting energy expenditure** (REE)
  - **Physical activity**
  - **Thermic effect of food** (TEF)

Basal Energy Expenditure (BEE) vs. Resting Energy Expenditure (REE)

- **BEE-**Sum of all internal working activities of the body at **TOTAL** rest
- Expressed as kcal/day
- Also called basal metabolic rate (BMR)
- **REE** is similar but not exactly the same. Maintaining the stringent conditions required to measure a true BEE is rather difficult; therefore, measurements are most often expressed as REE.

Measurement of Resting Metabolic Rate

- How are **resting metabolic** rate (RMR) or **basal metabolic rate** (BMR) measured?
  - **Indirect calorimetry**
    - Metabolic rate calculated on the basis of the rate of oxygen utilization
  - **Thyroid function test** – responsible for body metabolism
    - Measures the activity of the thyroid gland and the blood levels of the hormone thyroxine



Predicting Resting Metabolic Rate, cont'd

- **General formula**
  - Men
    - 1 kcal x kg body weight x 24 hours
  - Women
    - 0.9 kcal x kg body weight x 24 hours

  Calculate your **Basal Metabolic Rate**

  1 kg = 2.2 pounds

Factors Influencing Basal Metabolic Rate

- Lean body mass (muscles and organs)
  - Greater metabolic activity in lean tissues
- **Growth periods**
  - Growth hormone stimulates cell metabolism and raises BMR (15%-20%)
- **Body temperature**
  - Fever increases BMR (7%/degree Fahrenheit)
  - Periods of starvation may cause a decrease in body temperature (adaptive thermogenesis) to conserve energy
- **Hormonal status**
  - Example: Hypothyroidism = Decreased BMR

BODY MASS INDEX

Body mass index (BMI) is measure of body fat based on height and weight that applies to both adult men and women.

BMI Categories:

Normal weight = 18.5-24.9

Overweight = 25-29.9

Obesity = BMI of 30 or greater

Calculate your BMI

BMI = weight in **pounds** x **703** / **inches squared**

Ex: 150 pounds x 703 = 105450

5’ 8” = 68 inches x 68 inches = 4624

105450/ 4624 = 22.8 BMI

Physical Activity

- Energy expenditure for physical activity goes above and beyond energy used for resting energy needs.
- Energy output during physical activity varies widely across individuals.
- **3500 extra calories = 1 pound**;
  - That is 500 extra calories per day to gain 1 pound in a week or exercise 500 calories off per day to lose 1 pound in a week

Physical Activity Level Factors

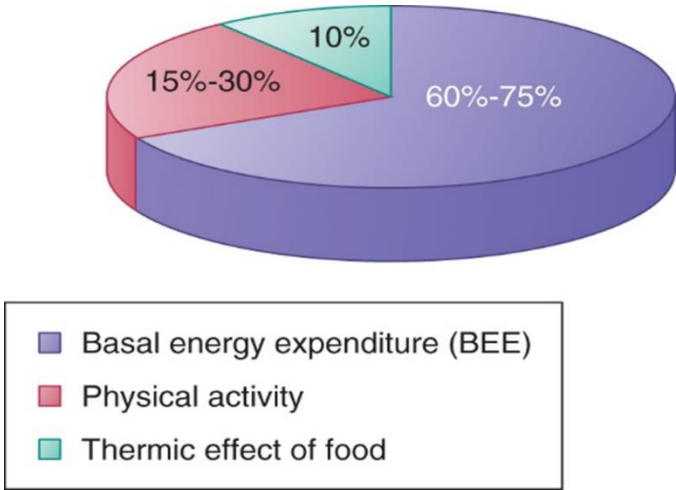
- Categorize physical activity level (PAL) according to standard values
  - 1.2: Chair or bed bound
  - 1.4-1.5: Sedentary
  - 1.6-1.7: Very light
  - 1.8-1.9: Moderate
  - 2.0-2.4: Heavy

Thermic Effect of Food

- Extra energy for digestion, absorption, and transport is required after eating.
- **5% to 10%** of the body's total energy needs for metabolism relate to the **processing of food**.

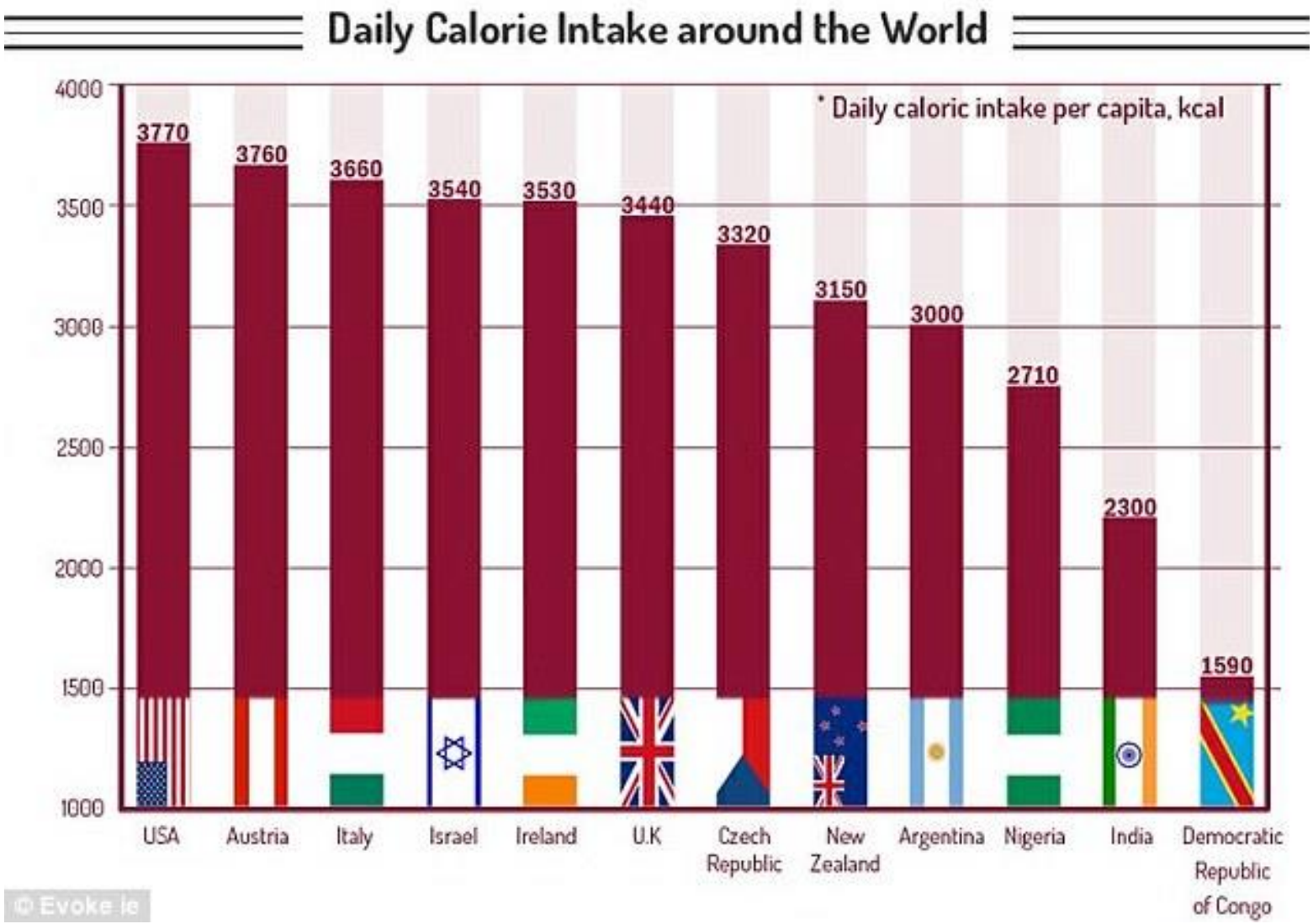
Total Energy Requirement

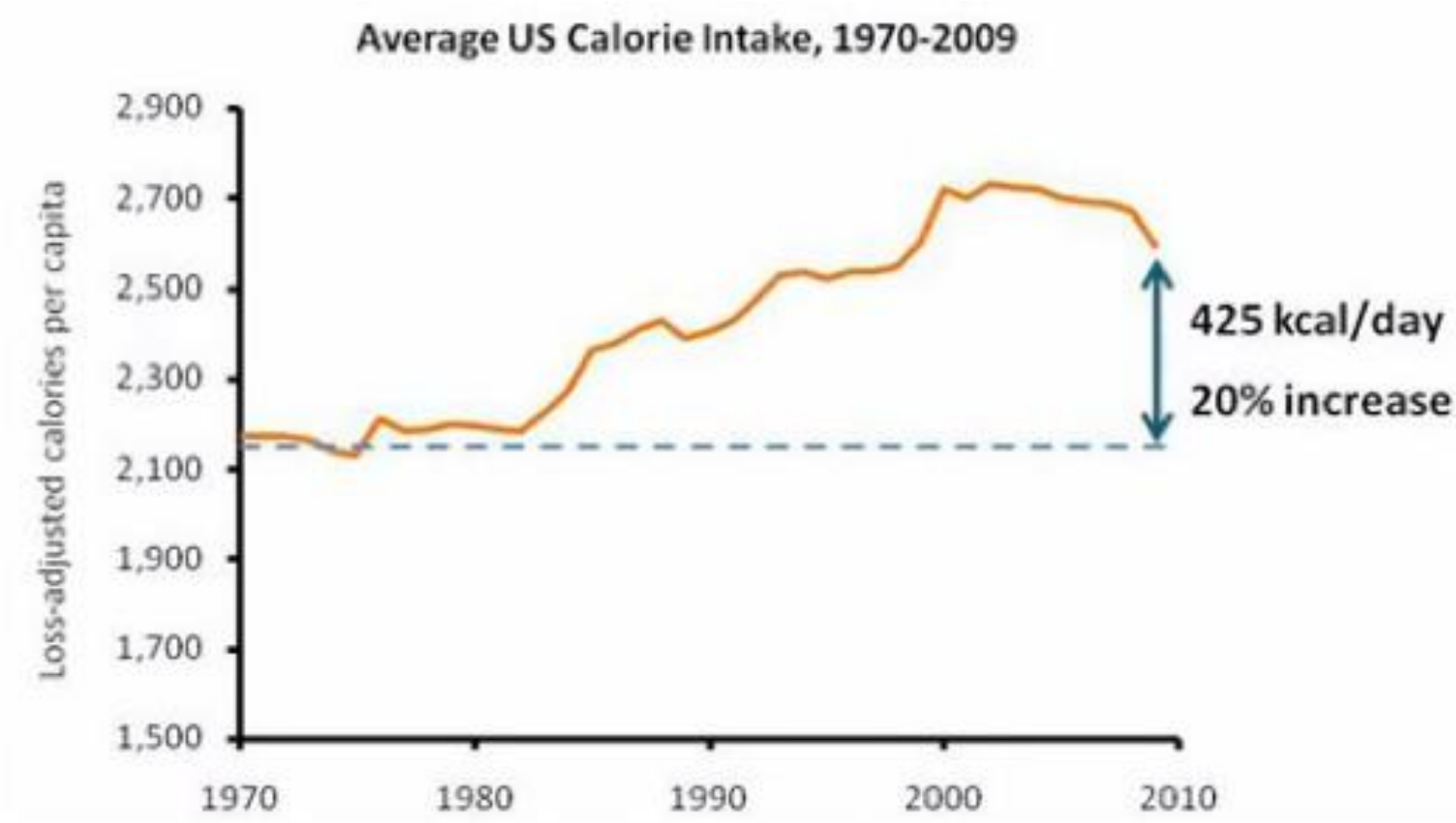
- Total energy requirement: BEE+ Physical activity + Thermic Effect of Food
- To maintain daily energy balance:
  - Food energy intake = Body energy output
  - Intake > output = Weight gain (extreme: obesity)
  - Intake < output = Weight loss (extreme: anorexia)



Life Cycle

- **Growth periods**
  - Extra energy per unit of body weight is necessary to build new tissue
  - Infancy, adolescence, pregnancy
- **Adulthood**
  - Energy needs plateau as full growth achieved
  - BEE then declines 1% to 2% per decade, reducing energy needs
  - Rapid decline occurs at age 40 (men) and 50 (women)





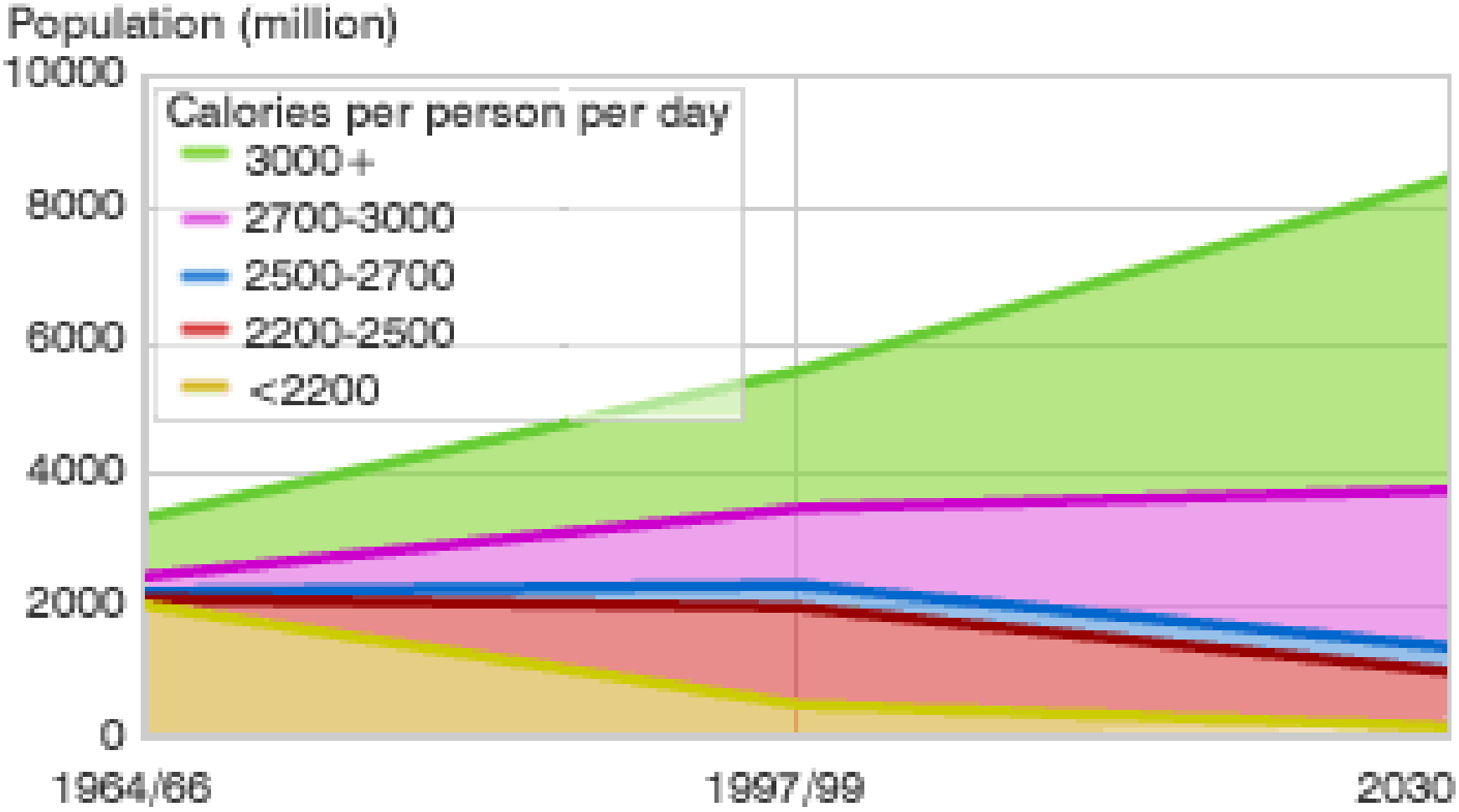
Source: Dr. Stephan Guyenet. The American Diet. 2012.

Daily calorie needs based on age, gender, and activity level

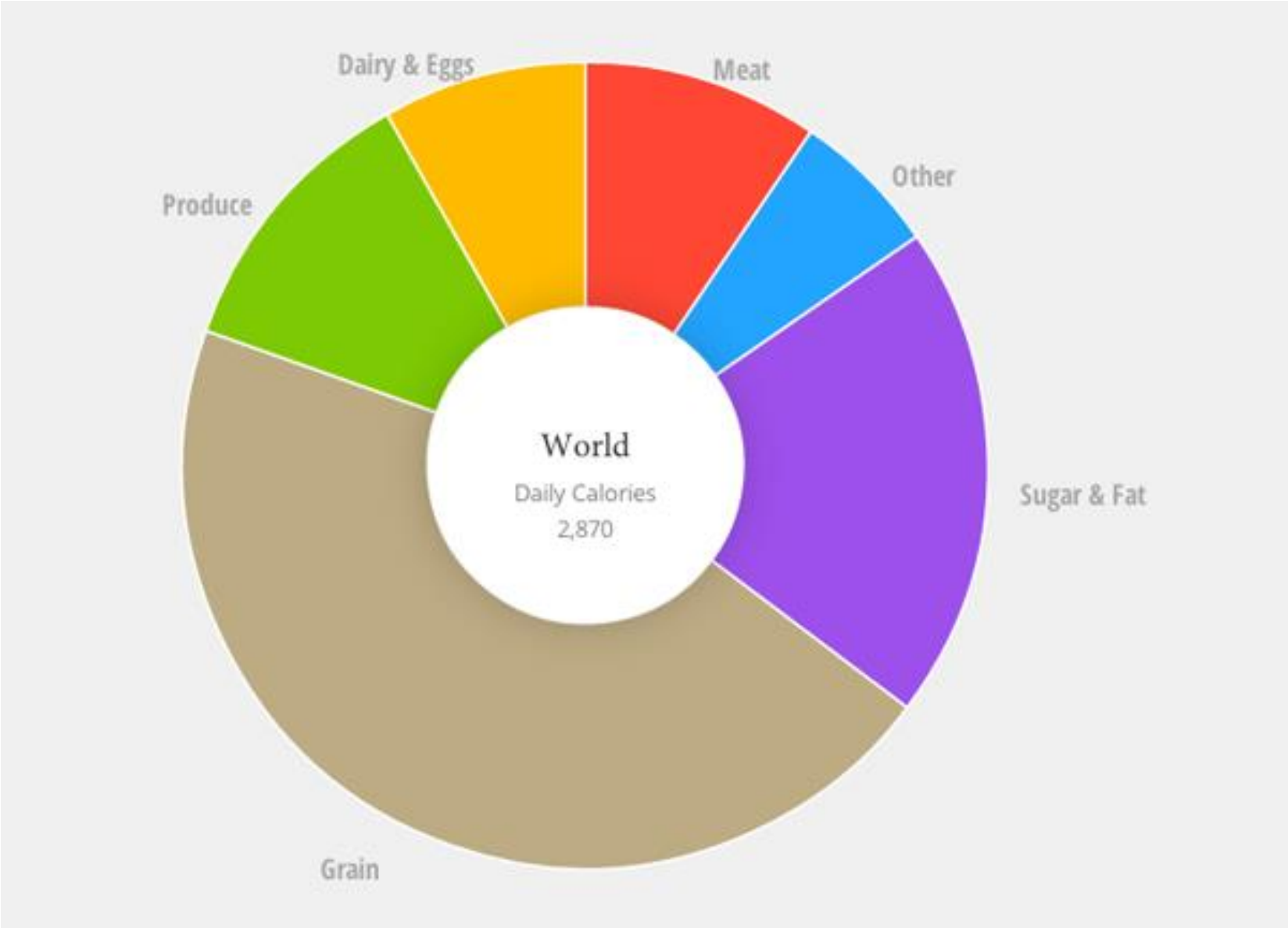
Age (Years)	Gender	Sedentary (Not Active)	Moderately Active	Active
2-3	Male or female	1,000	1,000	1,000
4-8	Male Female	1,200 – 1,400 1,200 – 1,400	1,400 – 1,600 1,400 – 1,600	1,600 – 2,000 1,400 – 1,800
9-13	Male Female	1,600 – 2,000 1,400 – 1,600	1,800 – 2,200 1,600 – 2,000	2,000 – 2,600 1,800 – 2,200
14-18	Male Female	2,000 – 2,400 1,800	2,400 – 2,800 2,000	2,800 – 3,200 2,400
19-30	Male Female	2,400 – 2,600 1,800 – 2,000	2,600 – 2,800 2,000 – 2,200	3,000 2,400
31-50	Male Female	2,200 – 2,400 1,800	2,400 – 2,600 2,000	2,800 – 3,000 2,200
51 and older	Male Female	2,000 – 2,200 1,600	2,200 – 2,400 1,800	2,400 – 2,800 2,000 – 2,200

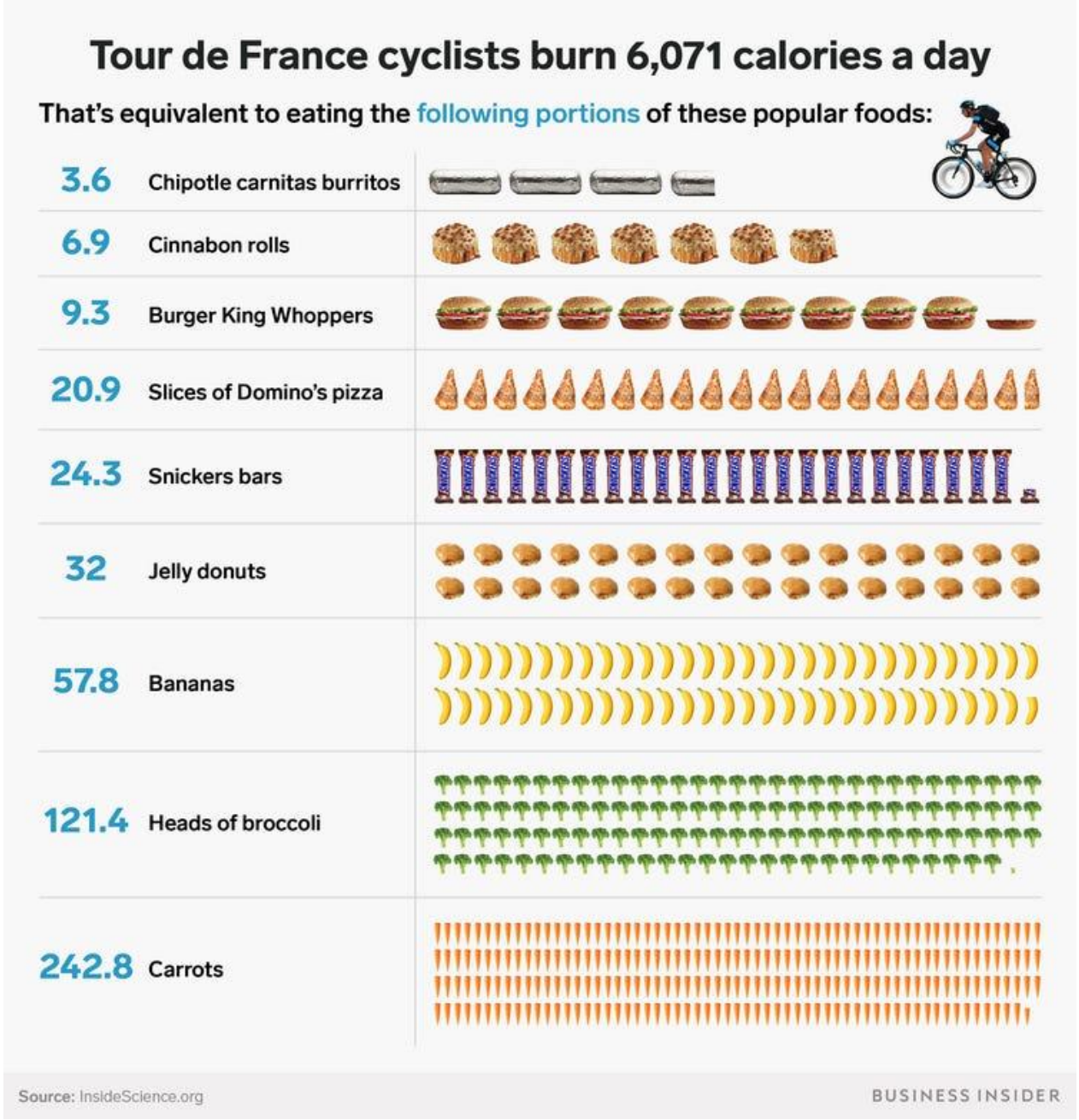
Adapted from US Department of Agriculture and US Department of Health and Human Services. *Dietary Guidelines for Americans, 2010.* 7th ed. Washington, DC US Government Printing Office 2010. Http://www.health.gov/dietaryguidelines/2010.asp. Accessed March 18, 2014

Calorie consumption levels among the world's population



SOURCE: FAO



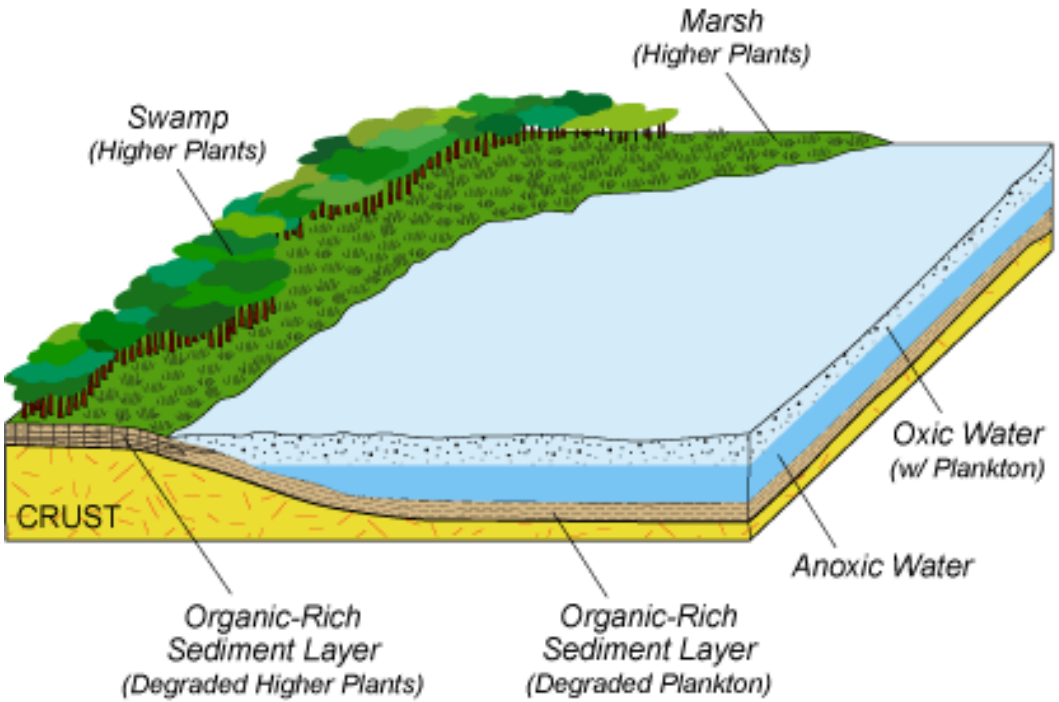


“Origin of Oil”

1. The story of oil and gas begins with planktonic organisms living in the ocean (or in lakes).

2. Zooplankton eat phytoplankton (algae) that use the Sun’s energy to produce organic matter and energy through photosynthesis.

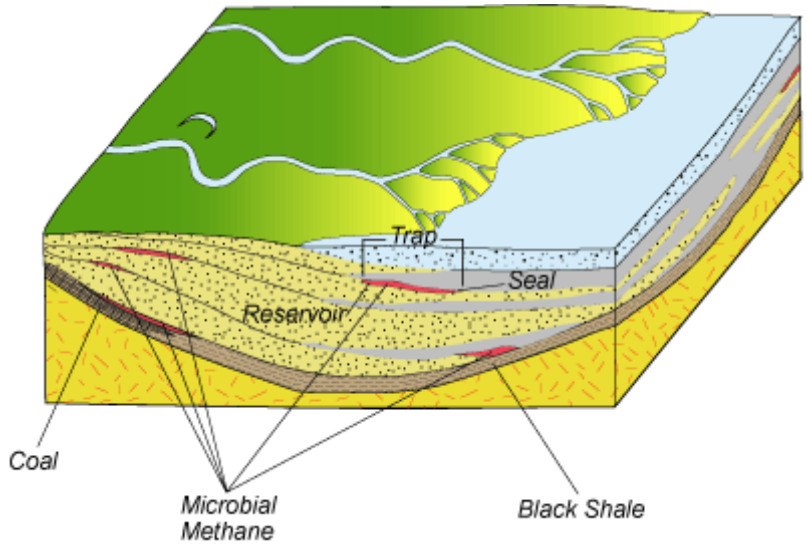
3. As the planktonic organisms die, their remains begin to settle to the sea floor under anoxic conditions (without oxygen).
4. Over time, layer upon layer of sediments accumulate, containing the remains of planktonic organisms.

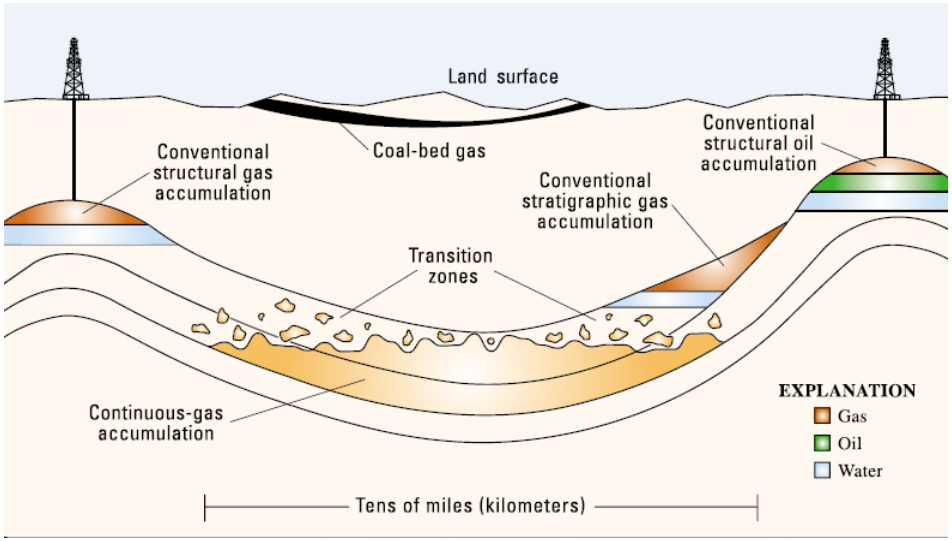


5. Thick sequences of sediments are deposited and the planktonic organisms buried in them are heated and compressed until the organic matter begins to change into **kerogen**, a solid, waxy organic material.
6. With the high temperatures and pressures of greater depth of burial, the kerogen begins to change into **hydrocarbons**.
7. With even more heat and pressure, the hydrocarbons are broken down into **petroleum** (oil) and **natural gas**.

8. The petroleum and natural gas migrate into porous and permeable sedimentary rocks such as sandstone, which serves as a petroleum **reservoir** rock.

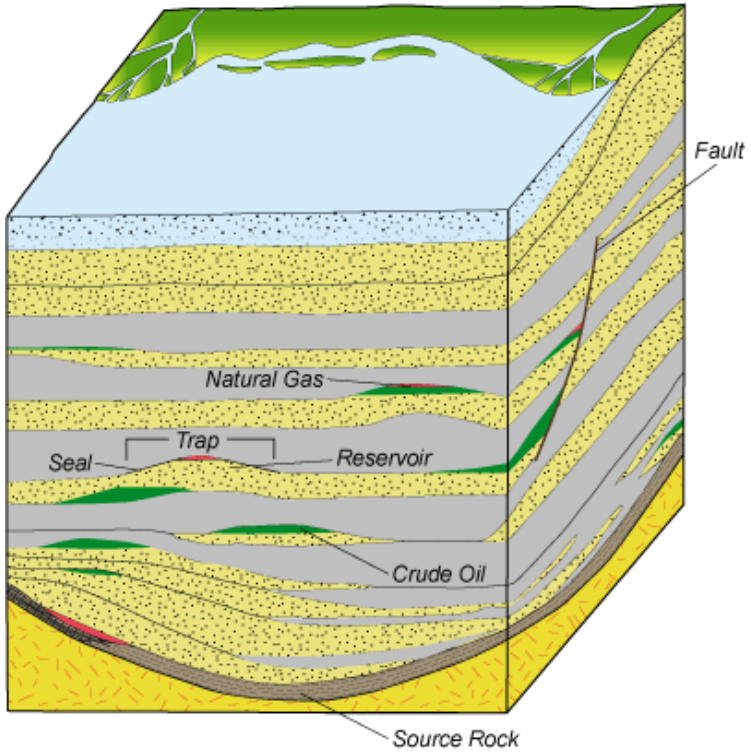
9. Oil floats on water, and gas is even lighter than oil, so petroleum and natural gas move upward within the reservoir rock, until they are stopped by an impermeable sedimentary layer such as shale, which forms a **trap**.





10. More and more petroleum and natural gas accumulate and become concentrated in the trap, forming an **oil field**.

11. Geologists use various tools, such as seismic surveys, to study Earth to locate oil fields beneath the ground. If a location seems promising, drilling may begin.



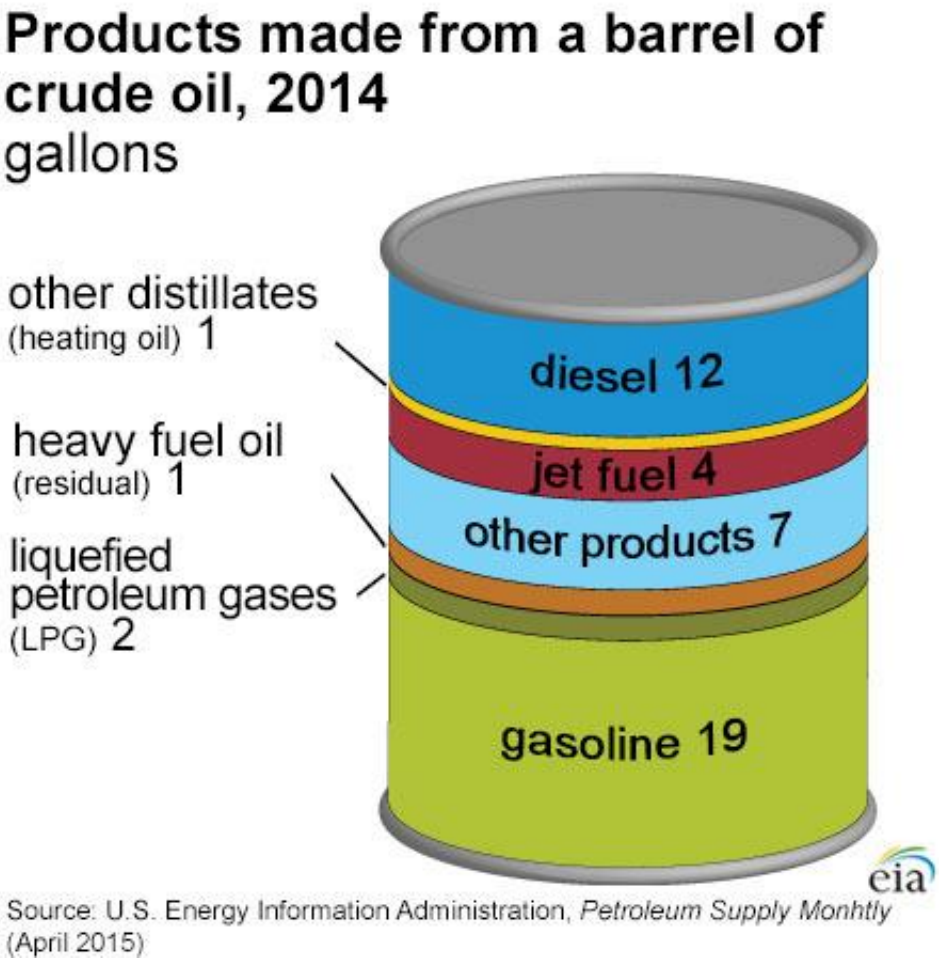
12. Wells are drilled into the ground in the oil field to extract the petroleum, which is called **crude oil**.

13. The crude oil is transported to a **refinery**, where it is separated by distillation and other processes into fuels such as gasoline, butane, kerosene, liquid petroleum gas, jet fuel, diesel fuel, fuel oil, and chemicals used to manufacture plastics.

What is Oil (or Petroleum)?

- Liquid hydrocarbons that are present in certain layers of sedimentary rock (the geosphere).
- Petroleum can be extracted from the rock and refined to produce fuels and chemicals.

Petroleum products

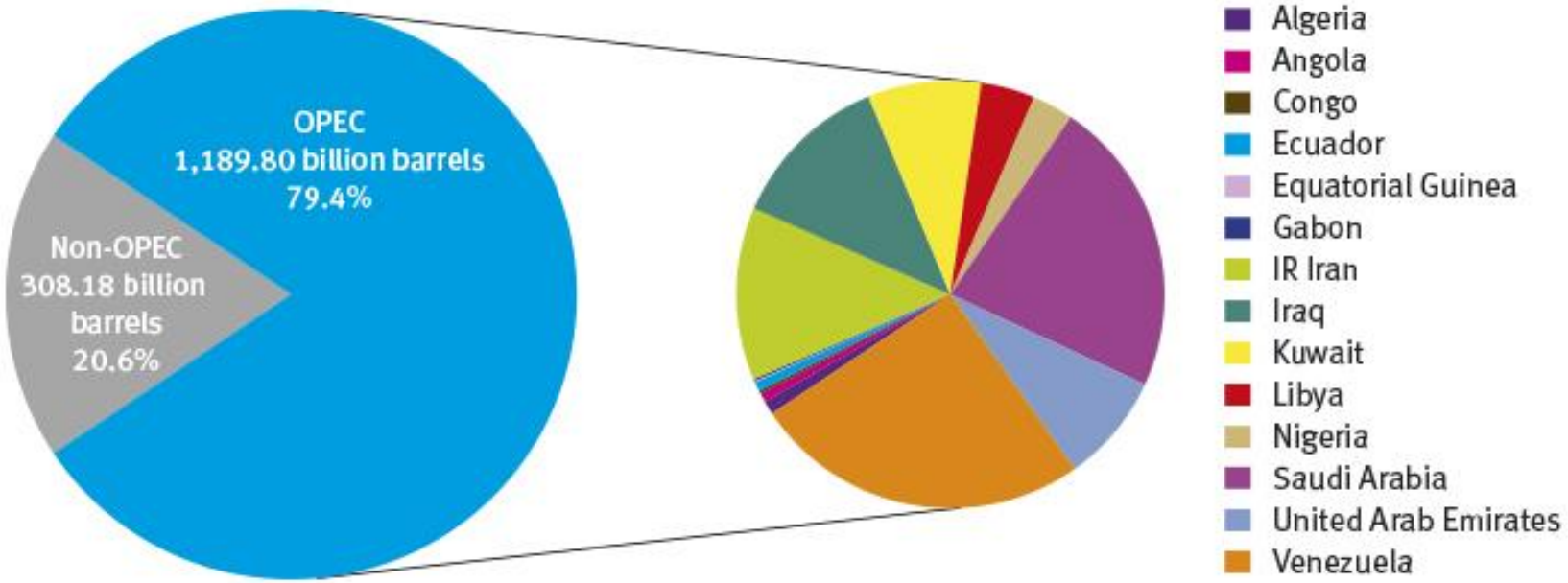


Other products:

- Kerosene
- Lubricants
- Waxes
- Asphalt
- Chemicals

A barrel of oil is 42 gallons.

OPEC share of world crude oil reserves, 2018



OPEC proven crude oil reserves, at end 2018 (billion barrels, OPEC share)

Venezuela	302.81	25.5%	Kuwait	101.50	8.5%	Algeria	12.20	1.0%	Gabon	2.00	0.2%
Saudi Arabia	267.03	22.4%	UAE	97.80	8.2%	Ecuador	8.27	0.7%	Equatorial Guinea	1.10	0.1%
IR Iran	155.60	13.1%	Libya	48.36	4.1%	Angola	8.16	0.7%			
Iraq	145.02	12.2%	Nigeria	36.97	3.1%	Congo	2.98	0.3%			

Source: OPEC Annual Statistical Bulletin 2019.

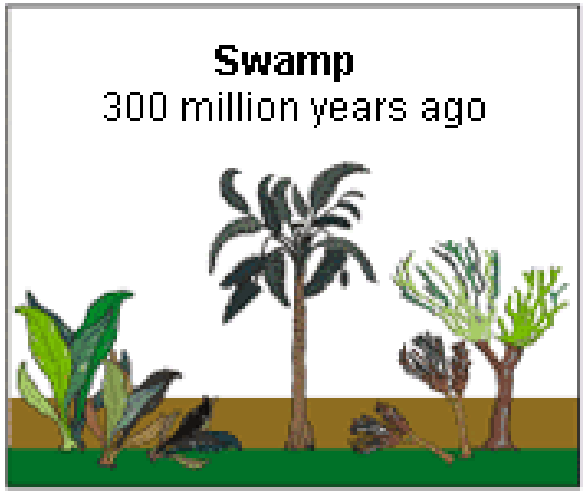
What is Natural Gas?

- The major component in natural gas is **methane**, CH_4
- Other gases that may be present include:
  - **ethane**, C_2H_6
  - **propane**, C_3H_8
  - **butane**, C_4H_{10}

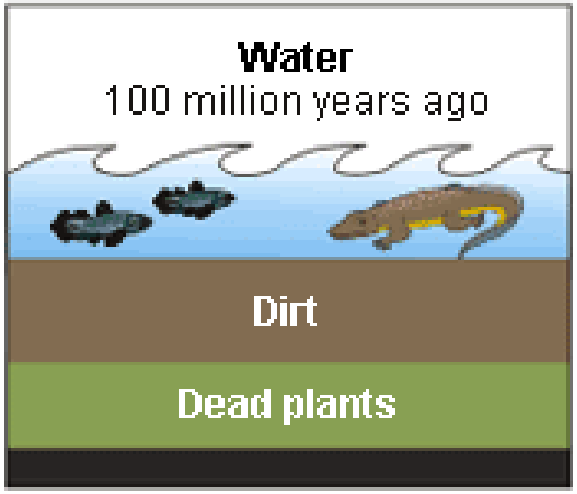
What is Coal?

- Organic sedimentary rock formed from plant remains deposited in swamps and marshes.
- The major use of coal is generating electric power.
- Burning coal is one of the largest sources of CO_2, a greenhouse gas related to global warming.

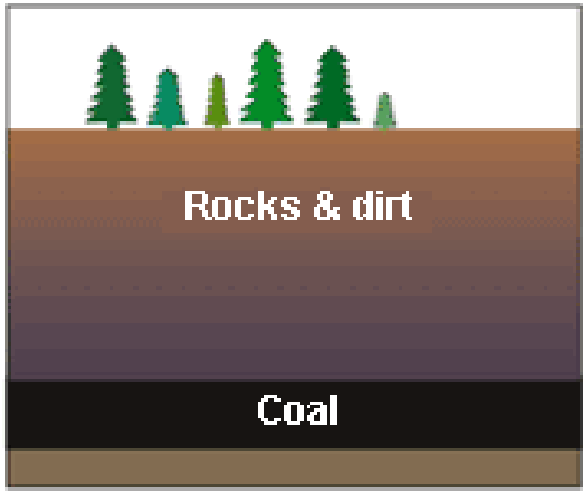
Coal Formation



Before the dinosaurs, many giant plants died in swamps.



Over millions of years, the plants were buried under water and dirt.



Heat and pressure turned the dead plants into coal.

- Think about the carbon cycle. Trace the carbon from the atmosphere into plants.
- Dead plants are buried under sediment, and converted into coal.
- When coal is burned, carbon returns to the atmosphere as carbon dioxide.

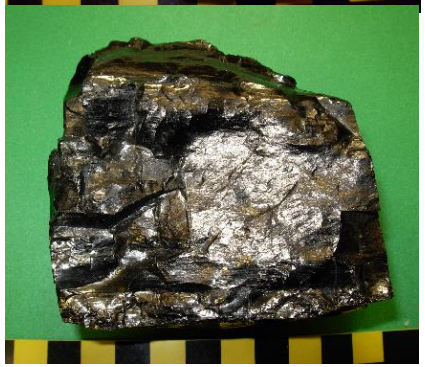
Types (or Ranks) of Coal

Low Rank

Increasing pressure, temperature and depth of burial

- Peat
- Lignite
- Sub-bituminous coal
- Bituminous coal
- Anthracite coal

High Rank



Peat: The sediment that forms coal

- Brown, partially decayed plant fragments.
- Vegetation accumulates in wetlands (swamps, marshes, peat bogs or lakes).
- Stagnant water (little or no oxygen) slows decomposition rate.

Lignite

- Soft, dark brown, gray or black, crumbly, sooty coal.
- Plant parts may be visible.
- Formed from compaction of peat under low burial pressures & temperatures.
- Low rank coal.
- Carbon content 46-60% (dry basis).

Sub-bituminous coal

- Intermediate between lignite and bituminous coal.
- Carbon content 46-60% (dry basis).

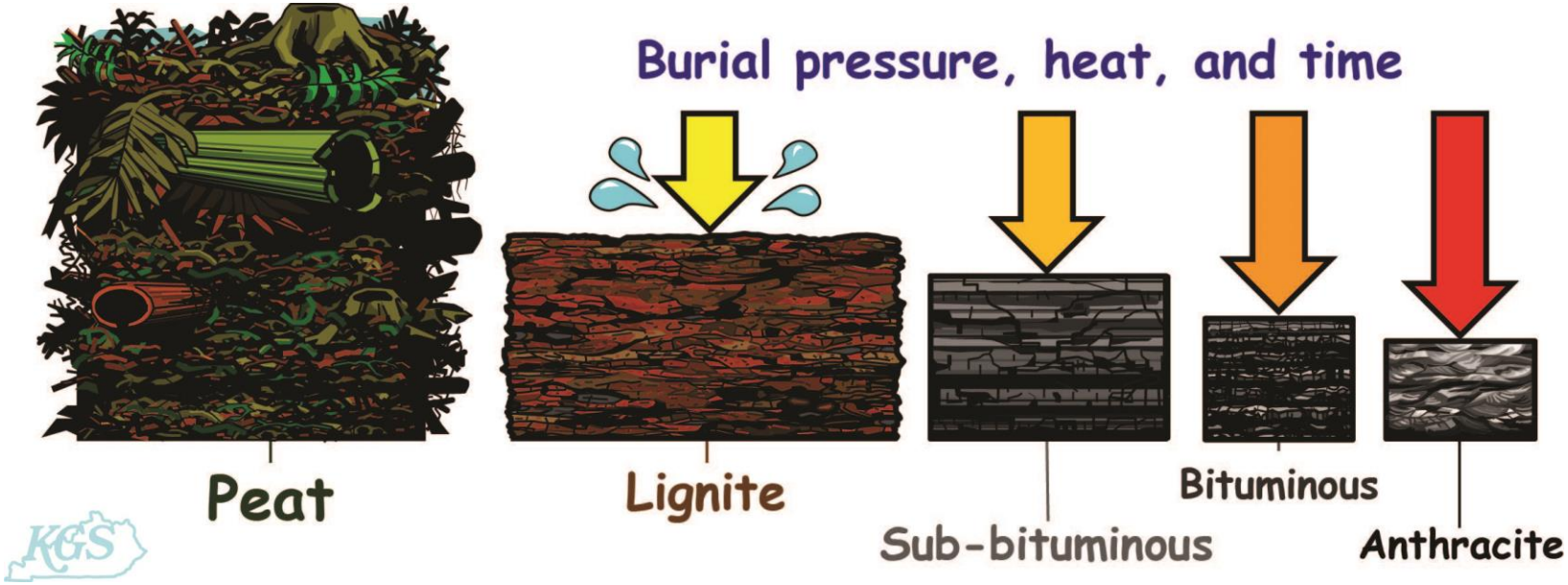
Bituminous coal

- Hard, but slightly sooty.
- Dull to shiny luster.
- May have layers.
- Deeper burial, longer burial, and higher temperatures than lower coal ranks.
- Most abundant coal rank in the United States.
- Carbon content 46-86% (dry basis).

Anthracite coal

- Hard, shiny coal with a silvery luster.
- A metamorphic rock formed from bituminous coal at higher temperatures and pressures.
- The highest coal rank.
- Carbon content 86-98% (dry basis).

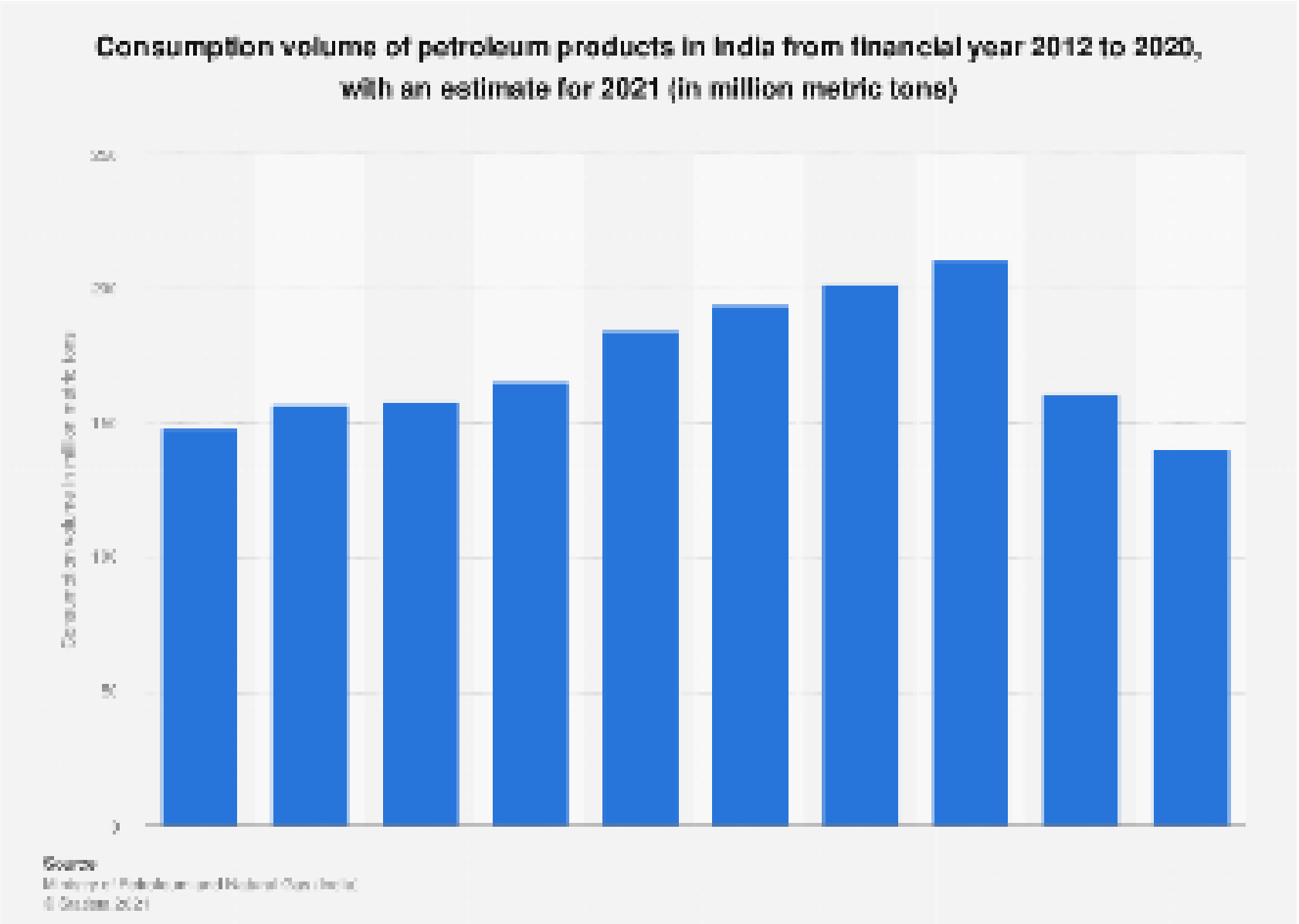
Coalification



- Water is expelled as peat is compacted.
- Plant material breaks down releasing natural gas (mostly methane).
- A bed of peat about 10 feet thick produces a layer of coal about 1 foot thick.

Carbon, Heating Value and Carbon Dioxide

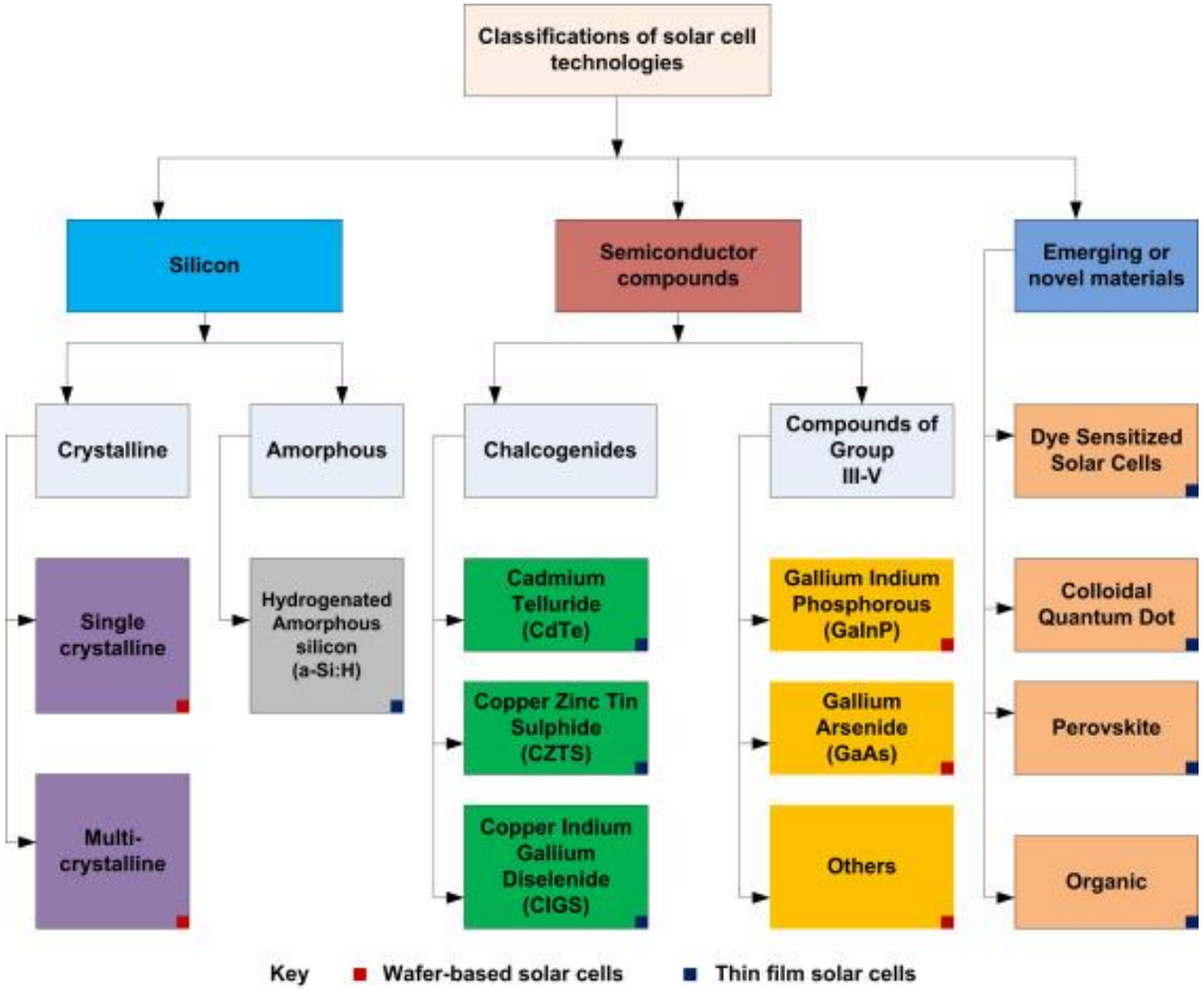
- Different types of coal contain different amounts of carbon.
- The highest percentage of carbon is found in the highest rank coal.
- High-rank coal also has a higher heat content (or heating value).
- When coal is burned, carbon dioxide is emitted – a greenhouse gas related to global warming.



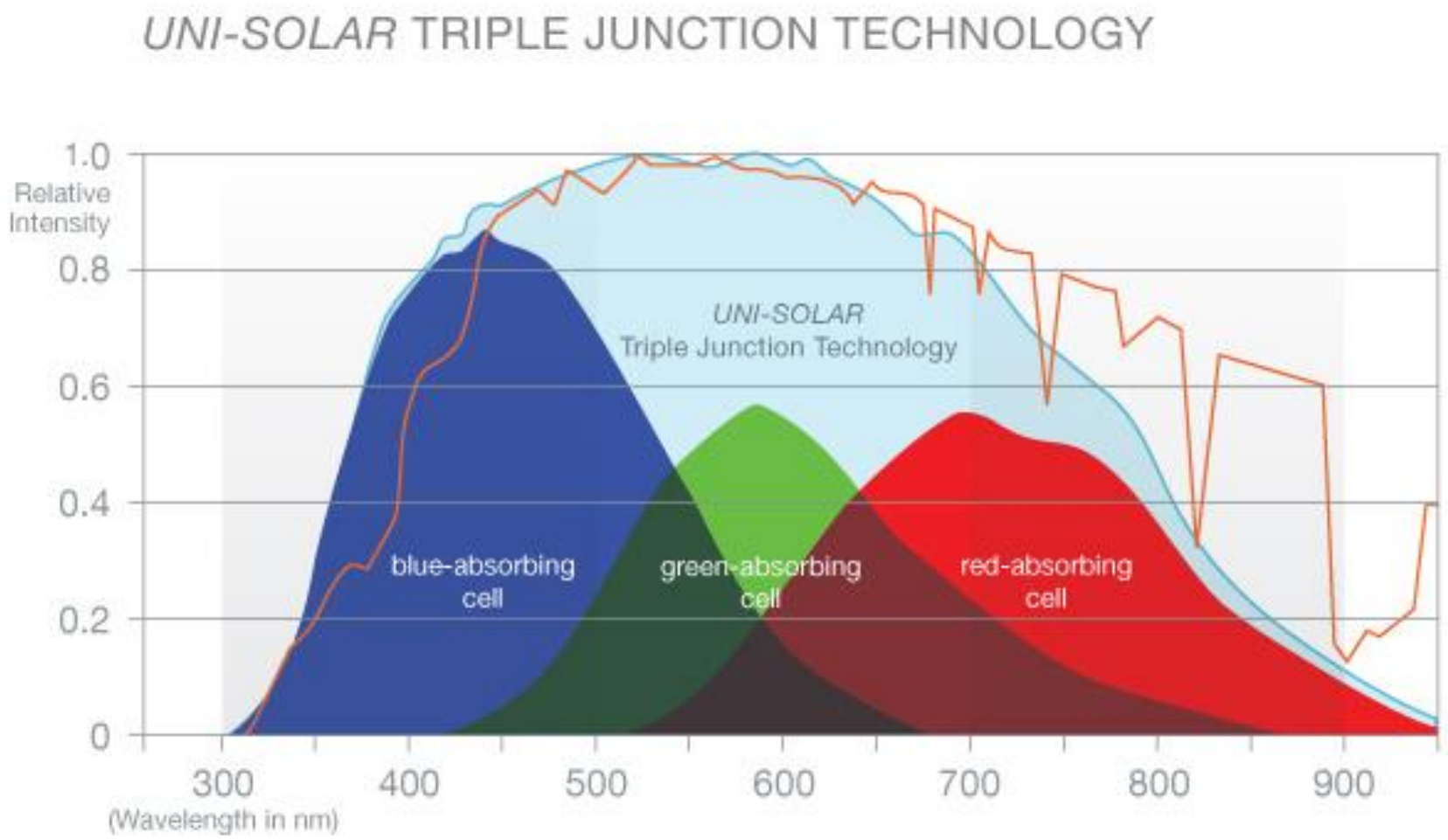
Renewable energy facts

- In 1921 Albert Einstein was awarded the Nobel Prize in Physics for his discovery of the photoelectric effect – and hence, solar panels.
- If taken advantage of to its fullest extent, sunlight beamed on the earth for 1 hour could meet world's energy demands for an entire year!
- Fossil fuels still get 4 times the subsidy of renewables from G20 nations.
- Renewable Energy creates 5 times more jobs than fossil fuels.
- Romans were the very first to use geothermal energy to heat their homes, with warm air moving under floors and inside walls.

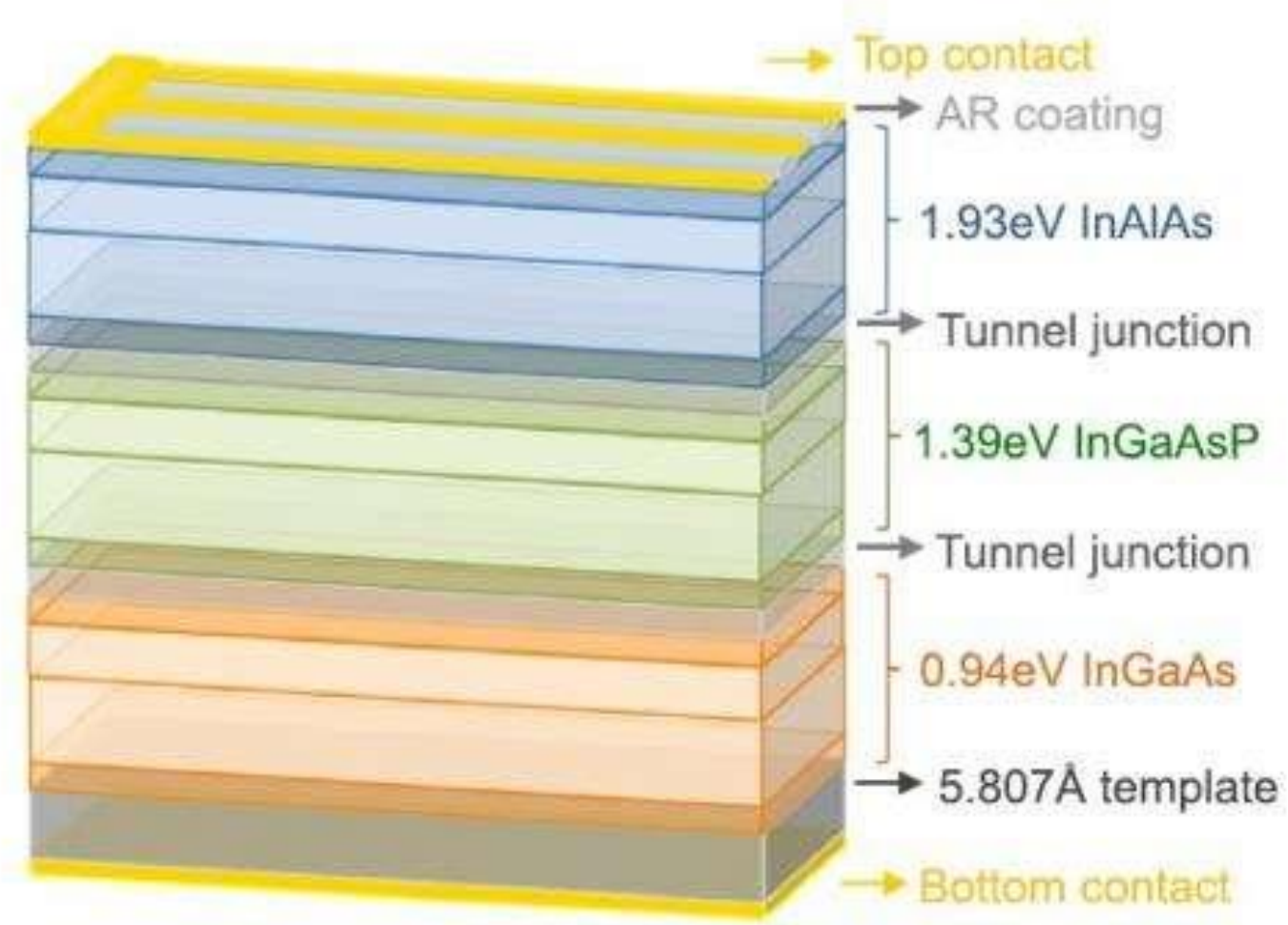
Solar energy



Spectrum of solar cell



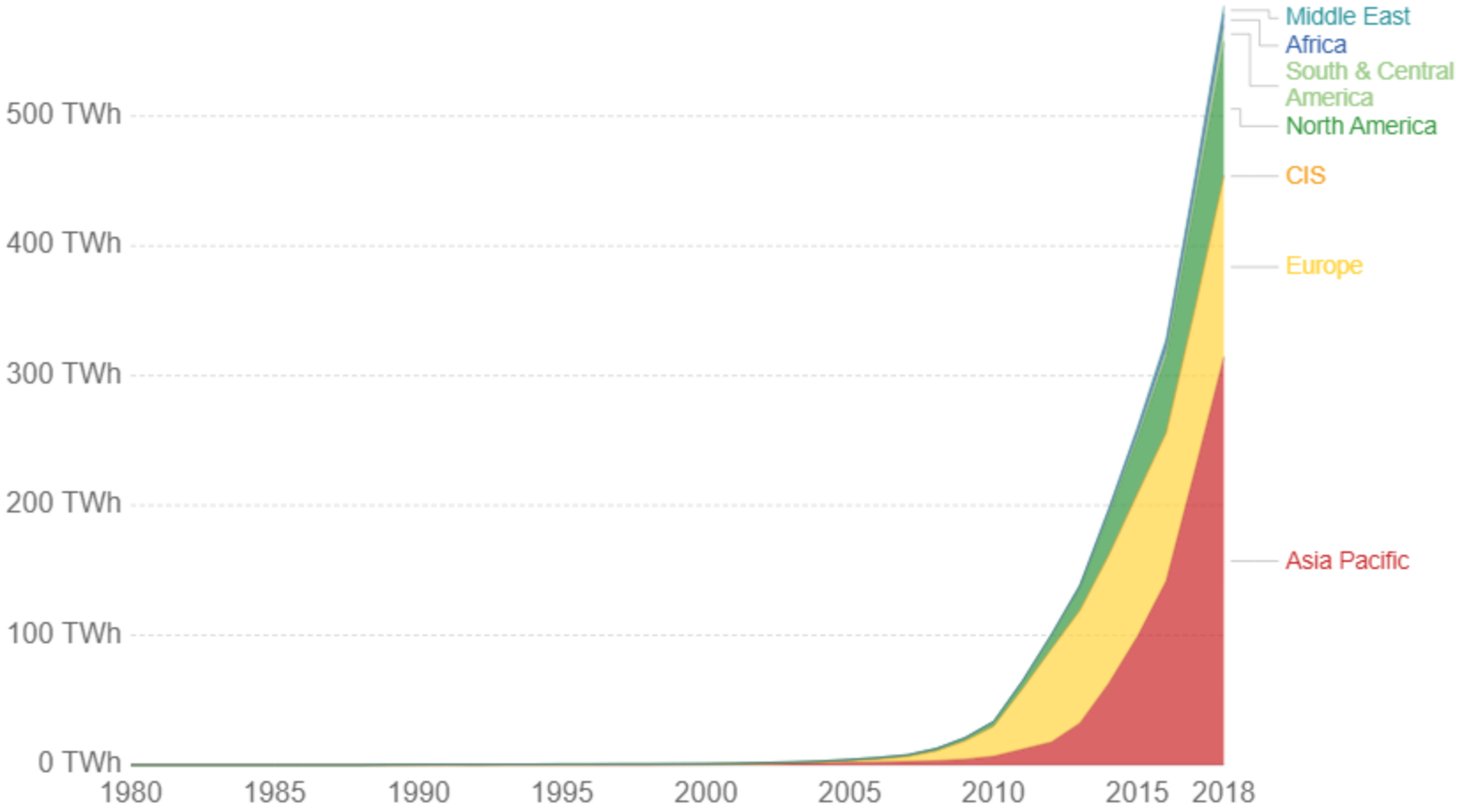
Multi junction solar cell



Solar energy generation by region

Solar energy generation is measured in terawatt-hours (TWh) per year.

Our World in Data



Source: BP Statistical Review of Global Energy (2019)

CC BY

Note: CIS (Commonwealth of Independent States) is an organization of ten post-Soviet republics in Eurasia following break-up of the Soviet Union.

Wind energy from Denmark

- Denmark has continued to be a world leader in utilising their windy conditions as a power source and they are well on track for meeting their goal of using wind power to produce half of all their electricity by 2050.

Geothermal power from Iceland and the Philippines

- The Philippines recognised the potential of geothermal energy and now rank second (after the USA) in the world's top geothermal countries. Iceland is also a geothermal energy pioneer. The country is located over a rift in continental plates which makes it incredibly tectonically active, with a large number of volcanoes, hot springs and earthquakes – ideal for geothermal power.

Tidal energy from Norway

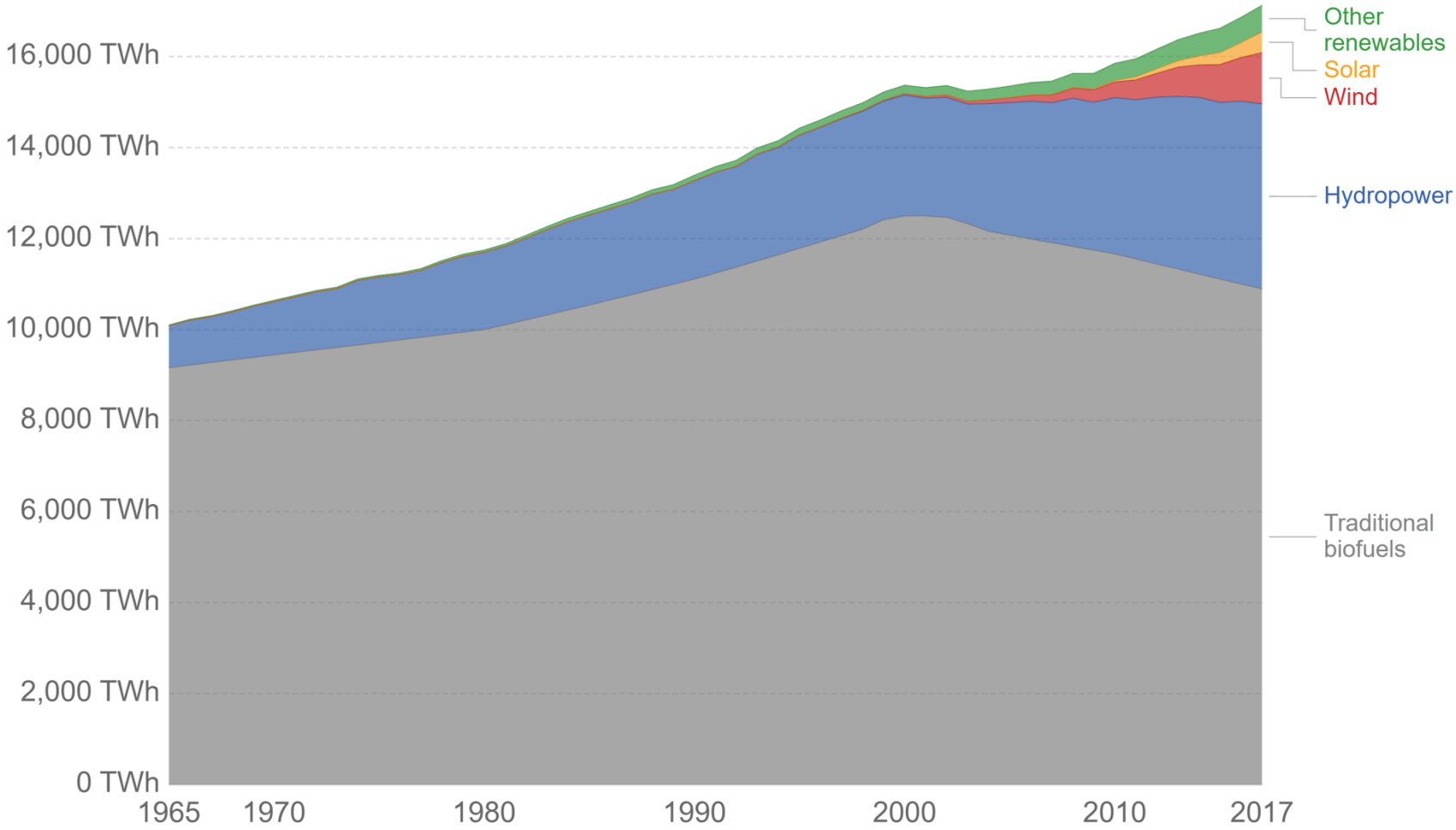
- Tidal energy – a form of hydropower – is widely used in Norway. The country is home to some of the strongest tidal currents in the world, namely the Saltstraumen strait – where 400,000,000 cubic metres of seawater passes through every 6 hours. So cleverly, Norway have utilised their extreme tidal and ocean conditions to create a powerful alternative energy source.

Lightning energy from Venezuela

- Lightning strikes are another naturally occurring event that produce huge amounts of electricity. On average, each strike can generate five million joules, so finding a way to harness this power could be a huge advance in renewable energy. You may think that this would be difficult as lightning doesn't strike twice, but in fact Catatumbo River in Venezuela experiences 1.2m lightning strikes each year, showing a natural phenomenon that could be harnessed as a natural energy source.

Global renewable energy consumption, World

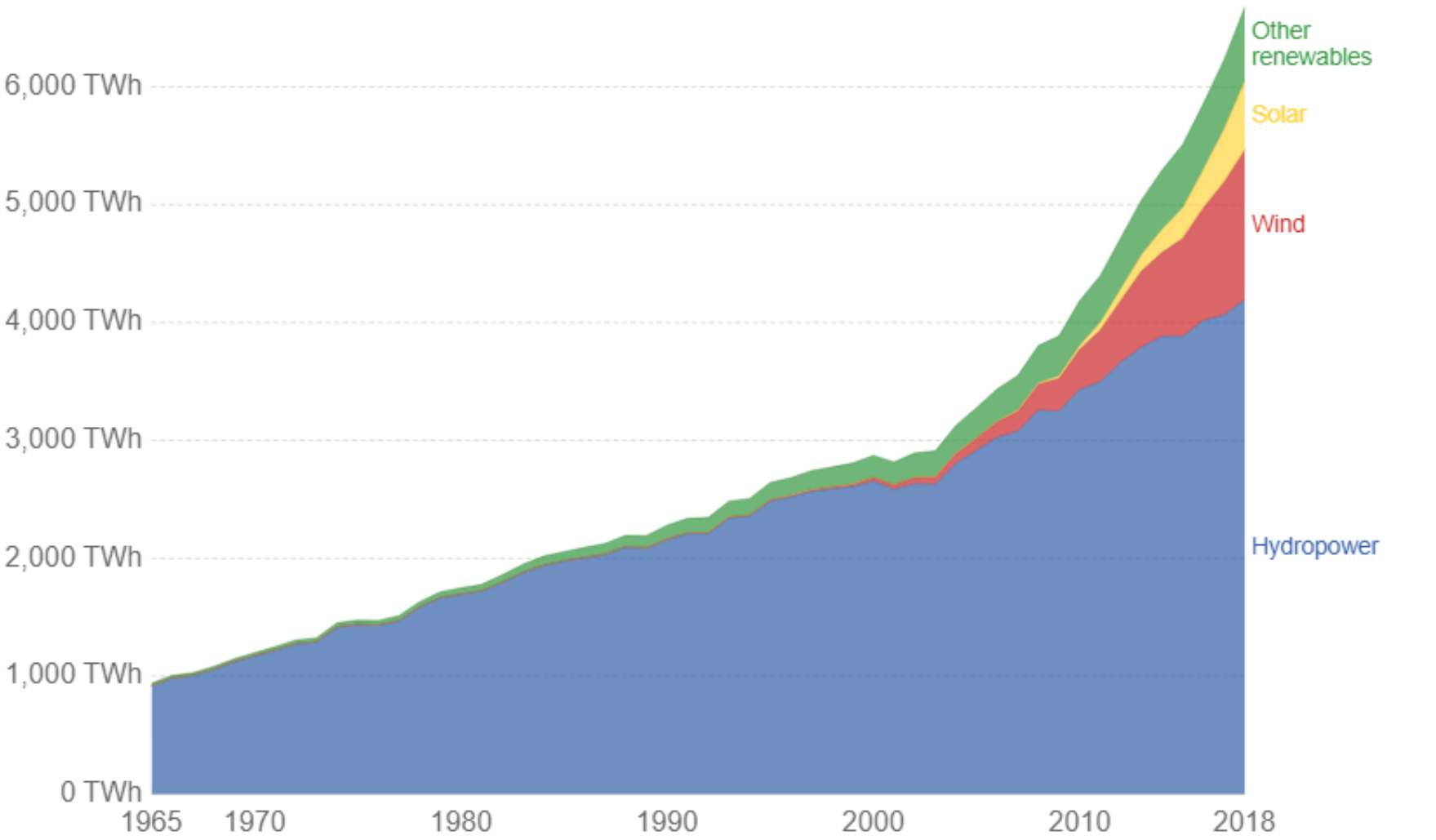
Renewable energy consumption measured in terawatt-hours (TWh) per year. Traditional biofuels refer to the consumption of fuelwood, forestry products, animal and agricultural wastes.



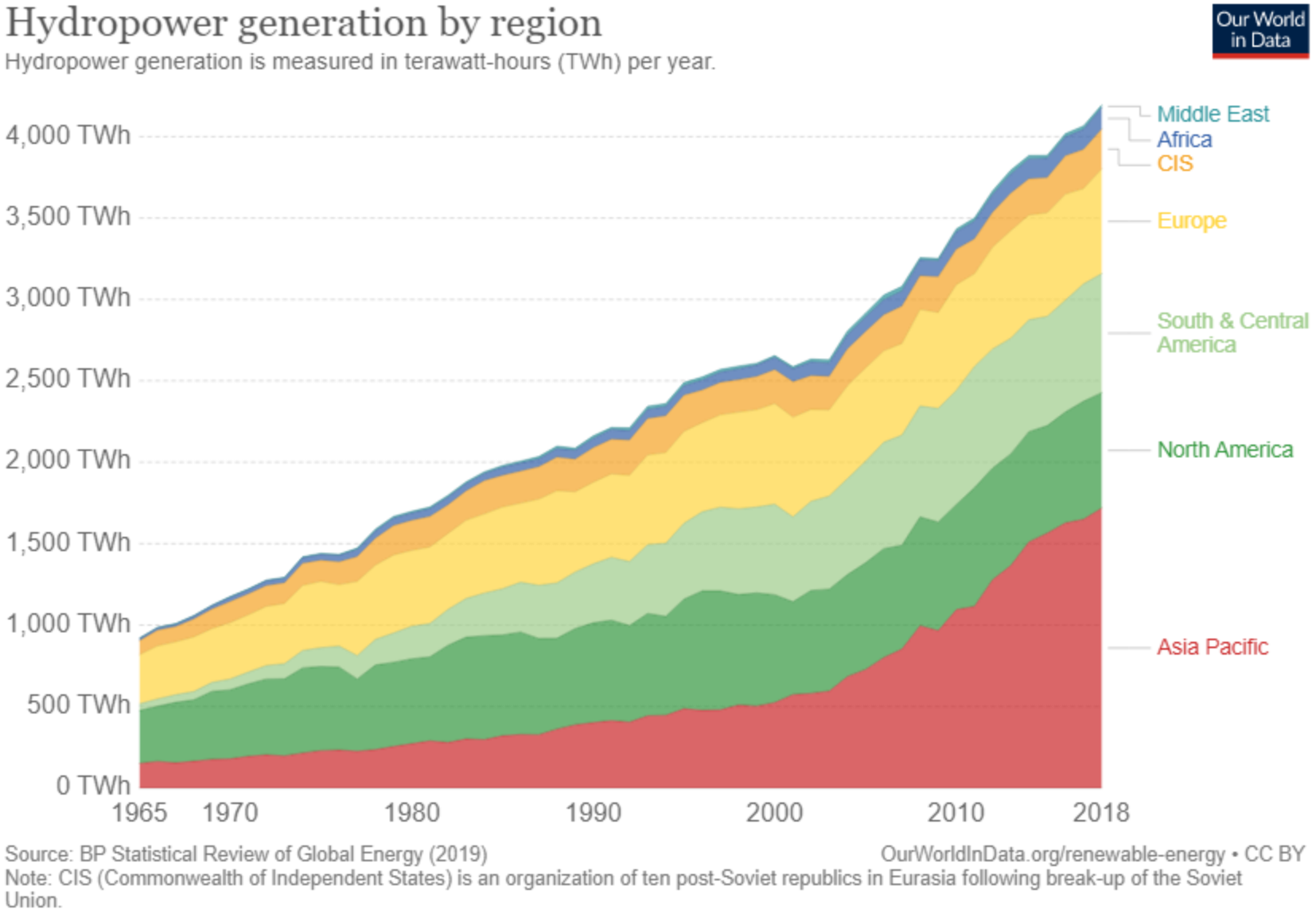
Source: Vaclav Smil (2017) & BP Statistical Review of Global Energy (2019)

OurWorldInData.org/renewable-energy • CC BY

Renewable energy generation, World

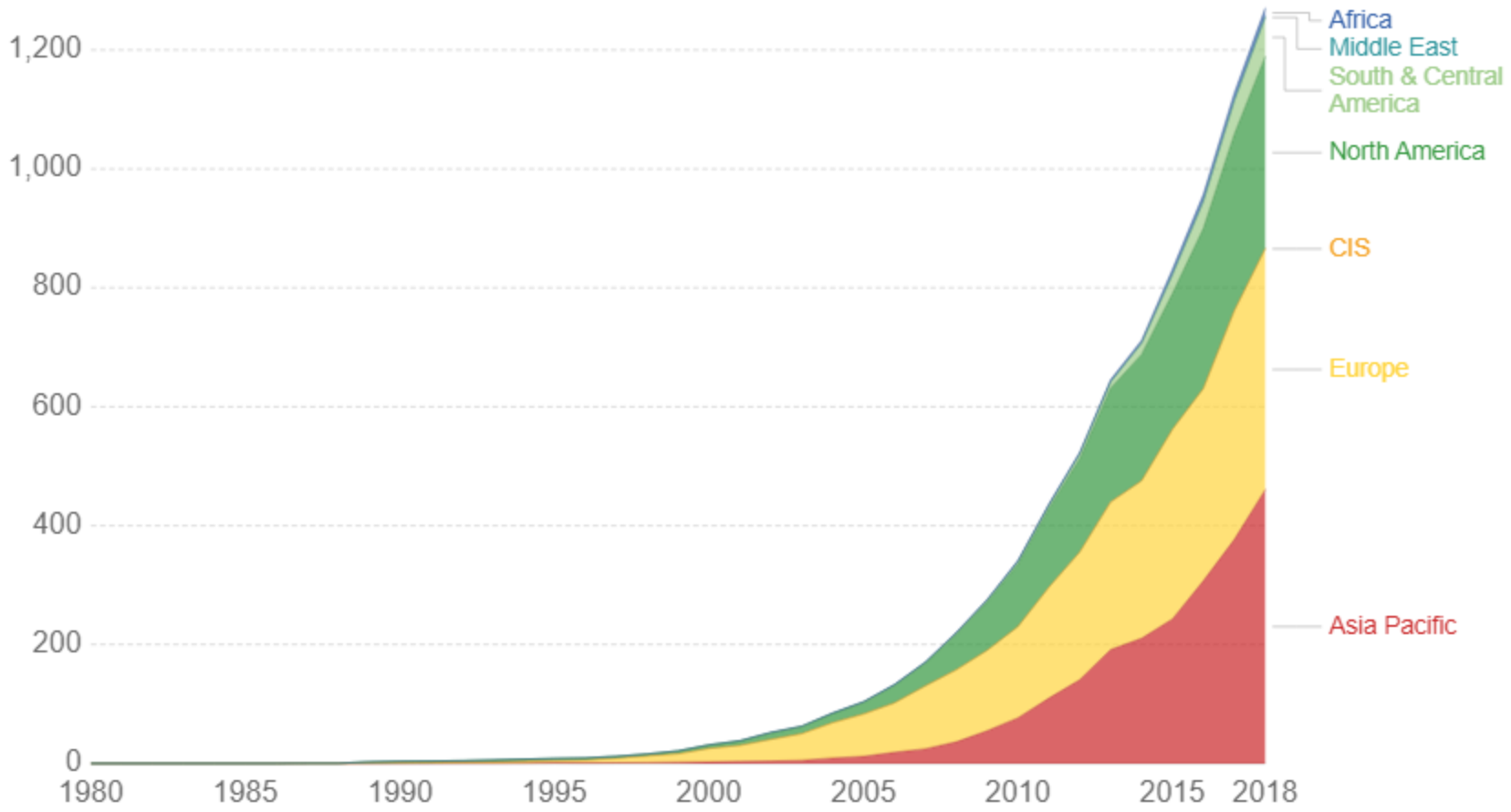


Source: BP Statistical Review of Global Energy (2019)
OurWorldInData.org/renewable-energy • CC BY
Note: 'Other renewables' refers to renewable sources including geothermal, biomass, waste, wave and tidal. Traditional biomass is not included.



Wind energy generation by region

Wind energy generation is measured in terawatt-hours (TWh) per year. Figures include both onshore and offshore wind sources.



Source: BP Statistical Review of Global Energy (2019)

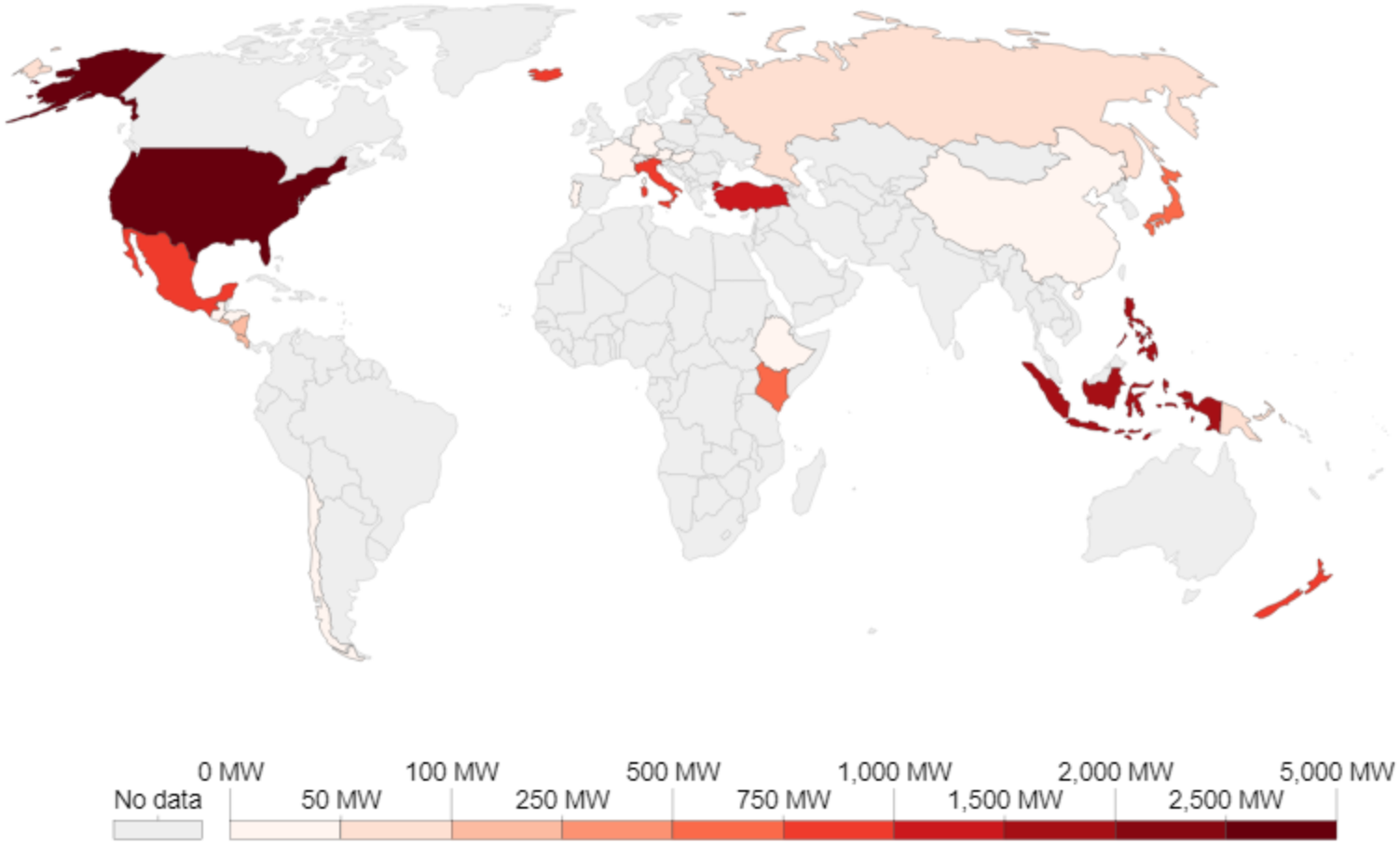
CC BY

Note: CIS (Commonwealth of Independent States) is an organization of ten post-Soviet republics in Eurasia following break-up of the Soviet Union.

Installed geothermal energy capacity, 2018

Cumulative installed capacity of geothermal energy, measured in megawatts.

Our World in Data



Source: BP Statistical Review of Global Energy (2019)

OurWorldInData.org/renewable-energy • CC BY