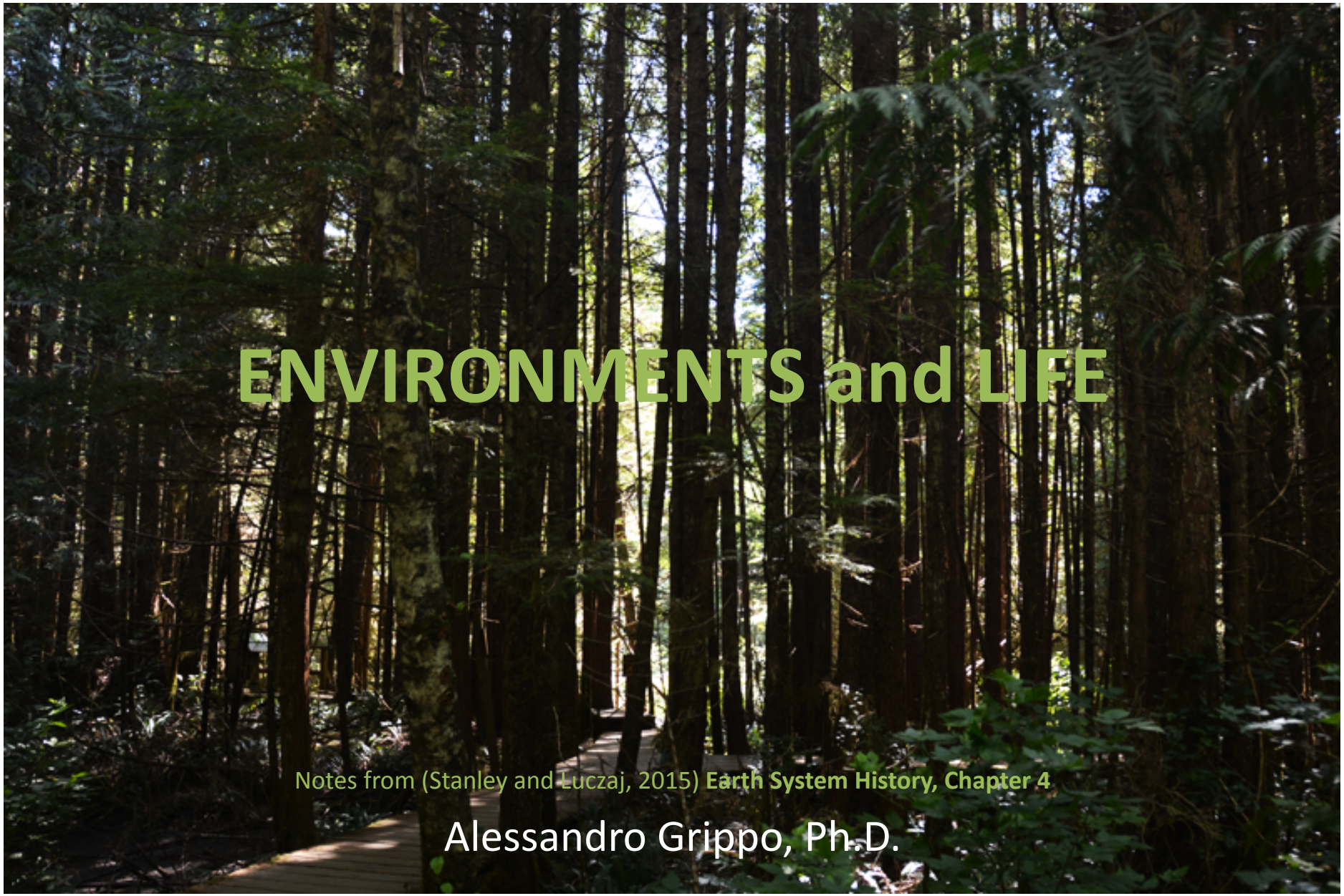


ENVIRONMENTS and LIFE

Notes from (Stanley and Luczaj, 2015) **Earth System History, Chapter 4**

Alessandro Grippo, Ph.D.

The temperate rainforest of the Pacific Northwest in Ucluelet, Vancouver Island, British Columbia, Canada

preamble

- So far, we have studied:
  - Fossils
    - what they are
    - how are they preserved
    - what information do they provide us with
      - depositional environment
      - relative time
  - The diversity of life
    - different taxonomic groups alive today
    - the Tree of Life
- Purpose of this chapter is to understand the distribution of life in different physical environments

Introduction

- **Climate** is the environmental factor that exerts the greatest control of species distribution both on land and in water

- Climate can be studied in different ways but temperature and precipitation are the simplest way to identify climate zones

- This chapter covers the mechanisms that create the prevailing climatic patterns on Earth

Climate vs. Weather

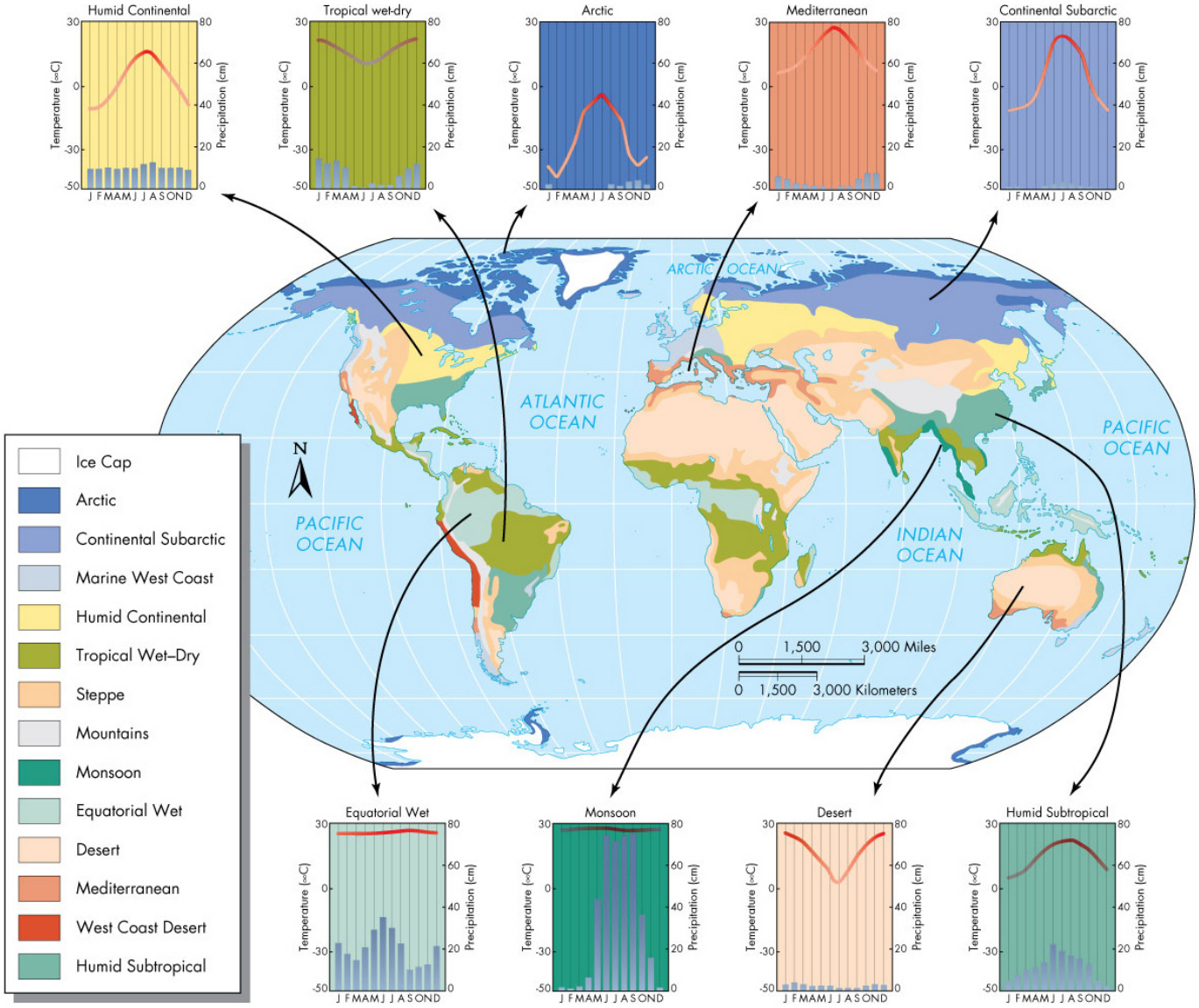
- **Climate** refers to characteristic atmospheric conditions over a long period of time
  - Years or decades
  - Example: Pacific Northwest generally has mild temperatures, high humidity, and lots of rain

- **Weather** refers to atmospheric conditions over short periods of time
  - Days or weeks
  - Example: Visiting Seattle for a week you may only experience bright, sunny, dry conditions

What controls climate?

- The amount of incoming solar radiation
  - Solar output has changed over geological time
- The distribution of oceans and land masses on Earth
  - Continents cluster (Pangea) and scatter (today's world), changing atmospheric and oceanic circulation, and continental climate patterns
- The amount of greenhouse gases and aerosols in the atmosphere
  - Both greenhouse gases and aerosols can be released in great amounts following volcanic eruptions
- Earth's orbital parameters (eccentricity of the orbit, tilting of Earth's axis, precession of equinoxes)
  - Orbital parameters change the amount and the timing of incoming solar radiation

Today's climate zones



Uniformitarianism does not mean "No change"

- Physical and chemical laws, biological mechanisms do not change *per se* but:
  - The conditions under which they operate do change
    - changes in rock abundance and atmospheric composition
    - changes in sea level
    - changes in the composition of floras and fauna, and their interaction with the environment
    - changes in climate (for instance, icehouse vs. greenhouse times)

Configuration of Earth's surface

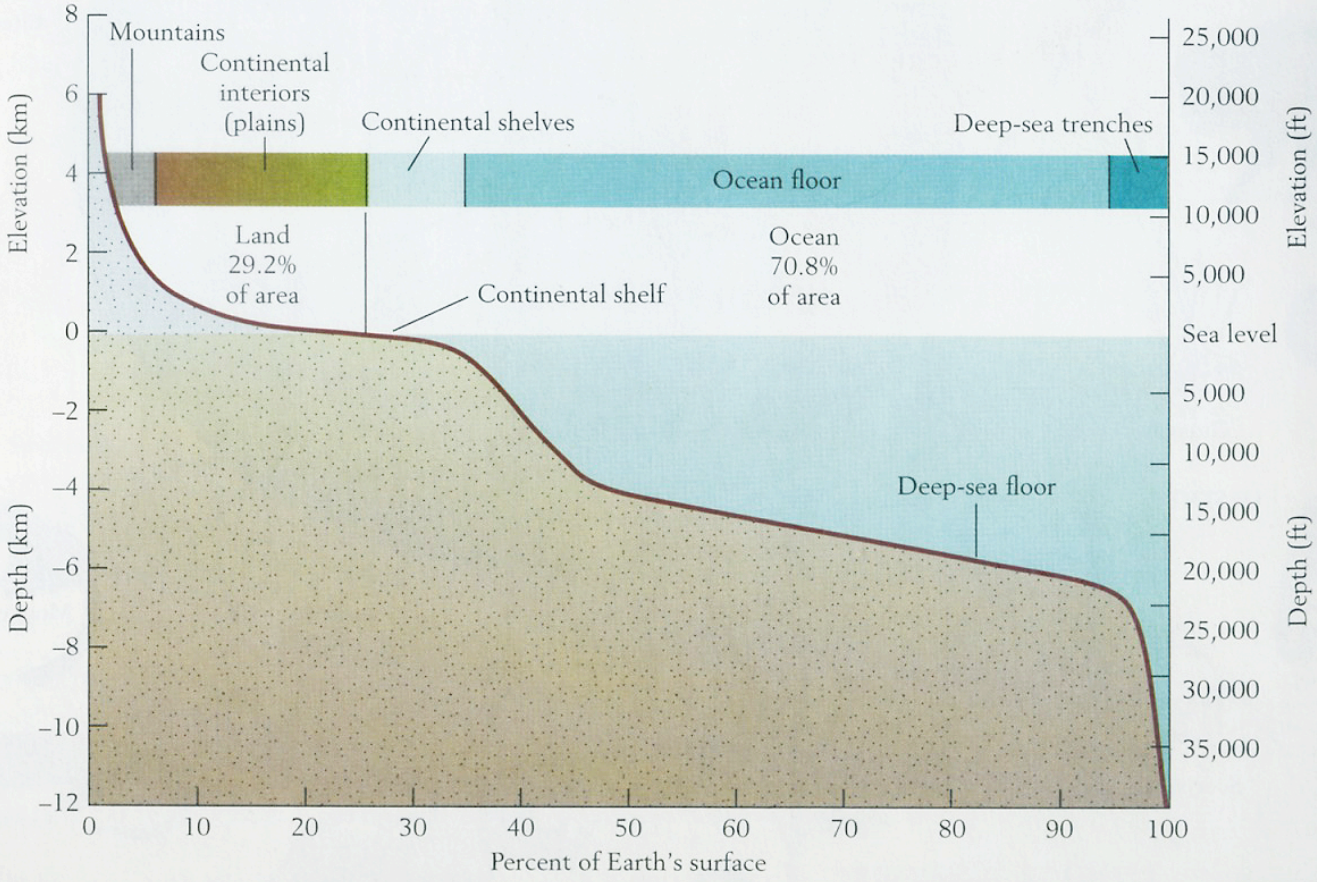


FIGURE 4-1 Elevation curve of Earth's surface. The curve shows the relative amounts of land and seafloor that lie at various distances above and below sea level. The plot is cumulative, depicting the total percentage of land that lies below each depth or elevation. About 70 percent of Earth's surface lies below sea level. Continental shelves are borders of continents flooded by shallow seas. As the left side of the diagram shows, mountains account for relatively little of Earth's surface.

Habitats and Ecology

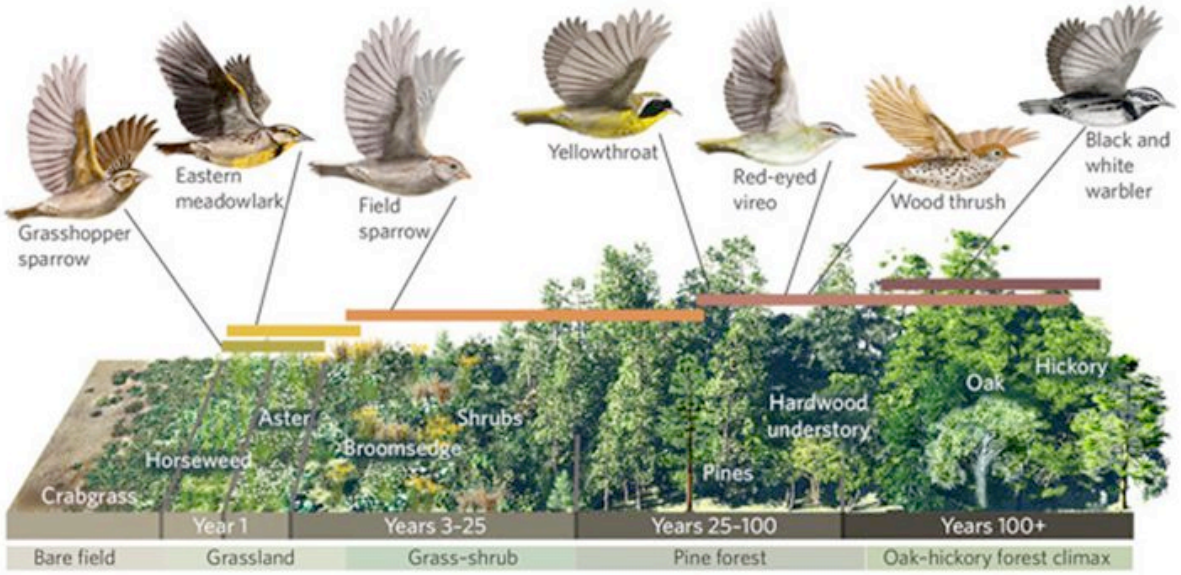
- Habitats are those settings on or close to Earth's surface that are inhabited by life
- Habitats can be terrestrial or aquatic (marine or freshwater)
- Ecology studies the factors that determine the distribution and the abundance of organisms in natural environments

definitions

- Ecological niche
  - A species' niche is its ecological role or "way of life," which is defined by the full set of conditions, resources, and interactions it needs (or can make use of)
- Life habit
  - how a species lives within its niche
- Species are constrained by limiting factors
  - physical and chemical factors: for instance amount of moisture on land, or salinity in the ocean
  - competition for resources (including food and living space)
  - predation

Ecological Niche

- **Ecological Niche** – the role a species serves in its ecosystem
  - including what it eats, what eats it, and how it behaves
  - No 2 species have the same ecological niche



Habitat vs Niche

Habitat

- The habitat is the place where an organism lives out its life.
  - It is <u>where</u> the organism finds food, shelter and mates.

Niche

- A niche is its role in the community and how it interacts with the environment.
  - <u>How</u> it obtains food, mates and protection from predators.

A community of organisms and its environment form an **ecosystem**

- Population: a group of individuals that
  - belong to the same species
  - live together in the same area

- Different populations in the same area form an ecological community
  - within a community, some species feed on others
    - producers and consumers

- Producers
  - photosynthesizing organisms
    - A few bacteria, algae, plants
  - chemosynthesizing organisms
    - Bacteria (uncommon)

- Consumers
  - primary consumers, or herbivores
  - secondary consumers, or carnivores
  - omnivores

- Parasites
  - Feed on living organisms, occasionally causing their death

- Scavengers
  - Feed on dead organisms

Ecosystems

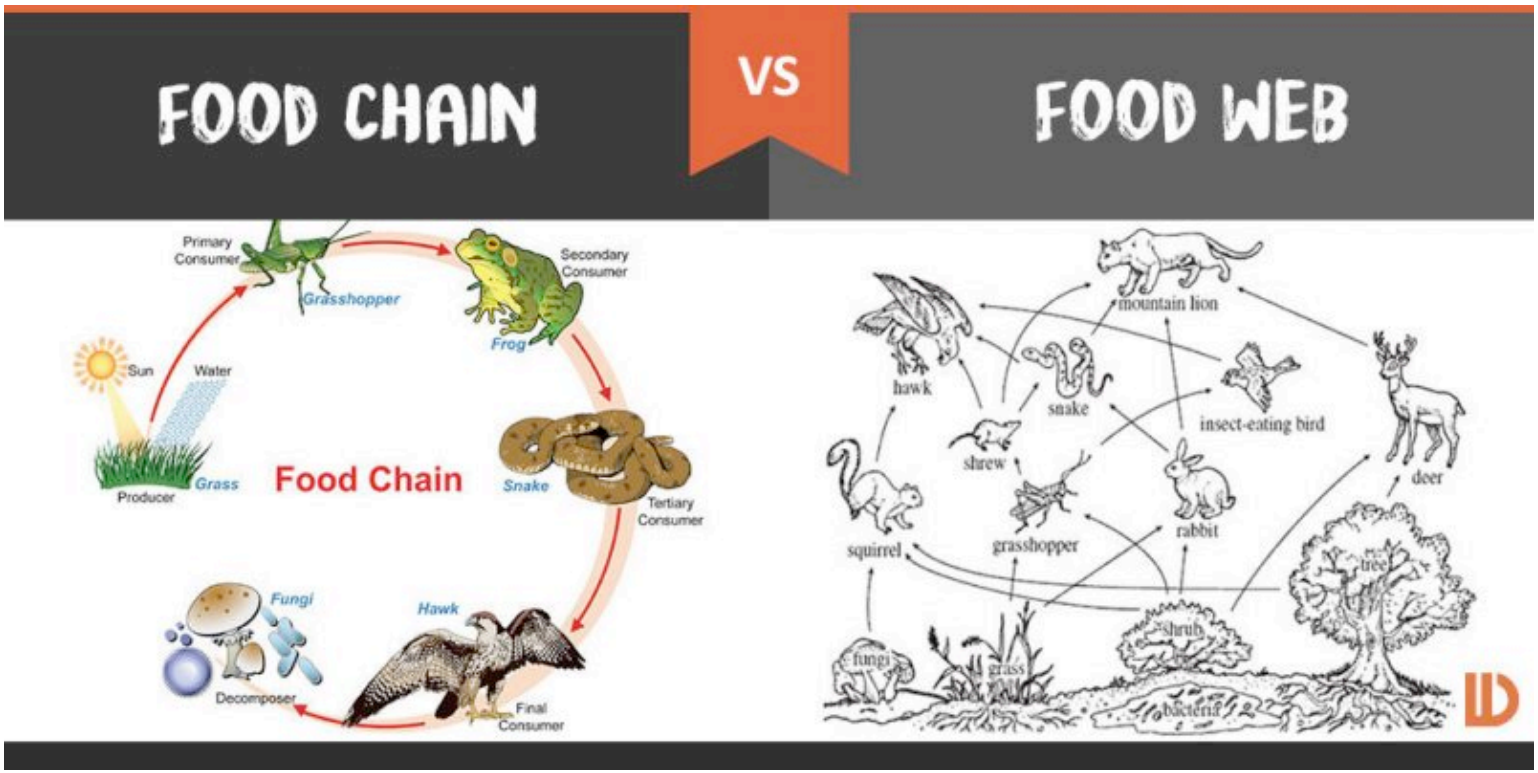
- **Ecosystem**: an ecological community and the physical environment they occupy

- Small ecosystems occur within larger ones:
  - Earth as a whole is an ecosystem, a beach is an ecosystem, the intertidal zone is an ecosystem, the pores between the grains of sand are an ecosystem, and so on

- Fauna vs. Flora, and Biotas
  - Animals and animal-like protists (such as foraminifera and radiolarians) are defined as faunas
  - Plants and plant-like protists (such as coccolithophorids and diatoms) are defined as floras
  - A community of faunas and flora living together is defined as a biota

Flows of energy through an ecosystem

- Food chains vs. food webs
- Materials are lost in each step of the food web
  - Burned as energy for the life functions of the eater
  - Not everything can be absorbed/digested
  - Materials do not sop at higher level: scavengers and decomposers recycle organic matter



Diversity and Opportunistic Species

- The concept of diversity refers to the abundance of different species living together within the same community
- Diversity is normally low in habitats that present difficulties for life
- Diversity is affected by:
  - physical conditions (e.g., deserts vs. shallow tropical shelves)
  - abundance of predators
  - environmental disturbances
- Opportunistic species are those that specialize in invading newly vacated habitats

Biogeography

- Biogeography studies the distributions and abundances of organisms on a broad geographic scale on Earth

- Limits to distribution and abundance:
  - Temperature
  - Barriers (of all kinds)
    - Land barriers for marine biota
    - Ocean barriers for terrestrial biota

    - .. plate tectonics modifies these barriers over geologic time

the Atmosphere

- Permanent gases
  - Gases whose proportions stay constant
    - Nitrogen and oxygen
  - Have little effect climatically

- Variable gases
  - Gases whose proportions vary with time and space
  - Play important roles in atmospheric dynamics
    - Carbon dioxide, water vapor, ozone, methane, nitrous oxide, and halocarbons

- Aerosols
  - Particles whose proportions vary with time and space

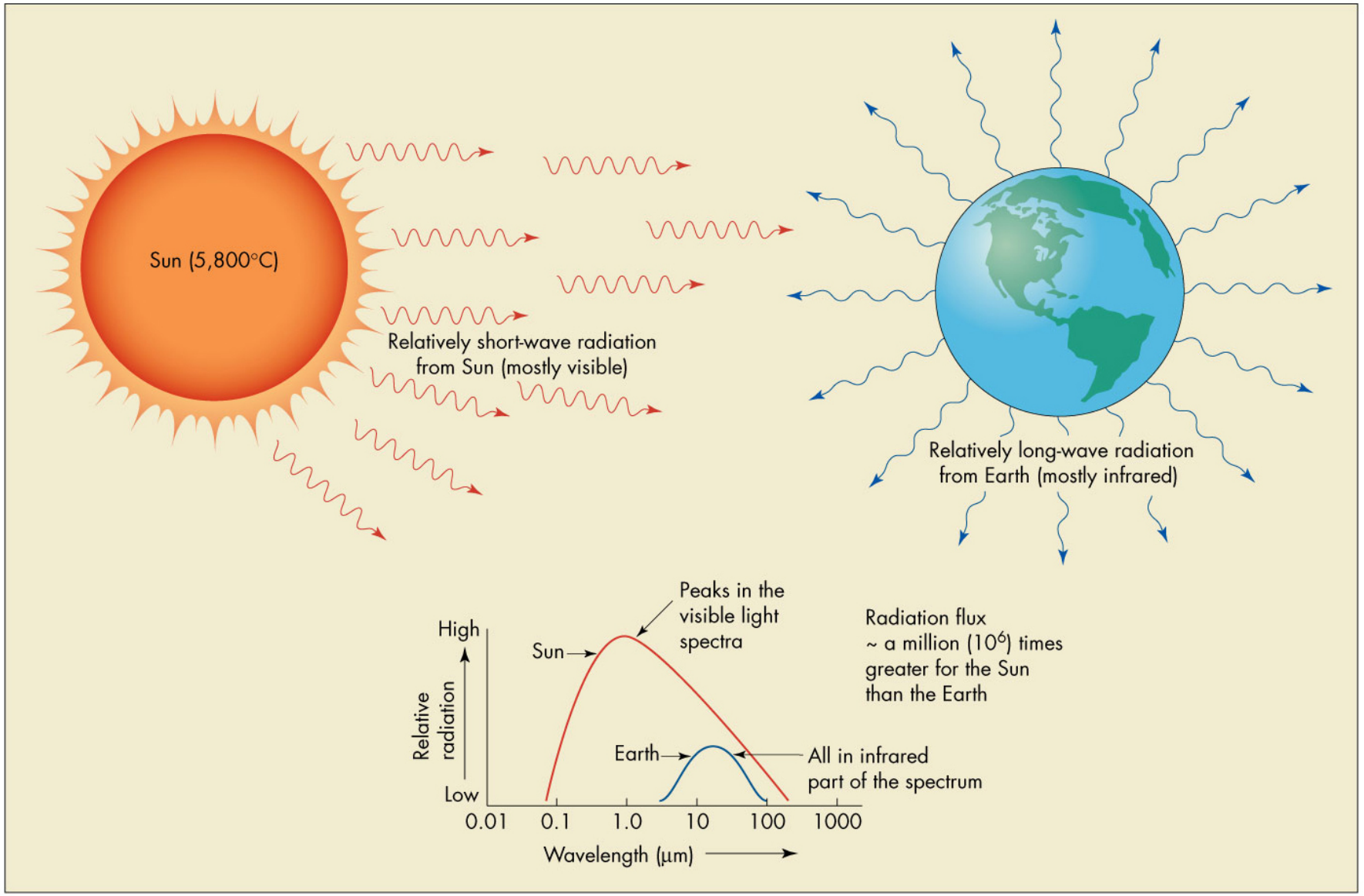
TABLE 12.1 Composition of the Atmosphere

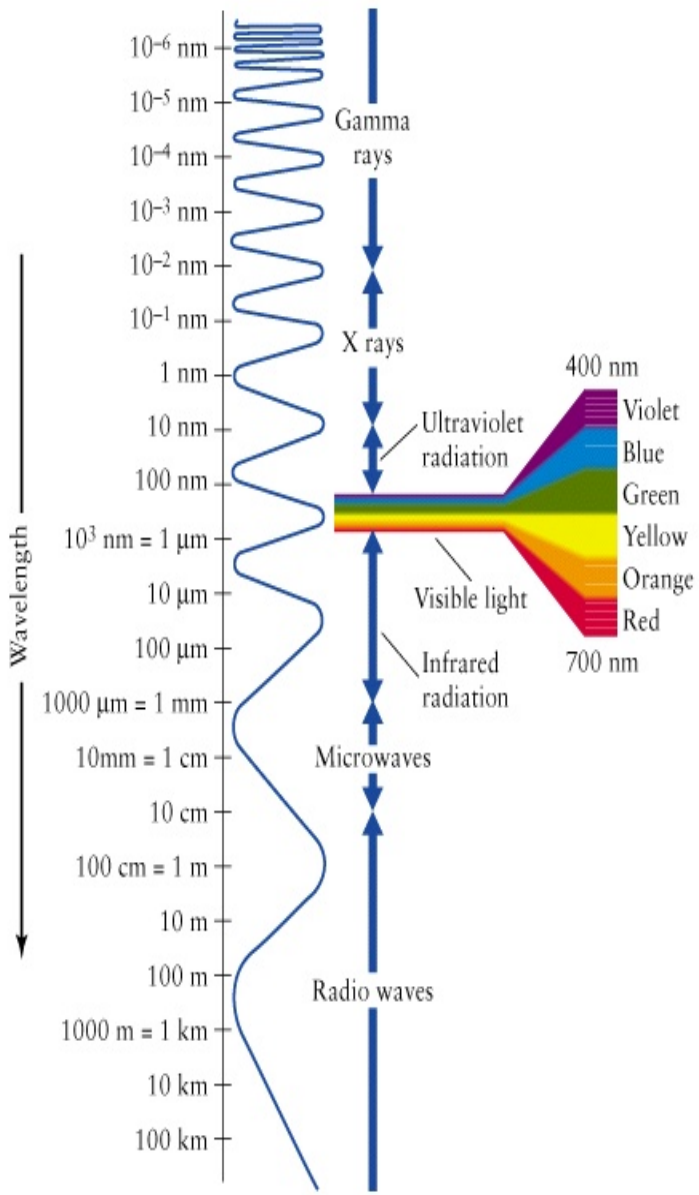
Permanent Gases		Variable Gases	
Nitrogen	78.08%	Water Vapor	0.2–4%
Oxygen	20.95%	Carbon Dioxide	0.038%
Argon	0.93%	Methane	0.00017%
Neon	0.0018%	Nitrous Oxides	0.000032%
Helium	0.00052%	Ozone	0.000004%
Krypton	0.00011%	Halocarbons	0.00000002%
Xenon	0.00009%		
Hydrogen	0.00005%		

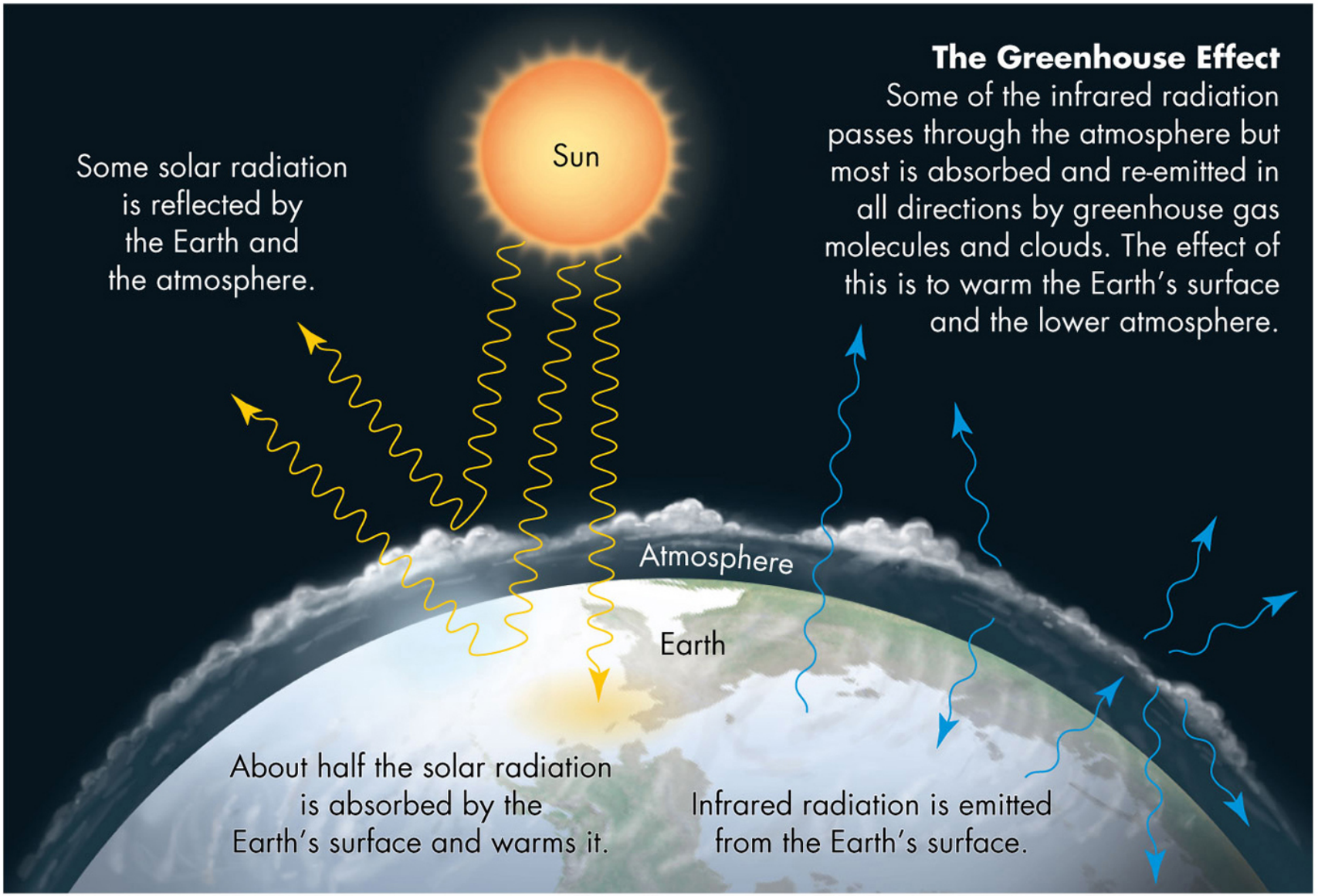
Percentage by volume. Data in part from Bryant, E., *Climate Process & Change*. New York: Cambridge University Press, 1997.

the Greenhouse Effect

- Earth's temperature depends, in part, on:
  - Amount of sunlight received
  - Amount of sunlight reflected
  - Amount of reradiated heat that is retained
- Earth's energy balance
  - Currently, more energy is received from the sun that it is lost to space
- Sunlight received is short wave and mostly visible
- Earth radiates back into space mostly in the long-wave infrared frequencies
- Greenhouse gases: water vapor(H_2O), carbon dioxide (CO_2), methane (CH_4), and chlorofluorocarbons absorb infrared radiation sent back by Earth, and are warmed
- As a consequence, the lower atmosphere is much warmer than if would be if all this radiation were able to escape into space


Sun (5,800°C)
Relatively short-wave radiation from Sun (mostly visible)
Relatively long-wave radiation from Earth (mostly infrared)
Peaks in the visible light spectra
Sun
Earth
All in infrared part of the spectrum
Radiation flux ~ a million (10^6) times greater for the Sun than the Earth
High
Low
Relative radiation
0.01
0.1
1.0
10
100
1000
Wavelength (μm)


Wavelength
10^{-6} nm
10^{-5} nm
10^{-4} nm
10^{-3} nm
10^{-2} nm
10^{-1} nm
1 nm
10 nm
100 nm
10^3 nm = 1 µm
10 µm
100 µm
1000 µm = 1 mm
10mm = 1 cm
10 cm
100 cm = 1 m
10 m
100 m
1000 m = 1 km
10 km
100 km
Gamma rays
X rays
Ultraviolet radiation
Visible light
Infrared radiation
Microwaves
Radio waves
400 nm
Violet
Blue
Green
Yellow
Orange
Red
700 nm


The Greenhouse Effect
Some of the infrared radiation passes through the atmosphere but most is absorbed and re-emitted in all directions by greenhouse gas molecules and clouds. The effect of this is to warm the Earth's surface and the lower atmosphere.
Sun
Some solar radiation is reflected by the Earth and the atmosphere.
Atmosphere
Earth
About half the solar radiation is absorbed by the Earth's surface and warms it.
Infrared radiation is emitted from the Earth's surface.

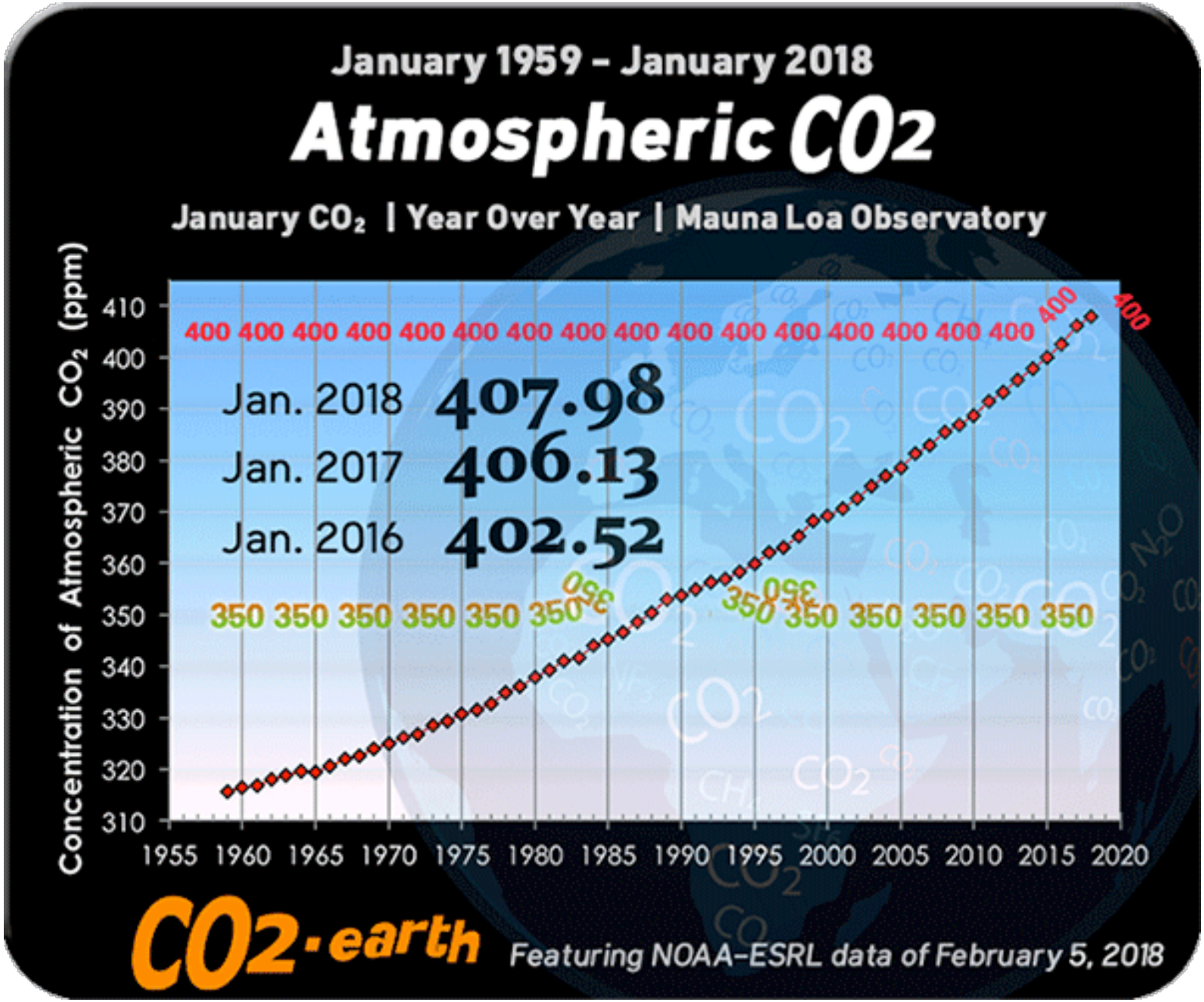
- Greenhouse effect is a natural and necessary process
  - Earth would be 33° colder without it
  - All surface water would be frozen
  - Little life would exist

- Most of the natural effect is from water vapor

- Human activities have increased amounts of greenhouse gasses
  - Anthropogenic (human caused) component of warming

- Carbon dioxide accounts for most of the anthropogenic greenhouse effect

- Carbon dioxide concentration
  - Past concentrations have varied between 200 ppm to about 300 ppm
  - Today concentration is above 400 ppm
  - Predicted to reach at least 450 ppm by the year 2050


January 1959 - January 2018
Atmospheric CO2
January CO2 | Year Over Year | Mauna Loa Observatory
Concentration of Atmospheric CO2 (ppm)
410
400
390
380
370
360
350
340
330
320
310
400 400 400 400 400 400 400 400 400 400 400 400 400 400 400 400 400 400
Jan. 2018 407.98
Jan. 2017 406.13
Jan. 2016 402.52
350 350 350 350 350 350 350 350 350 350 350 350 350 350 350 350 350 350
1955 1960 1965 1970 1975 1980 1985 1990 1995 2000 2005 2010 2015 2020
CO2·earth
Featuring NOAA-ESRL data of February 5, 2018

end of part 1