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Chap 11: Origins of Agriculture:
A focus on our agricultural past, present, and future

<u>Lecture Outline</u>:

- Hominin evolution and early humans, our foraging past
- The rise of agriculture and first domesticated crops
- Sustainable food systems: Current agricultural methods must change to adapt to the changing climate
- The cereal grains that feed the world
- Natural and artificial selection
- The Dust Bowl: Causes and consequences
- The Green Revolution and Industrial Agriculture (costs and benefits)
- The rapid rise of the human global population
- The current food crisis in the face of a growing human population. How can we feed the world and not deplete natural resources?



~9000 year old *Cucurbita pepo* seed discovered in a cave in Oaxaca, Mexico

Figure 2.2 Plant Biology, 2/e

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Before the advent of agriculture ~10,000 years ago, humans were ***foragers***



John Cheung

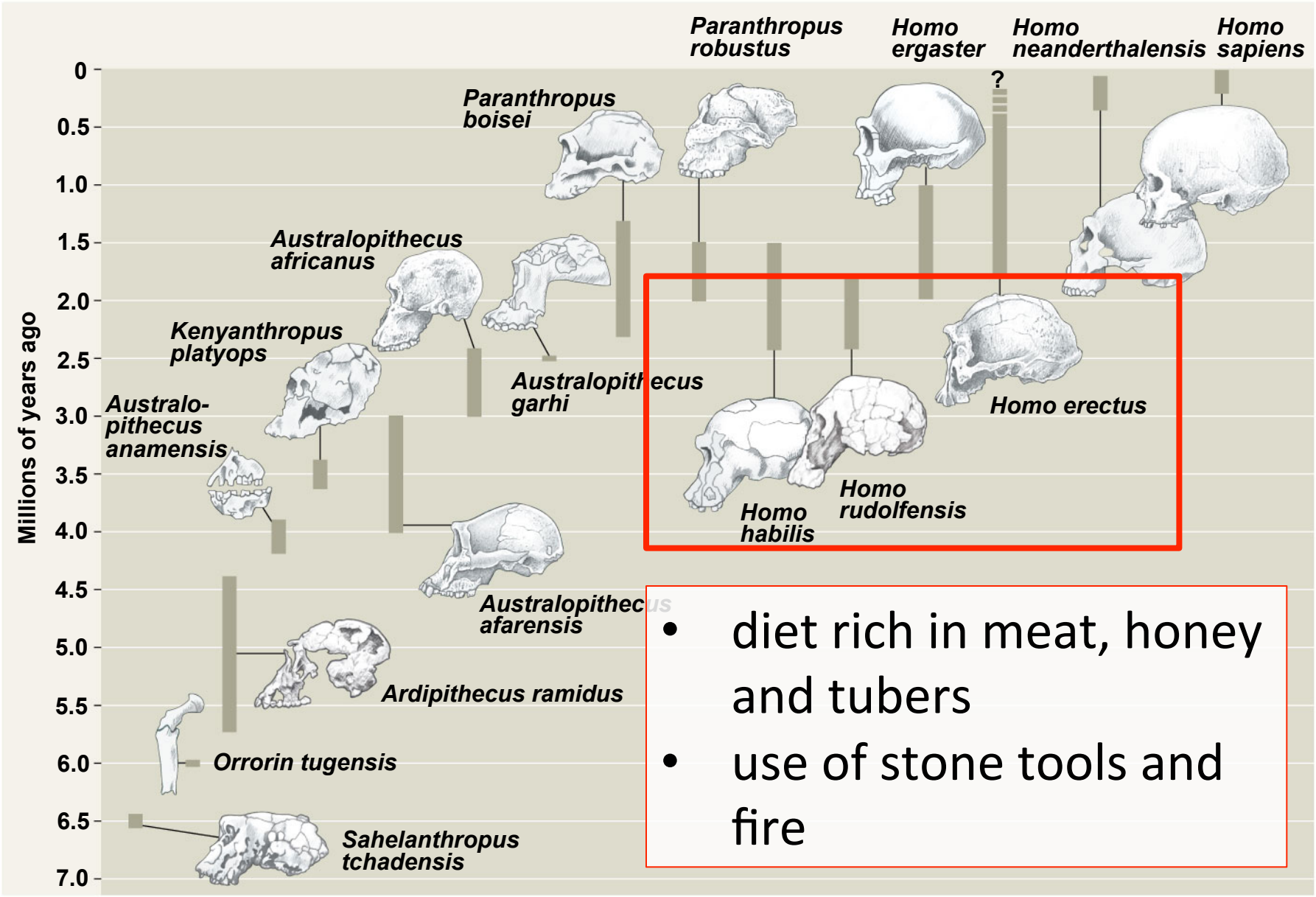
www.onesunartist.com

Human evolutionary history



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160,000 year old *Homo sapiens* fossil, *Ethiopia, 2003*



- diet rich in meat, honey and tubers
- use of stone tools and fire

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Early foragers knew which plants were edible, which were poisonous, and which had medicinal properties. They ate a diverse diet.

The development of agriculture happened in large part because of a changing climate.



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1st crops from the Fertile Crescent

- **wild barley**
- **wheat**
- **lentils**
- **peas**
- **chickpeas**
- **olives**
- **dates**
- **pomegranates**
- **flax**

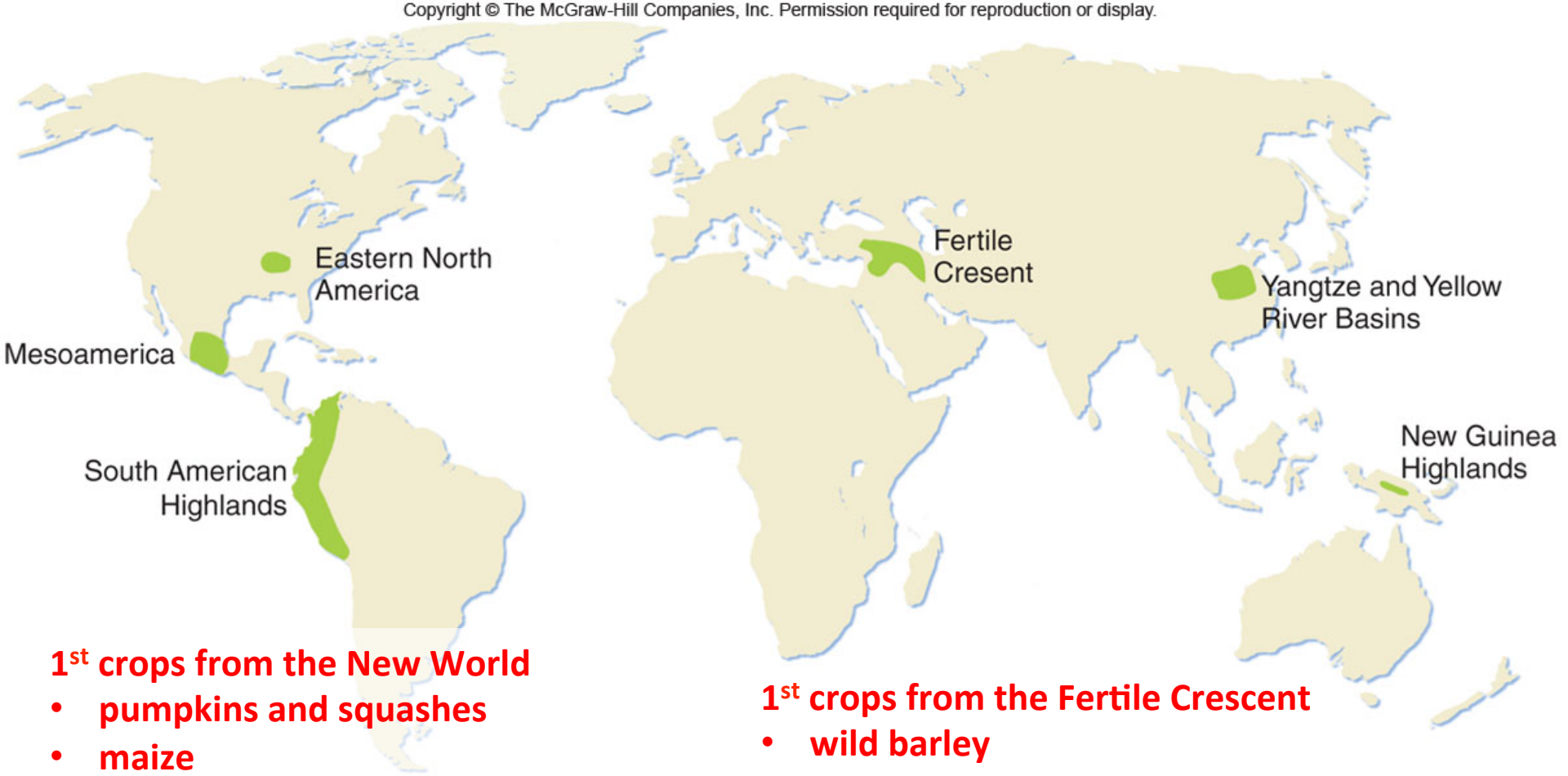
The Fertile Crescent today (Iran, Iraq, Turkey, Syria, Lebanon, Jordan, and Israel) in the face of climate change

The Fertile Crescent is left dry as Turkish dams reduce the Tigris and Euphrates rivers to a trickle.



Trees in the desert: https://www.youtube.com/watch?v=goBB4fVLRxc

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1st crops from the New World

- pumpkins and squashes
- maize
- lima beans
- common beans
- chili peppers
- tomatoes
- tobacco
- cacao (chocolate)
- avocado
- manioc/cassava

1st crops from the Fertile Crescent

- wild barley
- wheat
- lentils
- peas
- chickpeas
- olives
- dates
- pomegranates
- flax

3 major crops feed the human population







wheat

rice

maize

These plants are rich in carbohydrates, but do not provide a balanced diet.

By Christian Fischer, CC BY-SA 3.0, https://commons.wikimedia.org/w/
index.php?curid=16098817

http://www.idrc.ca/

The cost of transitioning from foraging to agriculture

- Humans got shorter and sicker when shifting to subsistence agriculture.
- Why?
  - seasonal hunger
  - reliance on single crops deficient in essential nutrients
  - crop blights
  - social inequalities related to trade
  - population density

Mummert et al., 2011. Stature and robusticity during the agricultural transition: evidence from the bioarchaeological record. *Economics and Human Biology* (3):284-301. http://www.ncbi.nlm.nih.gov/pubmed/21507735

Artificial selection of agricultural species demonstrates evolution

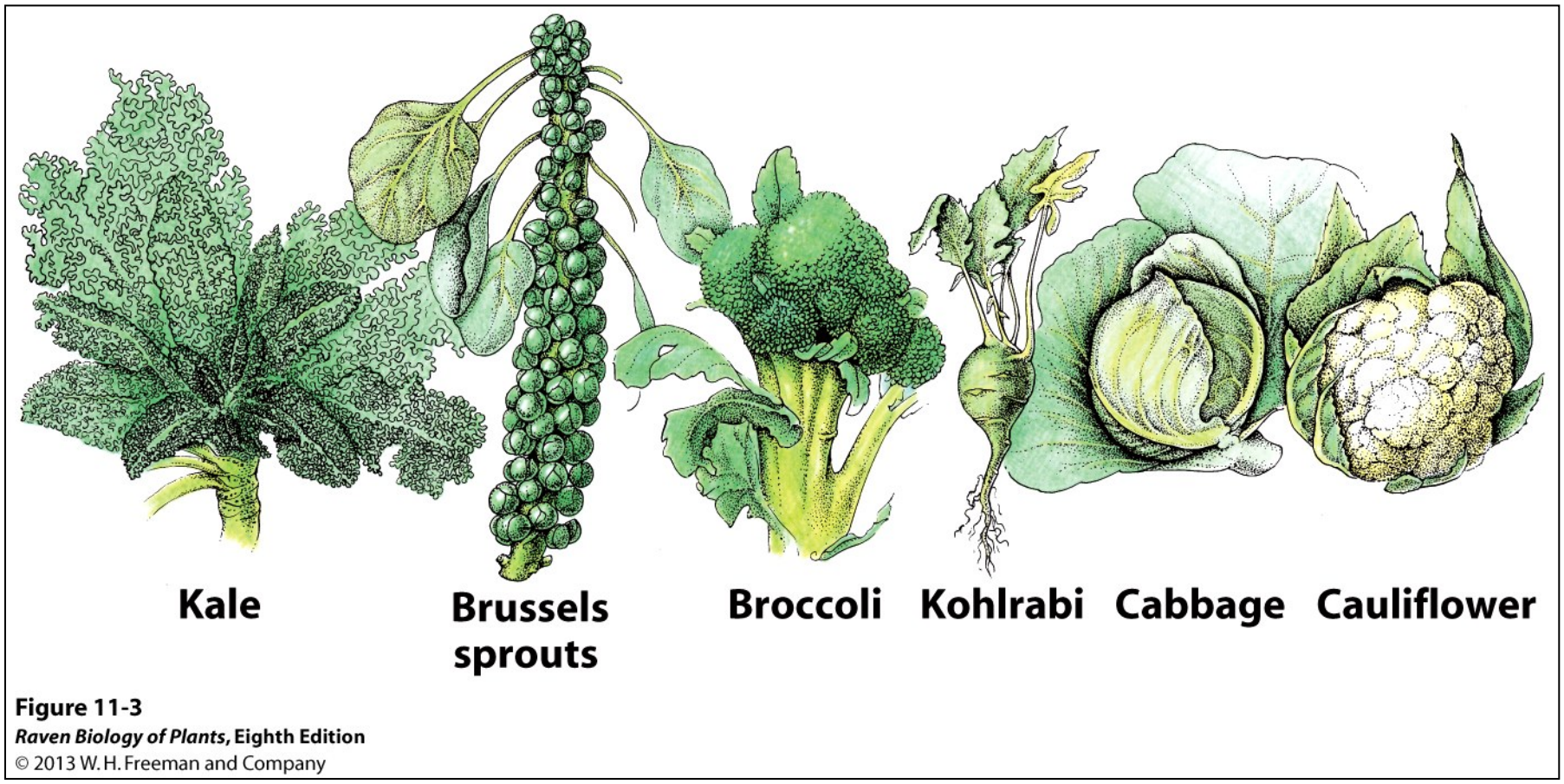
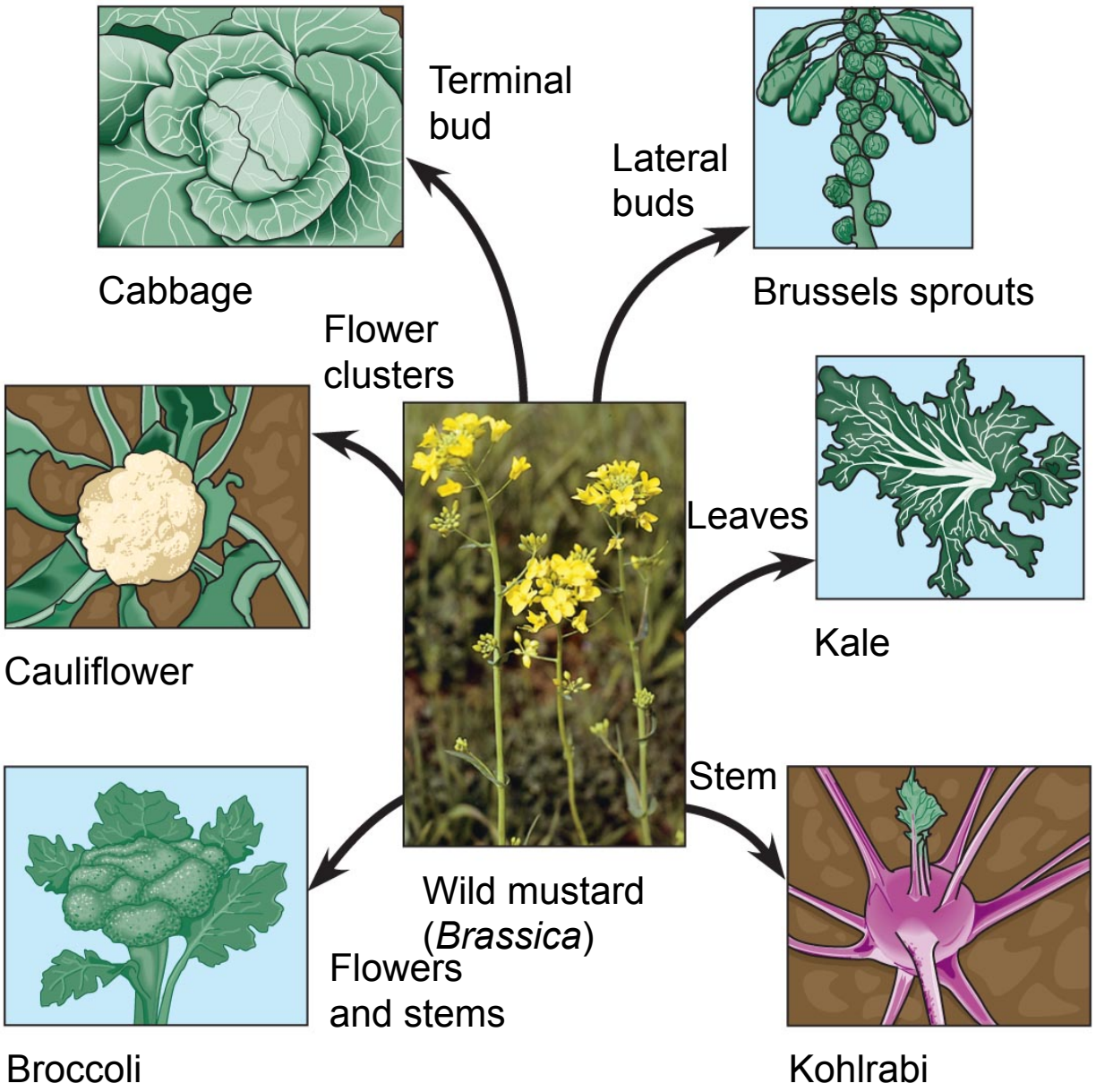


Figure 11-3
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Artificial selection of agricultural species



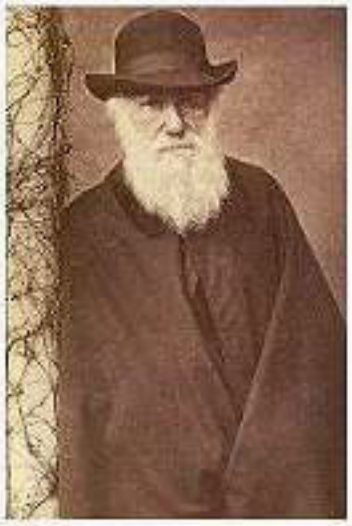
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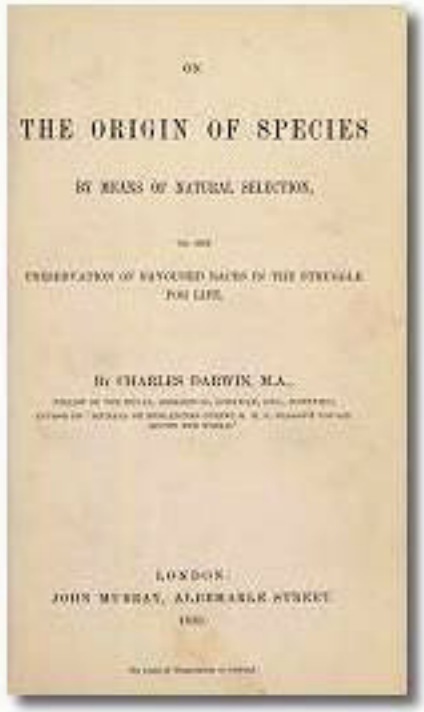
Natural selection

Main ideas of Darwin's book, the *Origin of Species*:

1. ***descent with modification*** explains life's unity and diversity

2. ***natural selection*** brings about the match between organisms and their environment



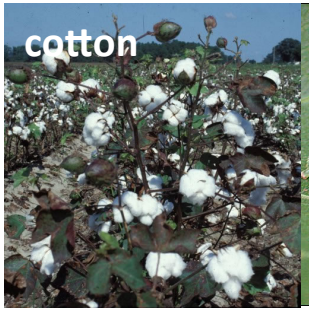


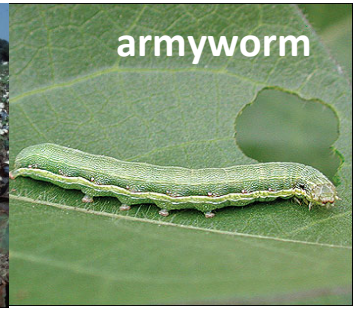
Charles Darwin

Evolution by natural selection

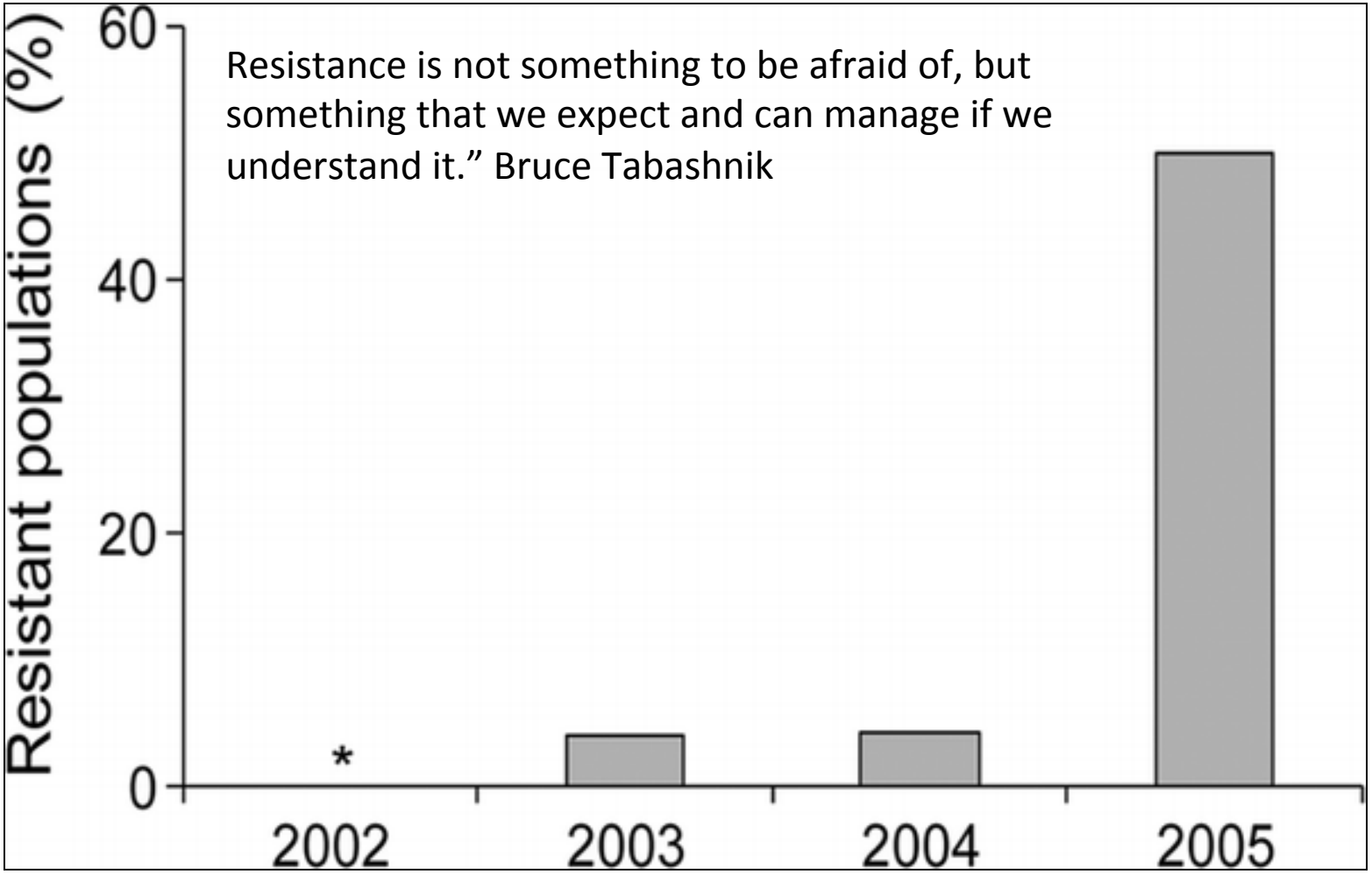
- ***natural selection*** = A process in which organisms with certain inherited characteristics are more likely to survive and reproduce than are organisms with other characteristics.

- What counts in natural selection is not "survival of the fittest" but a question of reproduction… the extent to which any particular type can ***outbreed*** its competitors.





Evidence for evolution: Insect resistance to *Bt* cotton

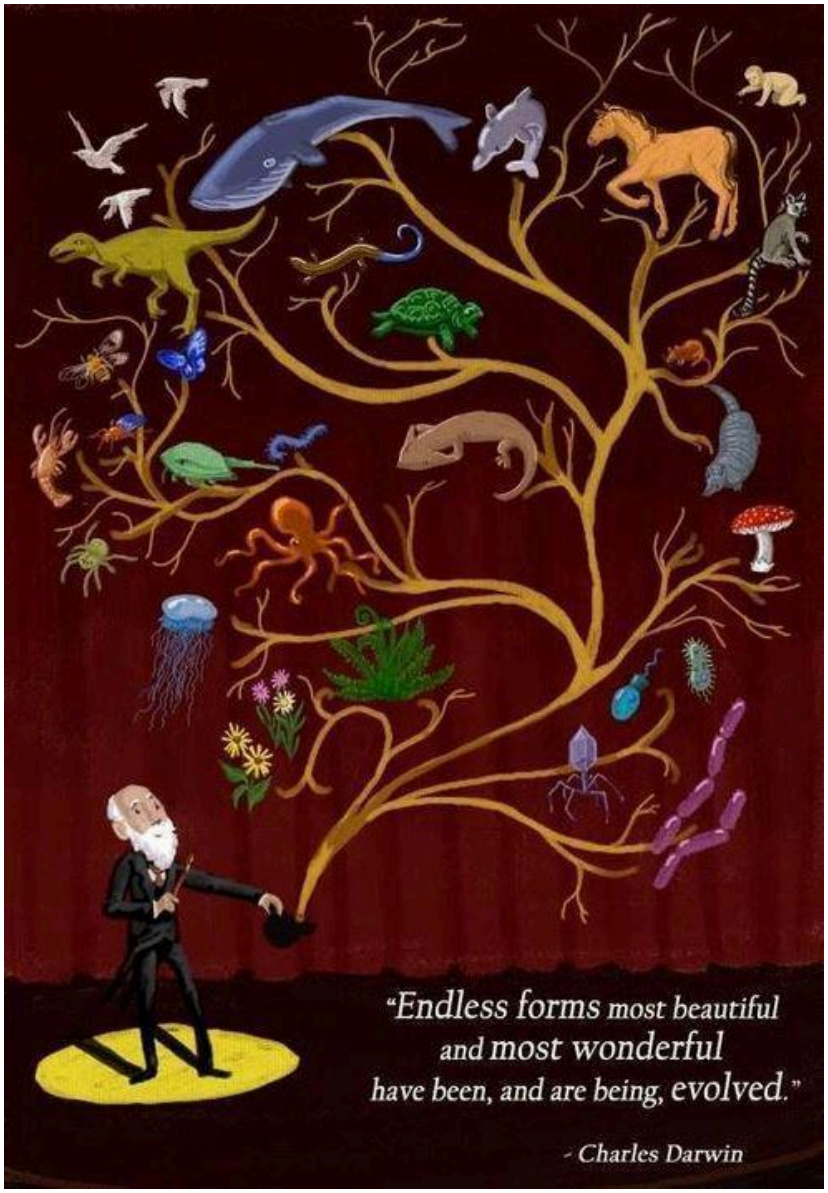


Bruce E. Tabashnik, J.B.J. Van Rensburg,and Yves Carriere. Field-Evolved Insect Resistance to Bt Crops: Definition, Theory, and Data. J. *Econ. Entomol*., 102(6): 2011-2025 (2009)

Natural selection: important points

1. Natural selection is an editing mechanism, **not** a creative force.

2. Natural selection favors traits that increase fitness in the ***current, local environment.***



Late 1800s: America's challenge was to make agriculture more efficient

U.S. pursued its potential to…

- Free people from farm labor
- Reduce income spent on food





“The nation that destroys its soil, destroys itself.”

U.S. President Franklin D. Roosevelt



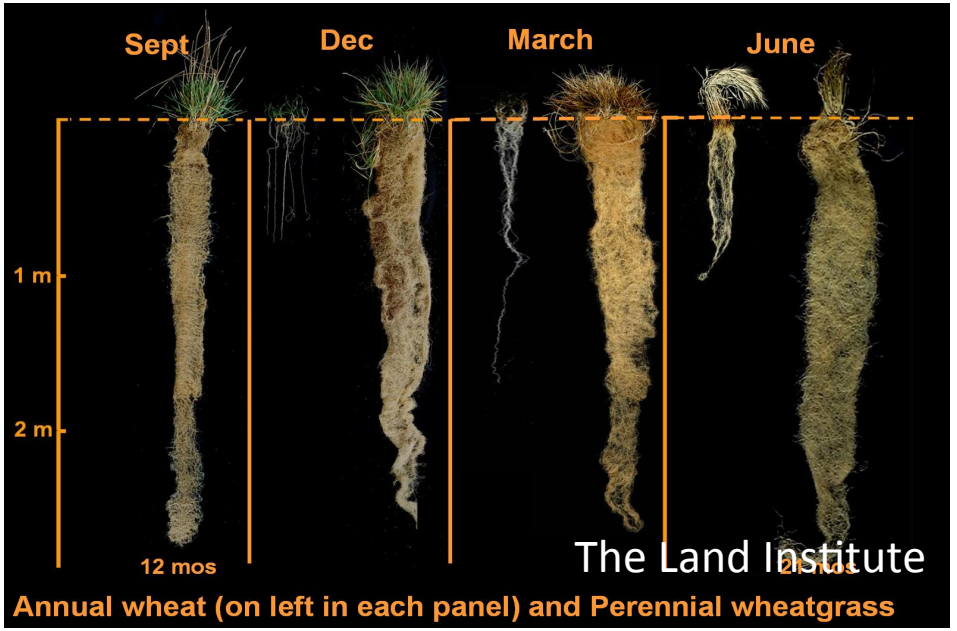
Dust storm during the Dust Bowl of 1937

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Why did the Dust Bowl happen?

1. Displacement of native, deep-rooted grasses that prevented soil loss and trapped moisture.
2. Years of severe drought
3. Decades without wind-erosion prevention: crop rotation, fallow fields, cover crops, etc.
4. Tilling the topsoil





https://www.youtube.com/watch?v=dMBLmPJ1M94

The Green Revolution in agriculture

"These and other developments in the field of agriculture contain the makings of a new revolution… I call it ***the Green Revolution***."

William Gaud, former United States Agency for International Development (USAID) director in 1968

The Green Revolution in agriculture

- credited with saving over a billion people from starvation
- development of high-yielding varieties of cereal grains
- expansion of irrigation infrastructure
- modernization of management techniques
- distribution of hybridized seeds, synthetic fertilizers, and pesticides to farmers

Major components leading to the success of the Green Revolution

1. fertilization
2. mechanization
3. irrigation

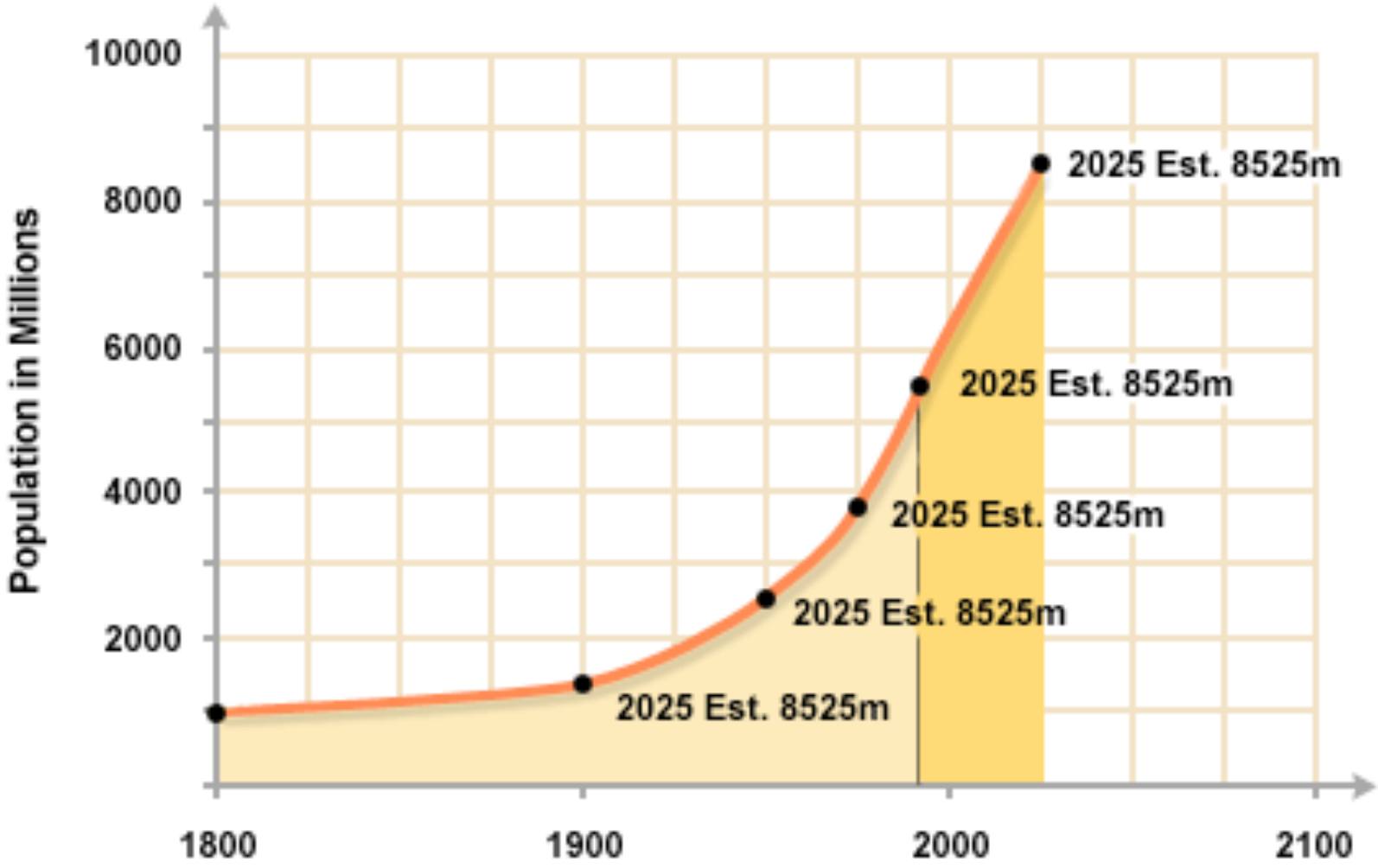




Figure 21-22
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Norman Bourlaug won the Nobel Peace Prize in 1970 in recognition of his contributions to world peace through increasing food supply.

Recent human population growth



During the 20th century alone, the population in the world increased from 1.65 billion to 6 billion. We are now (March 2016) at 7.4 billion and growing every second!

"By 2050, the world will need 70-100% more food than is now available."

More than 30% of the world's farmland has ***reduced in productivity*** stemming from poor soil conditions.

- chemical contamination
- mineral deficiencies
- acidity
- salinity
- poor drainage due to compaction

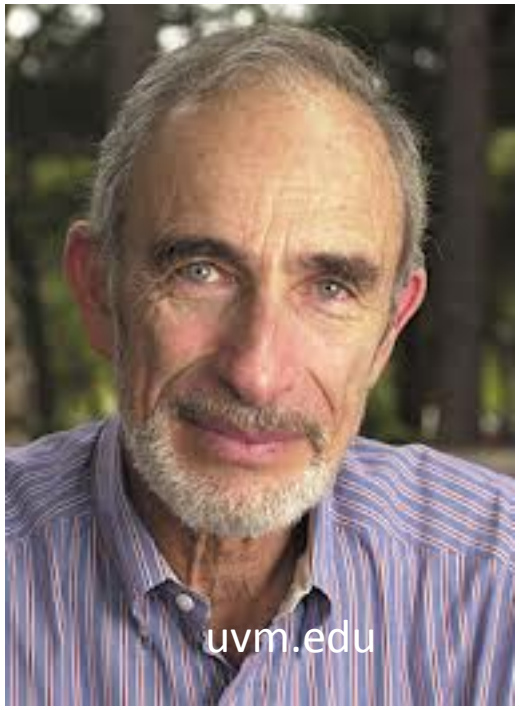
Evert and Eichhorn, 2013

The longevity of our human society depends on designing sustainable systems

Dr. Paul Ehrlich - "What Are the Chances a Collapse of Civilization Can Be Avoided?" UVM Burack lecture April 2013

Dr. Ehrlich's advice:

1. Rework our entire agricultural system.
2. Address the human population growth problem humanely.
3. Fix overconsumption patterns instantly.



Agriculture **can** become (*must* become?) sustainable



paradigm shift



- Reliance on "inputs"
- Monocultures
- Grow crops in same area each year
- Use of inorganic fertilizers

- Reduced to no reliance on "inputs"
- Polycultures
- Crop rotation
- Use of cover crops and organic fertilizers

Lecture Review, Agriculture

- Briefly describe the evolutionary history of our species *Homo sapiens.* What is the difference between a primate, a hominin, and a human?
- Describe the foraging method of early humans and some modern day cultures.
- Agriculture arose in several places in the world at the same time, about 10,000 years ago. What factors lead to the development of agriculture?
- List some of the first crops from both the Old and New World.
- What are the 3 major crops that supply the major of the human population's calories? What plant family do they belong to?
- Why did the Dust Bowl of the mid-1930s occur?
- What is the Green Revolution and how did it change agricultural practices?
- What is the current size of the human population globally and what issues are facing agriculture today?