Biology 115D

Evolution, Behavior, & Ecology

Peter Schulze

Fall 2023

SYLLABUS

Course Purpose

This course introduces the basic concepts of evolution, ecology, and animal behavior and, through its ‘lab’, the processes of doing science. This course serves as a basis for all higher-level Austin College biology courses.

Instructor

Peter Schulze, pschulze@austincollege.edu , IDEA Center 258,
office phone 903 813 2284, cell phone (for *urgent, important* matters) 903 814 6945

If you call my office phone and I do not answer, please send an email rather than leaving a voice message. Also, I do not generally answer unrecognized numbers on my cell. If you need to reach me urgently, text my cell phone. Make sure to tell me your name.

Office Hours: M 3:00-4:30, W 10:00-11:30, Th 2:00-3:30. Office hours are times protected for working with students. You are also welcome to meet with me at other times, either by appointment or just stopping by. I will post my regular schedule on my office door.

Who belongs here

Everyone who treats others with respect and is motivated to (or simply wishes or needs to) study the course topic is welcome in this class.

If you suspect that I may refer to you incorrectly, please let me know what you prefer.

A suggestion

Successful students study syllabi in detail, keep a calendar of key dates, review syllabi well ahead of each class so they can prepare properly, know what to expect of each day’s class and prepare appropriately, and follow instructions and guidance in syllabi. I strongly recommend that you do these things.

Students planning to enroll in Cell Biology (BIOL 116) this spring:

Chemistry 111is a prerequisite for Cell Biology (BIOL 116). If you do not have other credit for Chem 111, you must pass it this semester to take BIOL 116 this spring.

Student Learning Objectives

Explain the mechanisms and key processes of evolution & natural selection.

Explain the fundamentals and importance of key ecological processes and phenomena.

Describe the interrelationship between long-term evolutionary change and short-term ecological processes.

Describe some ways humans depend on but are damaging natural ecological processes, are causing extinctions, and are interfering with the course of evolution.

Develop the skills of a scientist, including collecting, analyzing, and describing data.

Variation among sections of BIOL 115

The various course sections are similar but not identical. Make sure you know the schedule, assignments, etc. for this section. Do not assume they are the same as a friend's assignments in another BIOL 115 section.

Title IX: Confidentiality and Responsible Employee Statement

Austin College staff and faculty are committed to helping create a safe and open learning environment for all students. If you (or someone you know) have experienced any form of sexual misconduct, including sexual assault, dating or domestic violence, or stalking, help and support are available. The College strongly encourages all members of the community to take action, seek support and report incidents of sexual misconduct to the Title IX Office. Please be aware that under Title IX of the Education Amendments of 1972, I must disclose information about such misconduct to the Title IX Office. For more information about reporting options and resources at Austin College and the community, please visit https://www.austincollege.edu/campus-life/title-ix-office/.

Check your austincollege.edu email

I will communicate with the class and with you individually through your austincollege.edu email address. I will consider these official course communications and will assume you have seen my messages.

Schedule

Class meetings**:** IDEA Center 208, MWF 1:30-2:50

Readings

Obtain the OpenStax text Biology 2E, available for free at the link at the end of this paragraph. Either read the web version or download a PDF of the book. If you download the PDF, I recommend the high-resolution version because its graphics are better than the low-resolution version. You may also purchase a printed copy, but I do not have experience with that procedure. https://openstax.org/details/books/biology-2e.

A non-profit organization produces this book and saves you more than $100 compared to a conventional text. If you are able, please make the requested donation. (I will not know whether you donate.) The donation page should open as you click through links to the various formats for accessing the book.

Other readings are specified on the course schedule below and available on Moodle or online. There are no texts to purchase.

Evolution and ecology simulations

The course schedule (below) includes several exercises based on computer simulations of various evolutionary and ecological processes using software developed by SimUText. You will download the relevant application to your laptop if you have a laptop. (People using Chromebooks or very old laptops will use a slightly different procedure that I will explain during class.) If you do not have a suitable device, we will make the simulations available on a college computer available to you. Please let me know if you do not have a laptop, Chromebook, or similar.

I will distribute the information for how to create an account later.

If the instructions for a simulation direct you to write a paper, I do not expect you to write the paper, just complete the questions in the workbook. However, if the workbook instructs you to run experiments, record observations, thoughts, etc. as a basis for writing a paper, complete those steps and those parts of the workbook, just do not write the paper. The schedule below specifies how each simulation will be graded.

Simulations are always due at the end of date (midnight) two class days after the date when the simulation is assigned in the syllabus. So, for example, a simulation assigned on a Monday would be due at midnight on the following Friday.

Some simulations involve workbooks that you will download, print, and complete by writing in them. Others involve automatically-graded online questions of one form or another.

For simulations that involve workbooks, part of your grade will be based on a single page image requested after the simulation completion deadline. SimUText workbooks pages with *complete*, *thorough*, *correct*, *legible* responses will receive full credit (even if some answers are wrong). Pages with superficial answers will receive partial or zero credit.

Questions about the simulations will be included on exams. You may help each other with completing the assignments, but do not use other's answers as your own, otherwise you *will (a) be representing others' work as your own (cheating), and (b) will not learn much and will not be able to answer questions about the material on exams.*

You may work with others to complete the simulations but *must operate a computer yourself, write your own answers in your workbooks, and complete the graded online questions by yourself. In the past, some students have copied each other's answers. I have noticed. Do not do that.* ***I will drop you from the class if I determine that you have intentionally cheated, or fail you if I detect cheating after the drop deadline.***

Please let me know immediately if a library computer does not run the software properly (pschulze@austincollege.edu). In that situation try another computer. When alerting me, please indicate which computer had trouble (there should be an Austin College equipment ID number on the computer).

Academic integrity policy

Imagine two societies, one comprised of people who deceive others for personal gain and another comprised of honest people who do not deceive others for personal gain. In which society would you prefer to live?

Each of our lives depend on the honest people vastly outnumbering dishonest, deceptive people. Cheating on a course assignment is an example of deception – pretending to have done, learned, or understand something that you have not done, learned, or understand. Perhaps many people cheated in high school. This is not high school. Life is complex. Your friends, acquaintances, and your larger society need you to contribute, not defraud everyone else.

Do not cheat. The college I attended expelled students forever for the slightest instance of intentional cheating. If it were up to me, that would be our policy here. Imagine the extra premium of an Austin College degree if it was widely known that only students who did not cheat graduated from Austin College.

No student may unfairly advance his or her academic performance or impede the performance of other students. Any activity that unfairly gives an advantage to a student or group of students is a violation of academic ethics.

I think students generally know when they are cheating, but just to be clear, some examples of violations include using notes on an exam, using a phone or other electronic device during an exam, changing answers after an exam has been graded and then claiming it was graded incorrectly, intentional plagiarism (if you do not know the definition of a word you read, look it up), failure to give credit to someone who has assisted with your work, fabrication of data, and removing items from the library in violation of library policy.

Follow all Austin College regulations on academic integrity. Austin College gives faculty wide leeway in choices of penalties for academic integrity violations. **My default**

penalties for an academic integrity violation are dropping from or failure of the course. Other college consequences are described in the college's publication *Environment* (http://www.austincollege.edu/campus-life/student-life/student-life-publications/). Lesser penalties (or no penalty) will be given only if I think a minor infraction resulted from a misunderstanding. Please let me know if you have any questions about academic integrity or what would constitute cheating on a particular assignment.

Assignments

Quizzes and Exams: There will be two quizzes, two midterm exams, and a final exam. The quizzes will precede the first exam. The primary purposes of the quizzes are to familiarize you with test question types and help you assess your preparation prior to a full-scale exam.

All material covered in assigned readings, simulations, lab sessions, or discussed during class is liable to show up on exams. Take notes about everything, not just the biology. For example, I might ask exam questions about my recommended studying procedure, about some advice I gave on the first few days or class that had nothing to do with biology specifically, or about some reading that you thought was "just for your interest," etc. Do not assume, "That wasn't about biology, so it won't be on the exam."

There will be no makeup quizzes or exams for inexcusable absences or for excusable absences that you failed to have approved ahead of time. If you miss an exam without making prior arrangements with me, then a score of zero will be recorded unless extenuating circumstances prevented your attendance. If I excuse you from taking an exam at the normal time due to circumstances beyond your control, your makeup exam will differ from the exam given to the rest of the class. **Do not schedule appointments (e.g. with a physician) that conflict with exams. Check all your syllabi and reschedule any upcoming conflicts wherever possible.**

It is difficult and time consuming for instructors to prepare alternative versions of exams. Avoid being one of the students who makes that necessary if possible (but do not hesitate to let an instructor know if a serious matter interferes with your ability to take an exam at a regularly scheduled time).

Grades

Your grade will be based on the following assignments. See the schedule below for due dates.

Nine simulations	9 x 15 points each
Two quizzes	2 x 20 points each
Two mid-term exams	2 x 100 points each
Pollination lab answers	30 points
Tree growth lab report	45 points

Final exam	1 x 200 points
Total	650 points

You can calculate your numerical average at any point in the semester. Simply divide the total number of points you have earned by the total number that have been available. Multiply that value by 100 to give your percentage to that date.

Extra Credit opportunities

Public service credit *(Awarded to the first student to alert me during class or by email to a confusing error in a class document.)*	*3 points each instance*
Proofreading credit *(Awarded to the first student to alert me by email to a minor typo in a class document.)*	*1 point each instance*

I will calculate semester grades based on the proportion of available regular points you earn during the semester.

Grades are defined in the *Austin College Bulletin* as:

A	Excellent
B	Good
C	Satisfactory
S	Satisfactory achievement (work must be at or above C- level)
D	Marginally passing
F	Failing
U	Unsatisfactory work
I	Incomplete
W	Withdrawal from the course
WM	Withdrawal from the course for documented medical circumstances

You should assume that at the end of the semester there will be no curve, and that, for example, A’s (A-, A, A+) will be assigned to averages from ≥90% to 100%, B’s will be assigned to averages from ≥80% to <90%, and so on.

Items submitted late will have their grades reduced by one grade interval (e.g., A to B) for the assignment for each day they are late. However, I will not accept simulations late without prior approval, formal accommodations, or special circumstances.

Note: Whether you make an A or a C in this class will affect your graduation GPA by only 0.06. Let that sink in. For example, if your graduation GPA with an A in this course would have been 3.50, then if you earn a C in this course your graduation GPA will be 3.44 – not much different. So, maintain a bit of perspective. Work hard. Do your best. Seek my help. <u>But do not freak out if you receive a disappointing grade for an</u>

assignment. If you receive a grade lower than you expect, *how you respond is much more consequential than the grade itself*.

This is not high school. 70 is not the minimum average to pass the course.

Attendance policy

Many students fail to do well if they do not attend class consistently. I expect attendance except when you are sick, otherwise might be contagious, or have a conflict with some other campus commitment, such as an intercollegiate sports event, whose schedule is beyond your control.

After a couple of classes, I will create a seating chart and check attendance (so find a place you like to sit). **After three unexcused absences, each additional unexcused absence will reduce your semester grade 2 percentage points. After six unexcused absences, I will drop you from the course.** Arriving late to class (after I have checked the seating chart for attendance) will count as an absence. This policy is to motivate attendance and therefore avoid students receiving poor grades because of missing many classes. I would rather not bother to take attendance, but I have learned over the years that students benefit if I do so.

I am reasonable (of course I think I am – haha) and will excuse absences for good reasons. Whenever possible, please communicate with me before any class session that you expect to miss for a compelling reason.

Disability Services

From the Austin College Disability Services Handbook:

Austin College seeks to provide reasonable accommodations for all individuals with disabilities and will comply with all applicable federal, state, and local laws, regulations and guidelines. It is the responsibility of the student to register with and provide verification of academic accommodation needs to the Director of the Academic Skills Center as soon as possible. The student also must contact the faculty member in a timely manner to arrange for reasonable academic accommodations. For further information regarding disability services or to register for assistance, please contact the office at 903-813-2454 or visit the Academic Skills Center.

If you have a formally diagnosed learning disability it is your responsibility to inform me and provide official documentation of any accommodations (e.g., extra time on tests, tests in a different room) approved by the staff of the Center for Student Success and Access Services.

It is also your responsibility to remind me about your accommodation before instances when they will be relevant. For example, if there is a quiz on the schedule for part of a class session, and you get extra time, alert me at the end of the prior class session or otherwise a day or two before the event.

Unless faculty are informed by the students directly, or an ailment is apparent (e.g. broken leg), faculty are not aware of medical issues that may interfere with student performance.

Technology

If you encounter access problems that affect your ability to participate in this course, please let me know and contact Dr. Beth Gill, Vice President of Academic Affairs and Dean of the Faculty, at bgill@austincollege.edu or 903.813.2226. She will assist with any and all accessibility issues.

Learning Environment (standard college statement)

The Mission Statement of Austin College affirms the importance of "a climate of civility and respect that encourages free inquiry and the open expression of ideas." Class members (including the instructor) are expected to treat each other with mutual respect in both word and deed. The learning environment policy includes the expectation that all class members arrive to class promptly, silence cell phones, focus their attention on class activities, and avoid non-essential exit from and re-entry into the classroom. Distracting, disruptive, or disrespectful behavior is specifically forbidden. The course instructor may drop or withdraw students from classes for violating the learning environment policy. Poor attendance, poor participation, misconduct, or disruptive or endangering behavior that interferes with faculty members' obligations to set and meet academic and behavioral standards are examples of behavior for which a drop or withdrawal are allowed. In case of serious infractions of the learning environment policy, the instructor will file an incident report with the divisional dean. The divisional deans will review the incident report and take appropriate action, which may include dropping the student from the class, or, in extreme cases, suspension or expulsion from the college. Due process will be followed, and students may appeal such decisions by contacting the Vice President for Academic Affairs. The content of speech or written work protected by academic freedom shall not be considered disruption or misconduct.

Details for Schulze BIOL 115:

I expect you to behave like a professional at a meeting. Pay attention when someone else is speaking. Do not leave during class unless an emergency occurs. Professionals do not engage in small talk or giggle with their coworkers during meetings. To do so distracts the speaker and other participants and causes those engaged in the behavior to miss others' comments. Silence your phone or turn it off before coming to class. Do not read or send text messages during class. Use a phone during class only if I request that you do so. If you expect an emergency communication during class, let me know ahead of time and sit near the door so you can duck out. Any other communication can wait.

If you view a cell phone or other electronic device during a quiz or exam, I will assume you are cheating, assign a grade of zero for the quiz or exam and may drop you from the course or assign a failing grade. I will not accept the excuse that you were checking the time. There is usually a clock on the wall. If you do not see a clock and you do not wear a watch, ask me the time if you are wondering.

If at all possible, avoid the need to use a restroom during an exam. If you have no choice, then make a request and go ahead, but **leave your cell phone on your desk** and recognize that <u>you invite suspicion by using a restroom during an exam</u>.

<u>Asking and responding to questions during class</u>

I encourage you to ask and respond to questions during class. Please raise your hand to ask or offer to answer a question. If you are shy or nervous about asking or answering questions or think asking or answering questions will give some sort of bad impression to your peers, try to overcome your fear or concern, or participate despite it.

If, on the other hand, you are routinely willing to answer questions and have already answered many questions during the semester, I will signal you to hold off to give others an opportunity, or at least allow more time for the rest of the group to ponder a question. If you ask a disproportionate number of questions, I will ask you to hold the rest of your questions until after class.

<u>Taking notes</u>

I will provide specific suggestions about taking, improving, and studying notes during one of the first sessions.

Accumulating evidence suggests that, for people who can do so, <u>taking notes by hand results in better understanding than taking notes on a laptop</u> (Mueller & Oppenheimer, 2014, Psychological Science, 25:1159-1168). *I encourage you to take notes by hand rather than with a computer*. If you use a computer, then at the very least do not attempt to “multitask” during lectures.

If you use a laptop or tablet during class, I may ask you to show me your computer screen at any time. This is because some students have surfed the net during class, distracting other students in the process.

The course schedule begins on the next page

Schedule

Potential modifications to this syllabus: If it becomes necessary to revise this schedule or other aspects of this syllabus, I will distribute revised copies as feasible and explain any changes during the following class session.

Evolution

Wed 23 Aug	Welcome. What is my responsibility? What is your responsibility? Introduction of Teaching Assistant Vernon Ng Moodle Why the topics of this course? What is evolution? What is natural selection?
Fri 25 Aug	1. AppStream user identification. 2. How to study and learn – discussion Read: Grant, A. 2019, How to improve your memory (even if you can't find your car keys), https://www.nytimes.com/2019/04/12/smarter-living/how-to-improve-your-memory-even-if-you-cant-find-your-car-keys.html. This article is from the *New York Times*. You have access to the *New York Times* through Abell Library. See access instructions here: https://aclibrary.austincollege.edu/nytimespass *I like Grant's suggestions, but I would not refer to the method he recommends as 'memorizing' and I do not find his bartender example helpful. I would call his recommended method "learning", as in developing enough understanding to be able to explain something. Commitment of some details to memory occurs in the process, but I consider the process different from, say, memorizing a random list of numbers or some other process where the concept of 'explanation' is irrelevant.*

	Prior to today's class, study the handout "Notes and Studying" (Moodle) and the accompanying example of excellent notes produced by a former student in this course. Imagine having notes this good when studying for an exam. (Moodle).
Mon 28 Aug	Evolution, artificial selection, natural selection, and their evidence Read: Chapter 18 sections "Introduction" and 18.1 of the OpenStax text Biology 2E. See the "Readings" section earlier in this syllabus for instructions on obtaining this free book.
Wed 30 Aug	1. Seating chart 2. Evolution, artificial selection, natural selection, and their evidence (continued) Read each of the following three articles. Each provides an example of evolution. The articles are from the *New York Times*. You have access to the *New York Times* through Abell Library. See access instructions here: https://aclibrary.austincollege.edu/nytimespass Attack of the superweeds: https://www.nytimes.com/2021/08/18/magazine/superweeds-monsanto.html Evolution of breath-holding ability in humans: https://www.nytimes.com/2018/04/19/science/bajau-evolution-ocean-diving.html Evolution of arsenic tolerance in humans: https://www.nytimes.com/2015/03/13/science/an-unlikely-driver-of-evolution-arsenic.html
Fri 1 Sep	No class today. Use the time productively.
Mon 4 Sep	No class today. Use the time productively.
Wed 6 Sep	1. Good vs. poor essay answers (see Moodle file "Bio 115 essay answer examples") (Moved to this Friday's session). 2. Evidence for evolution – continued **3. Discussion** – What is the evidence for evolution? Why are those things considered evidence for evolution? - Work with your group to make a list of the types of evidence for evolution by natural selection (note: type ≠ example, what is the difference?) - Describe one or more examples for each type of evidence.

	- Then develop a brief explanation of why each example is consistent with the theory of evolution by natural selection. - Be prepared to explain your responses to the class.

Fri 8 Sep	**Prior to class:** Create an account and prepare to access the SimUText application, either by downloading it to your laptop or learning how to run it through AppStream2.0 if you use a Chromebook. 1. Trust – discussion 2. Good vs. not so good essay answers. (Moved from Wednesday) 3. During class: introduction to SimUText simulations and work on the set of simulations called ***Darwinian Snails.*** *[5 points possible for whichever correctly-completed workbook page image I request later (with handwritten/hand-drawn answers) & 10 points possible for online questions.]* *This and all other simulations are due at midnight on the date that is two <u>class</u> days later, so for example, this one is due at midnight on Wed 13 Sep.*
Mon 11 Sep	**1. Quiz #1** (15 min, 20 points) based on material covered so far during class sessions and the associated reading material. 2. Natural selection and other natural processes that cause evolution. Read: Chapter 19. *Note: you are not responsible for the section on the Hardy-Weinberg Principle of Equilibrium or the associated material in chapter 19 figure 19.2.* Outside of class: **Run the simulation *Finches and Evolution.*** *[5 points possible for whichever correctly completed workbook page image I request later (with handwritten/hand-drawn answers) & 10 points possible for online questions.]*
Wed 13 Sep	Natural selection and other natural processes that cause evolution (continued).
Fri 15 Sep	**Before today's class:** **1.** Solve the puzzle at the following link, then read the accompanying article. http://www.nytimes.com/interactive/2015/07/03/upshot/a-quick-puzzle-to-test-your-problem-solving.html

	2. Read paragraph 2, p. 44 through paragraph 3, p. 46 and paragraph 2, p. 73 through paragraph 3, p. 76 of the (my) book *Obstacles to Environmental Progress*. These passages are about fundamental aspects of hypothesis testing. They are in the context of the book's larger topic, not this course's topic, but hopefully you will find them instructive. You may download the book for free here: https://www.uclpress.co.uk/products/186377. (The open access OpenStax text for this course has some material on the scientific method in its first chapter, but there are serious errors in that material. I do not recommend reading it because it could cause substantial confusion.) During class: 1. How science works– discussion 2. **Run the simulation *Understanding Experimental Design.*** *[Some other simulations involve a workbook, but this one does not. It uses an online dialog between you and the computer software. Online feedback prompts (5 pts) and graded questions (10 pts)]*
Mon 18 Sep	1. Natural selection and other natural processes that cause evolution (continued). 2. Review. Outside of class: **Run the simulation *How the Guppy Got Its Spots.*** *[5 points for Workbook page image I request later, 10 for online questions.]*
Wed 20 Sep	**1. Quiz # 2,** (15 minutes, 20 points) based on material covered from the first day of class through the previous class period. 2. Genetic diversity in populations Read: Chapter 19. **Run the simulation *Genetic Drift & Bottlenecked Ferrets.*** *[No Workbook. Online feedback prompts (10 pts) and graded questions (5 pts)]*
Fri 22 Sep	Plants and pollinators – data collection **Before lab: Read and carefully study** the document "BIOL 115 Pollination lab 2023" (Moodle). **Also**, if you have a smartphone,

	download the file "BIOL 115 Flower Guide" (Moodle) to your phone. Arrive at class with a good understanding of the lab procedure.
Mon 25 Sep	1. Quiz preparation effectiveness discussion. Answer these questions. How did you study for the quiz? Was that how you intended to study? If not, what was the difference? Were you confident that you were ready for the exam? Have you identified any ways to improve your methods for studying and learning? Would you change your preparation procedure next time? If so, how? Speciation (how new species arise) Read: Chapter 18.2 & 18.3 **Run the simulation *Flowers and Trees*.** *(5 points for Workbook page image I request later, 10 for online questions.)*
Wed 27 Sep	History and future of biological diversity 3 domains of life, the endosymbiont hypothesis, and major events in the history of life on earth Read: 1. Chapter 20 sections 20.1 and 20.3 2. Chapter 27 section 27.4 3. Chapter 47.1 section Biodiversity Change through Geological Time
Fri 29 Sep	What to look for when interpreting the results of an experiment
Mon 2 Oct	Review for exam
Wed 4 Oct	**Mid-term exam #1 (100 points)**
Fri 6 Oct	Fall break
Mon 9 Oct	No class
Wed 11 Oct	Evolutionary ancestry of humans & evolutionary misconceptions Read: 1. Chapter 29.7 2. http://humanorigins.si.edu/evidence/human-family-tree 3. https://humanorigins.si.edu/evidence/human-fossils/species/homo-naledi 4. The material in the first two bulleted lists at this page ("Misconceptions about evolutionary theory and processes," and "Misconceptions about natural selection and adaptation"): https://evolution.berkeley.edu/evolibrary/misconceptions_faq.php#a8

	Run Exercises 1-5 (not 6) of the simulation Domesticating Dogs. *(Workbook & graded online questions.)* *(5 points for workbook page image I request later, 10 for online questions.)*
Thu 12 Oct	*Last day to change a course from letter grade to pass/fail or vice-versa & last day to drop a course with no record on your transcript.*
Fri 13 Oct	How statistics work

Ecology and Behavior

Mon 16 Oct	Ecology introduction, climates, and biomes Read: Chapter 44
Wed 18 Oct	Population ecology: Niches, dispersal, distribution, metapopulations, life history, and population growth Read: Chapter 45.1-45.3
Fri 20 Oct	Plants and pollinators – data analysis
Mon 23 Oct	Population Ecology Intraspecific competition Human population size and growth Read: Chapter 45.4-45.5 Community Ecology: The realized niche, competition, and predation Read: Chapter 45.6 **Run the simulation *How Diseases Spread.*** *[No Workbook. Online feedback prompts (10 pts) and graded questions (5 pts)] Revised due date: Monday, 6 November*
Wed 25 Oct	Community Ecology: Succession, disturbance, & species diversity Read: Chapter 45.6 Read Leopold, A Sand County Almanac essay titled *Thinking Like a Mountain*. This is the book on permanent reserve that you used for the previous class session's reading. **Run the simulation *Intermediate Disturbance Hypothesis.*** Note: As usual, I do not expect you to write the paper that described on page 11 of the workbook, but I do expect you to complete the optional material on p. 8 and run the experiment you propose (p. 11). Record

	your experiment's results in the blank space on the next page and add one paragraph describing your conclusions. Also, do not skip sections 14.1 and 14.2 based on the two-dimensional graphs on workbook p. 7. *[5 points for Workbook page image I request later, 10 for online questions.] Revised due date: Friday, 10 November*
Fri 27 Oct	Growth rates of Michigan and Texas trees – data collection **Pollinators lab report due midnight tonight, individually authored.** Submit as a Word file attached to an email sent to pschulze@austincollege.edu. (Do not submit through Moodle).
Mon 30 Oct	Catch up, review, discussion
Wed 1 Nov	***Mid-term exam #2 (100 points)***
Thu 2 Nov	*Last day to drop a course with a W (withdrawn) grade recorded on your transcript.*
Fri 3 Nov	Growth rates of Michigan and Texas trees – data analysis
Mon 6 Nov	Behavioral Biology Why animals behave the way they do Innate behaviors, learned behaviors, and communication Interaction between evolution, ecology, and behavior Read: Chapter 45.7
Wed 8 Nov	Dynamics of Ecosystems Energy flows Read: Chapters 46.1- 46.2
Fri 10 Nov	Lab report organization and work on tree growth lab report
Mon 13 Nov	Dynamics of Ecosystems Cycles of elements Read: 1. Chapter 46.3 2. Leopold, *A Sand County Almanac*, essay titled *Odyssey*. This book is on "permanent reserve" under Schulze. Ask for it at the library circulation desk. Let the librarian or student worker know the book is on "permanent reserve" under "Schulze," not under BIOL 115.
	Synthesis & Implications

Wed 15 Nov	Human – environment interactions
	    Ecosystem services
	    Sustainability
	    Habitat protection and restoration
	
	Read: Chapter 47
	Watch: *Welcome to the Anthropocene* https://vimeo.com/39048998
	Calculate your Ecological Footprint:
	http://www.footprintcalculator.org/
	Read this International Geosphere-Biosphere Programme page on the Anthropocene
	http://www.igbp.net/globalchange/anthropocene.4.1b8ae20512db692f2a680009238.html

Fri 17 Nov	Continued work on tree growth lab report during in class. Prior to lab: Complete a draft report that is as good as you can make it without more help.
Mon 20 Nov	*Thanksgiving Break*
Wed 22 Nov	*Thanksgiving Break*
Fri 24 Nov	*Thanksgiving Break*
Mon 27 Nov	Catch up or review
Wed 29 Nov	Review of the main concepts of this course
Fri 1 Dec	Review for final exam
Tue 5 Dec	**Final Exam 3:00-5:00**

BIOL 115d

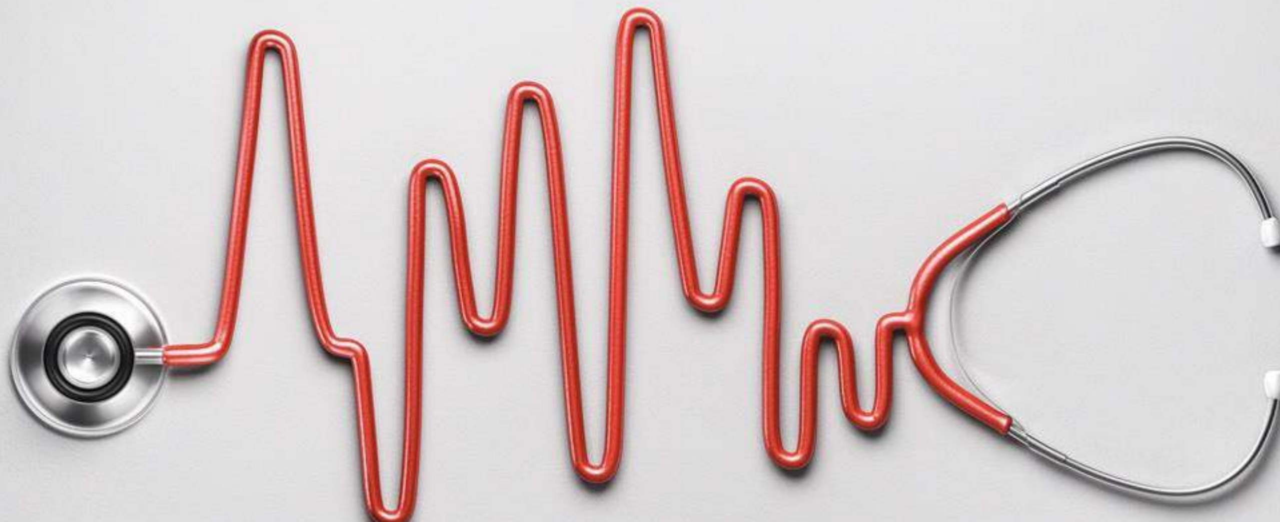
Evolution, behavior, and ecology

Peter Schulze
pschulze@austincollege.edu
IC 258
903-814-6945 (cell)

Who am I and what’s my job?

First Year Student Pre-Health Advising Sessions

If you are interested in a career in a health profession, you won't want to miss this



Where: IDEA Center 310

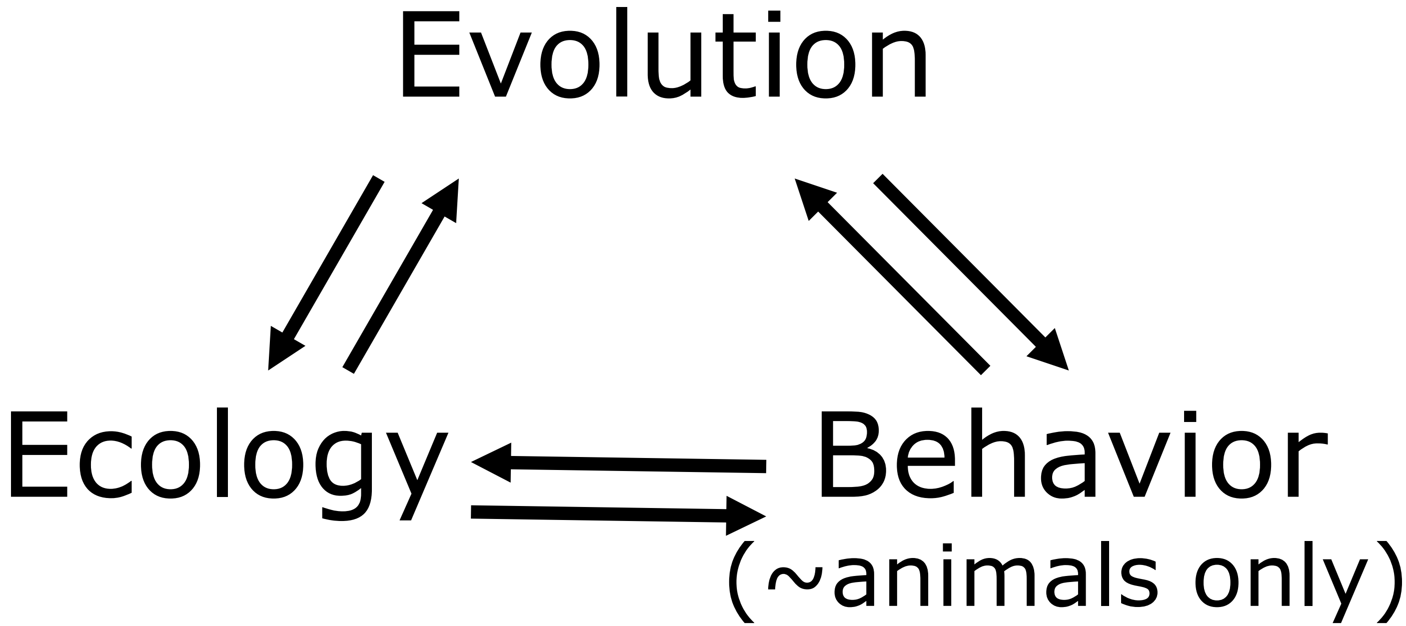
When: Sunday, August 27 2-3 pm or Monday, August 28 4:30-5:30 pm

Evolution, behavior, & ecology

What is evolution?
What is natural selection?

What is confusing, unclear, or seems impossible about evolution?

Why these topics in your first semester?

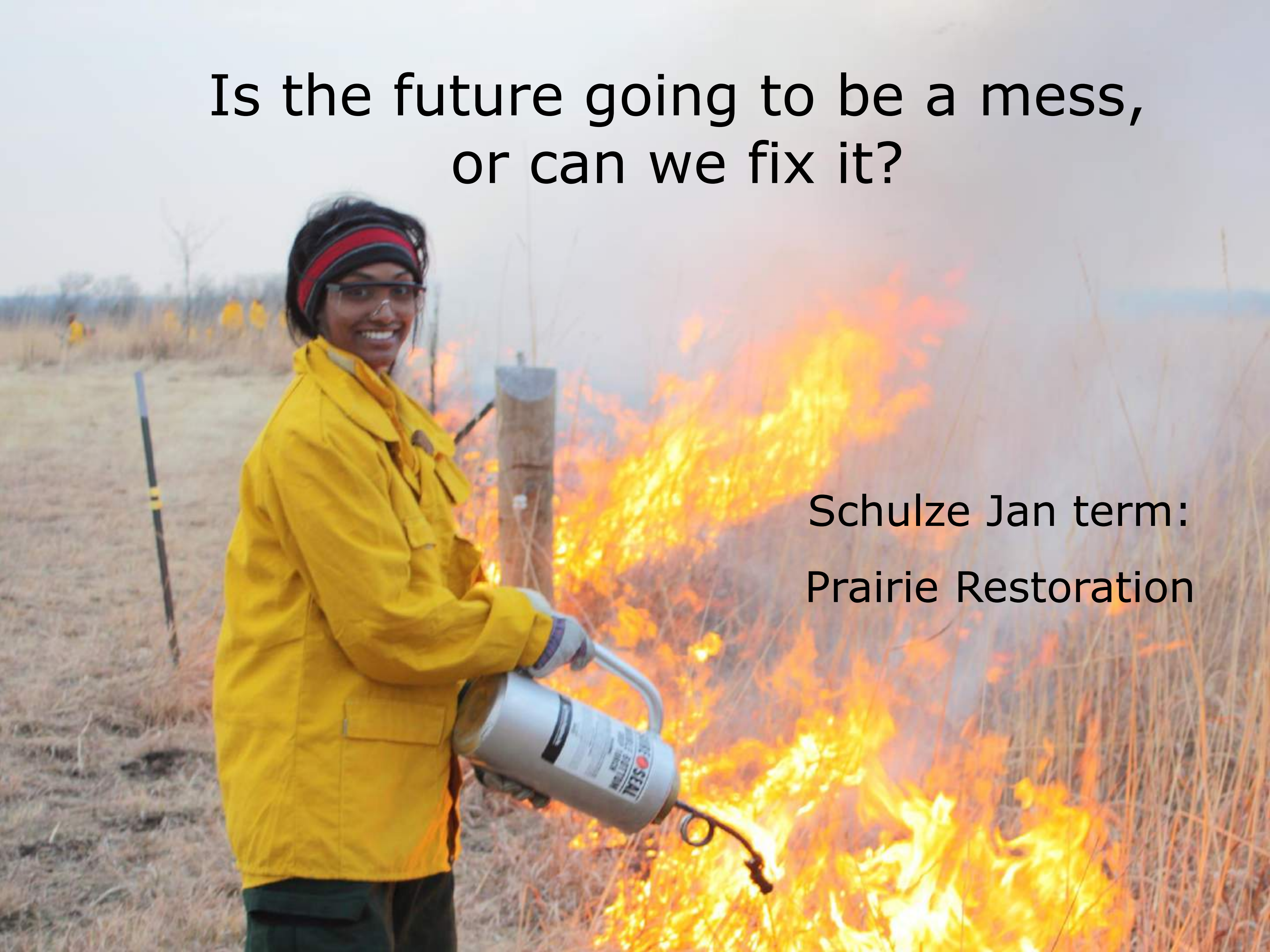

Evolution
Ecology
Behavior
(~animals only)

Ecosystem services

(things we get for free from ecosystems)

https://www.mining.com/wp-content/uploads/2016/10/six-months-after-wildfires-canadas-oil-sands-now-hit-by-di-caprios-new-movie.jpg, http://diplomatonline.com/mag/wp-content/uploads/2012/03/Diplomat_Dec100091.jpg

Is the future going to be a mess, or can we fix it?



Schulze Jan term:

Prairie Restoration

Evolution, artificial selection, natural selection, and their evidence

aka

What is evolution & how does it work?

Take a few minutes (without talking) to

1. List concepts/phenomena/ideas that occur to you about evolution or ecology. (3 min)

2. On the other side of the page make a diagram connecting related concepts (3 min)

3. Wherever it fits (3 min)
   Write 3 or more questions about evolution.

4. Add your name to the top of one page.
   Don’t worry – this will not be graded.

Evolution:

Lots to say about how things got to be this way.

Bacteria photo source: mentalfloss.com

Outline

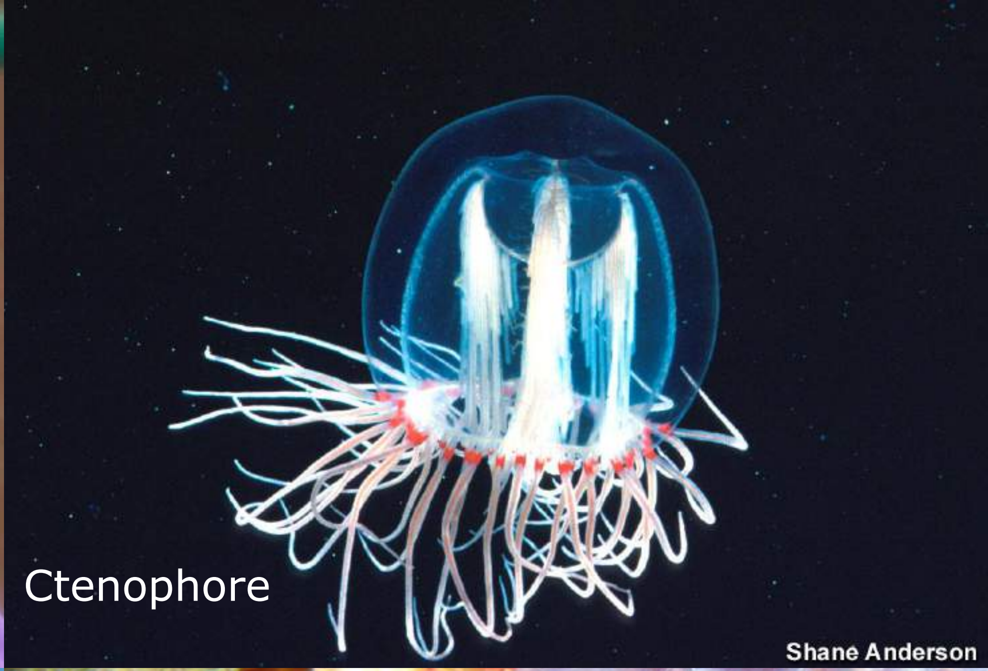
Evolution - 3 circumstances & 2 consequences

Observations of evolution in progress

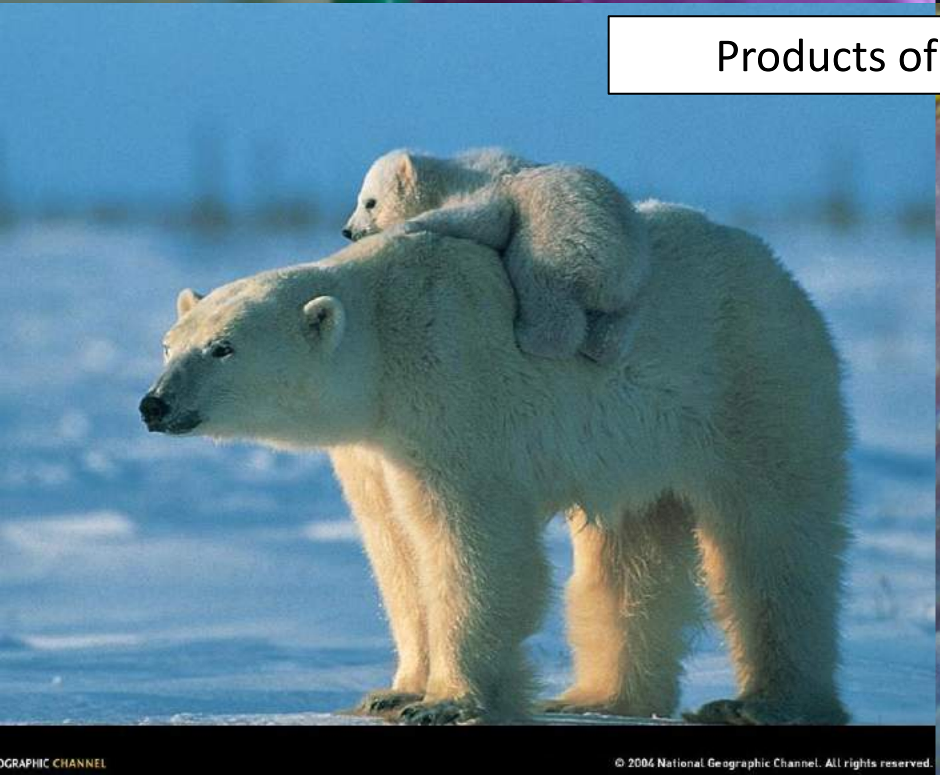
- artificial selection: intentional
- artificial selection: unintentional
- beak depths of Galapagos finches
- stickleback armor

Evidence of past evolution

- fossils
- molecular homologies
- anatomical homologies
- convergent evolution
- species diversity on archipelagos



Products of evolution



Evolution: definition

A change in the composition of a gene pool.

Gene pool = all of the genes in a population of a species.

Gene = a unit of heredity.

Population = a group of members of the same species with opportunities to interbreed.

Evolution

How to get from the ancestors of algae to Olivia

Dr. Jeremy Burgess/SPL/Photo Researchers, Inc.

The theory of evolution explains:

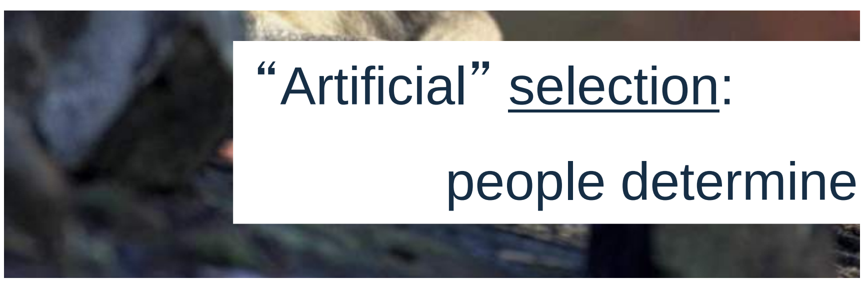
1. how species change

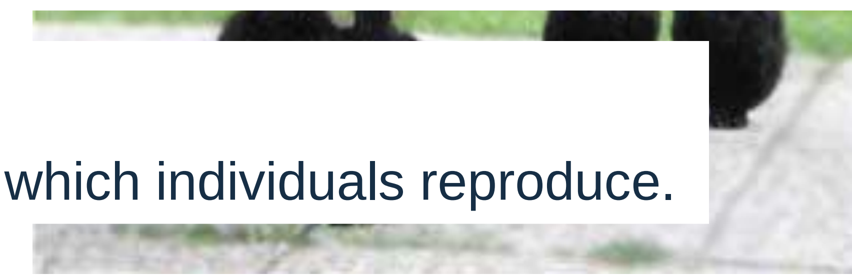
2. how new species arise

It does not explain how life got started.

How does dog breeding work?

Charles Darwin called evolution “descent with modification”





“Artificial” selection:

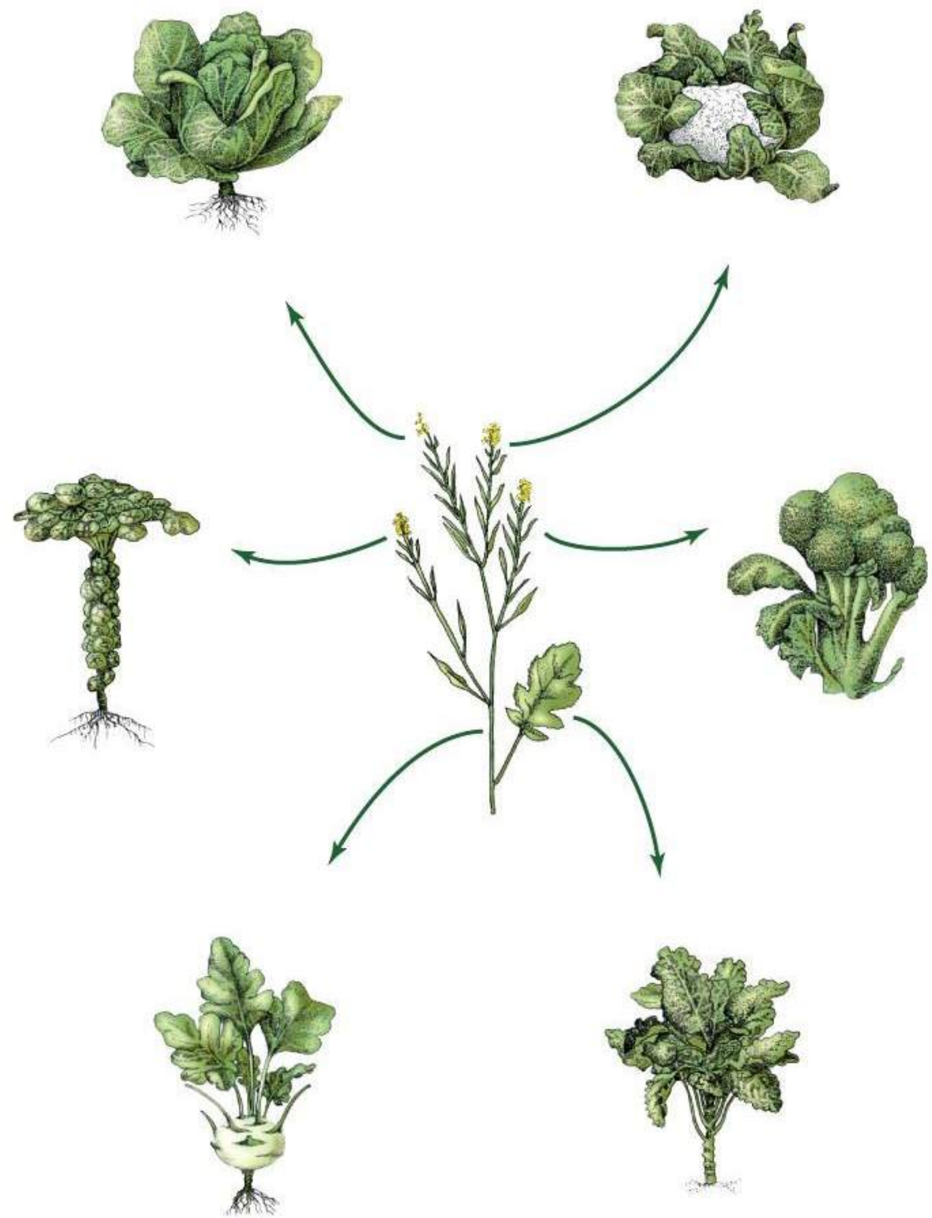
people determine which individuals reproduce.

Some individuals survive & reproduce, others don’t.

http://www.takeourword.com/TOW207/page2.html

Artificial selection in agriculture:

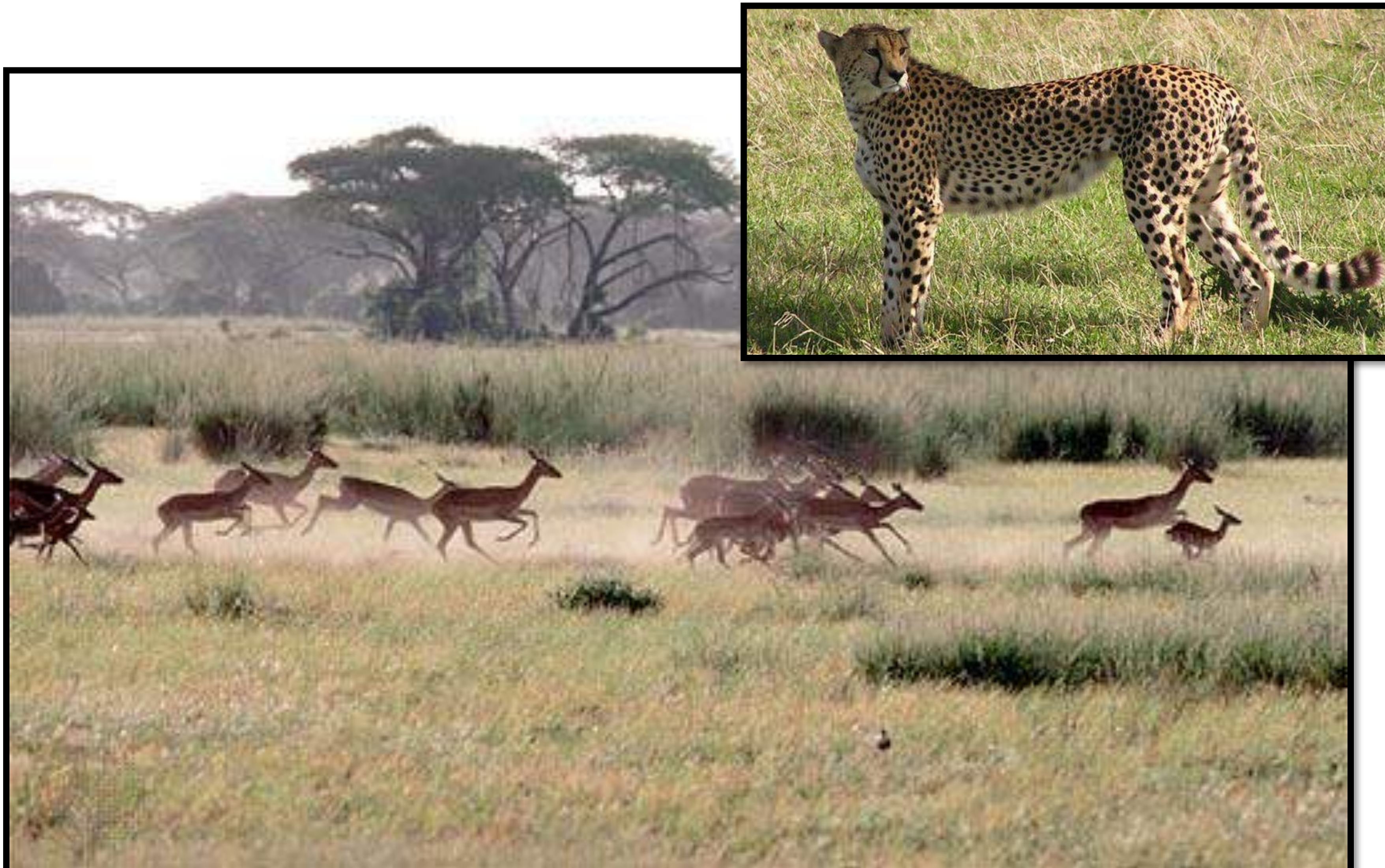
6 vegetables
from one ancestor.



PRINCIPLES OF LIFE, **Figure 15.4**

Natural selection:

natural, ecological processes determine which individuals survive & reproduce.



http://www.branchy.com/photos/africa/2004.01.07.07.47.40_cheetah.jpg

The 3 circumstances that routinely occur in nature

lead to the inevitability of natural selection

which in turn results in evolution.

1. More are born than the environment can support

http://www.mchenrycountyblog.com/uploaded_images/Crystal-Lake-on-Duck-and-10-ducklings-at-Gate-7-beach-721198.jpg

2. Individuals are not identical

(Usually inadvisable to use people for examples of general biological phenomena, but we are good at seeing differences in our appearances.)

3. Some of the variation among individuals is heritable (rooted in genes)

3 circumstances

1. More born than environment can support

2. Individuals not identical

3. Some variation among individuals heritable

2 consequences of those 3 circumstances

1. Individuals best suited to the environment are most likely to leave offspring (<u>natural selection</u>).

2. Because only the reproducers leave genes in the next generation, *the composition of the gene pool changes* (<u>evolution</u> happens).

https://commons.wikimedia.org/wiki/File:Black-footed_Ferret_Learning_to_Hunt.jpg

Break: Some old quiz questions

Describe and explain the effect of droughts caused by El Niño on bill sizes of *Geospiza fortis* finches on Daphne Island in the Galapagos.

Evolution occurs so that
___ species become better adapted to their environments.
___ species do not go extinct.
___ individuals survive and reproduce.
___ more advanced species arise.
___ all of the above.
___ none of the above.

What must you be able to do to be confident that the results of a blood test are correct or that electrical work done on your home is safe? (Answer this question with no more than one sentence <u>based on a topic we have discussed during class</u>).

Tons of evidence for evolution

<u>Some</u> of the real-time evidence:

- Artificial selection
  - Intentional artificial selection
  - Unintentional artificial selection
- Natural selection
  - Beak depths of Galapagos finches
  - Armor of stickleback fish

Resistance to antibiotics
(unintentional artificial selection)

Why take all your antibiotics

rather than stop when you feel better?

Pest resistance to pesticides

Warfarin resistant rats

17 species of insects resistant to all major classes of pesticides.

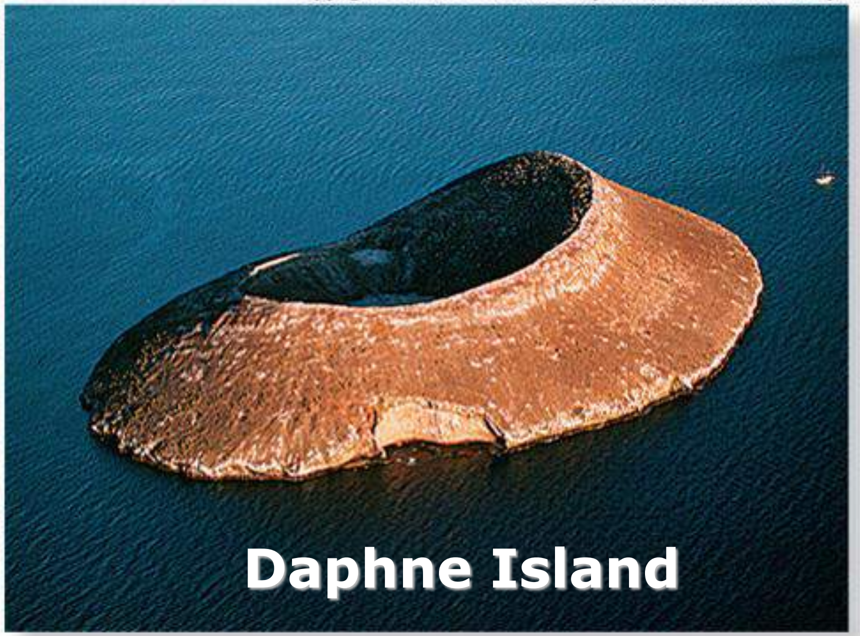
Bellinger Fact Sheet, Clemson

Why do commercially-harvested fish become reproductively mature at smaller sizes than previously

- Fishing often regulated to take largest fish
- Individuals that do not reproduce until large leave no offspring
- Individuals that reproduce early leave some offspring
- Artificial selection for reproducing when small

Science News, 26 Feb 2005 p. 133.

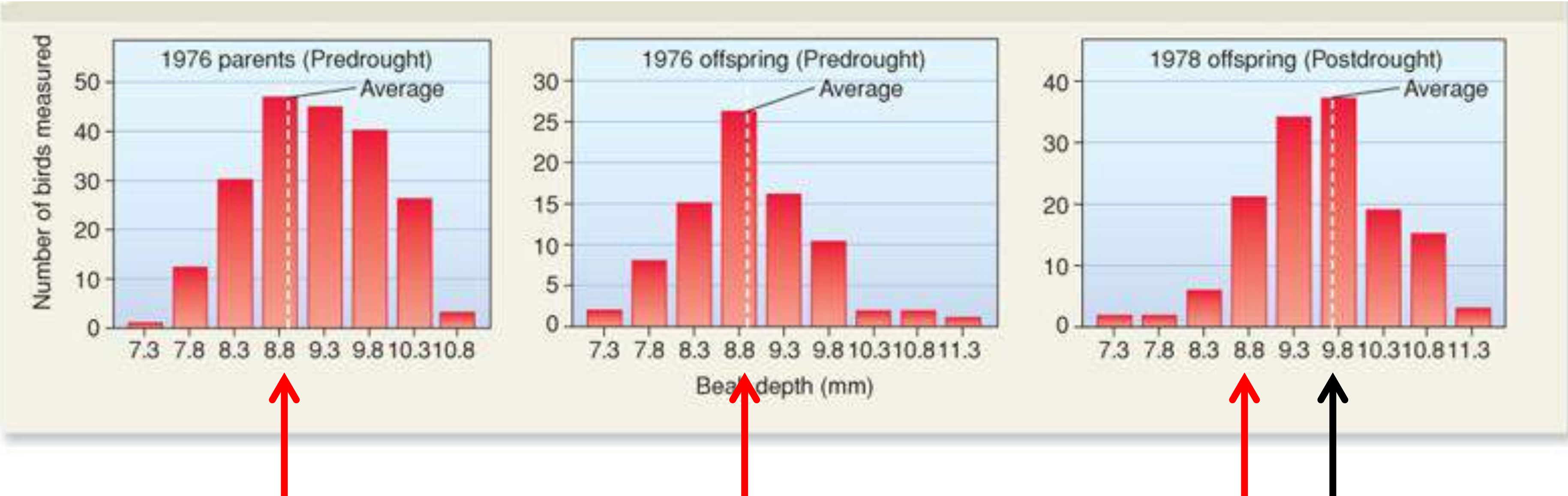
Changes in beak depths of Galapagos finches following drought



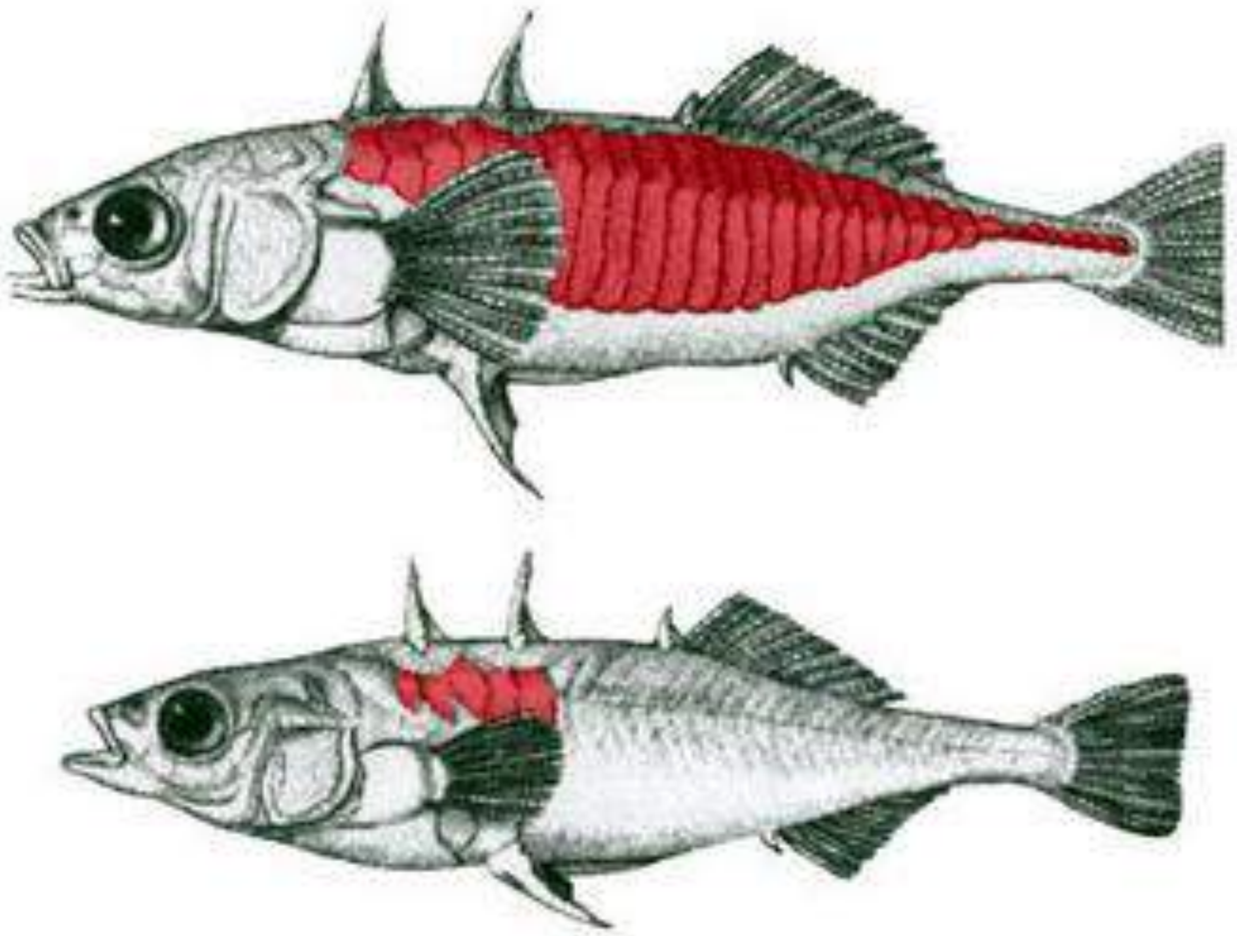
Drought on the Island:

1. the few available seeds tend to be large
2. birds with small bills cannot eat large seeds
3. many birds with small bills don’t survive
4. next generation of offspring mostly from large-billed parents
5. shift to larger bill sizes among population

Direct measurement of evolution as it occurs.



Armor of 3-spined stickleback



Ocean population

Lake populations

Review:
Observations of evolution in action

- Intentional artificial selection
- Unintentional artificial selection
- Galapagos finch bill depths
- 3-spined sticklebacks armor

Can you explain these examples and how they support the theory of evolution by natural selection?

Try it later. Try writing explanations.

Historical evidence <u>consistent</u> with evolution by natural selection

Descent with modification from a common ancestor

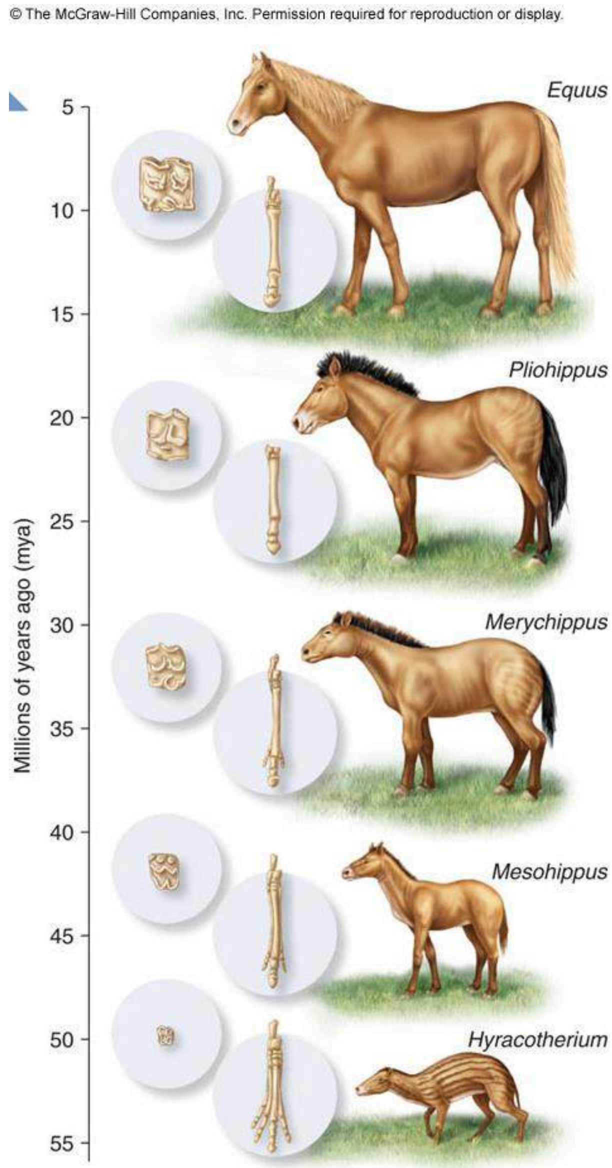
- Fossils
- Anatomical homologies
- Molecular homologies
- Convergent evolution
- Species diversity on archipelagos

(After we get through these slides and you study this material, make sure you can explain each of these.)

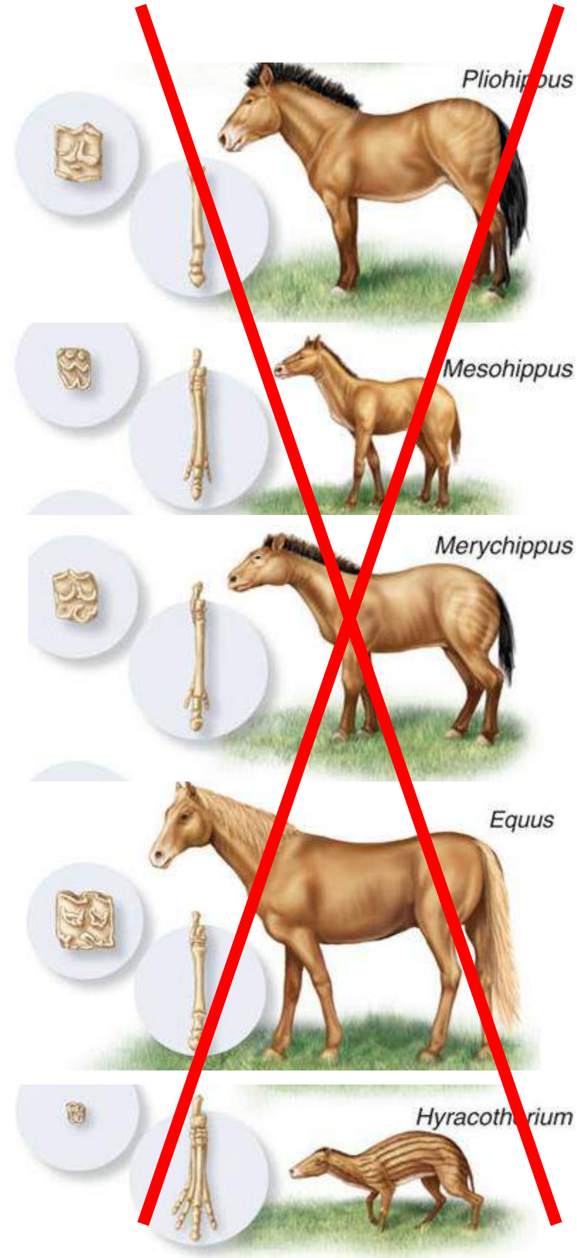
Sequential change in fossils, with many intermediates.

The sequence on the right, if observed, would have been inconsistent with the hypothesis of evolution by natural selection.

Observed sequence

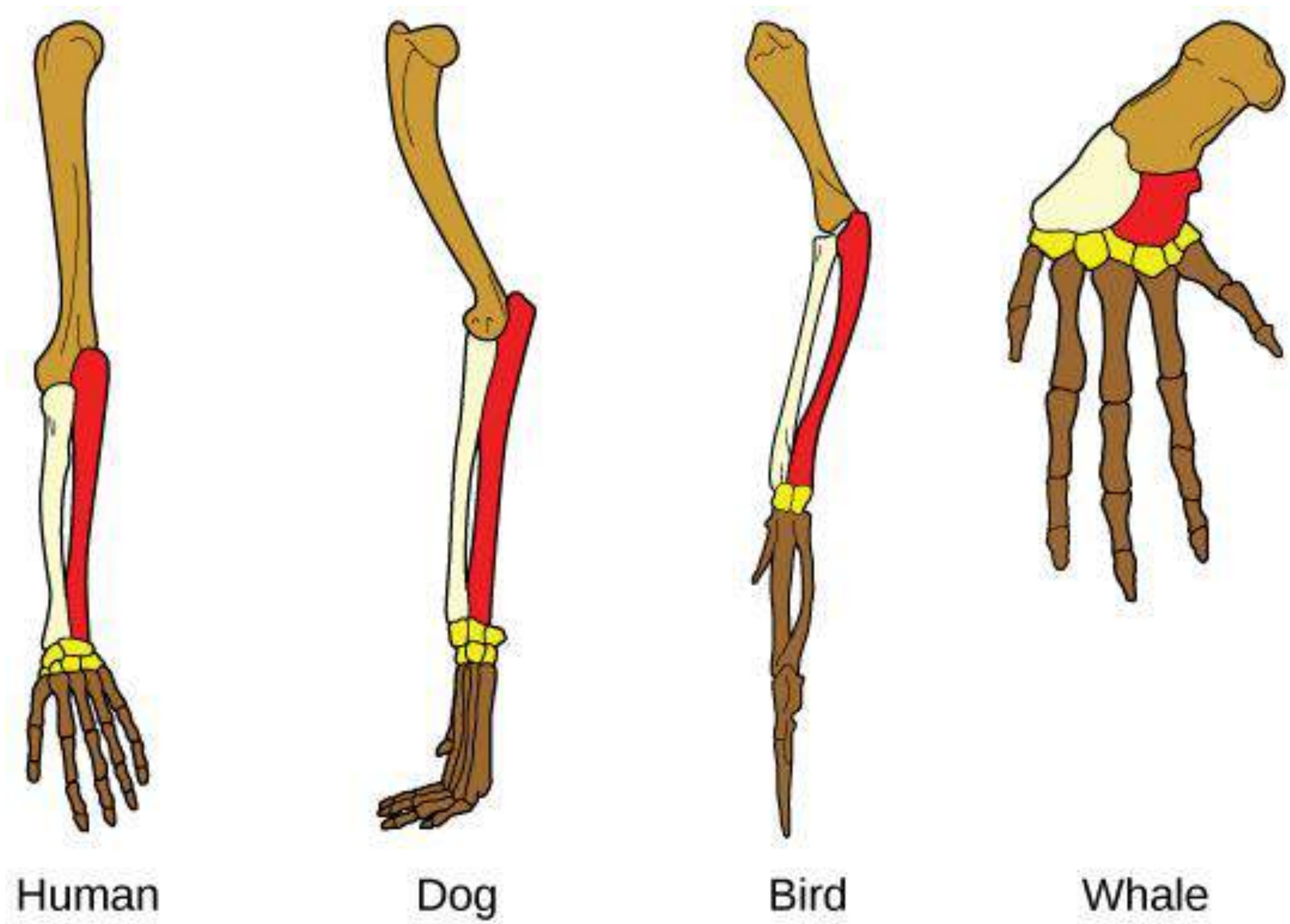


Possibility not observed



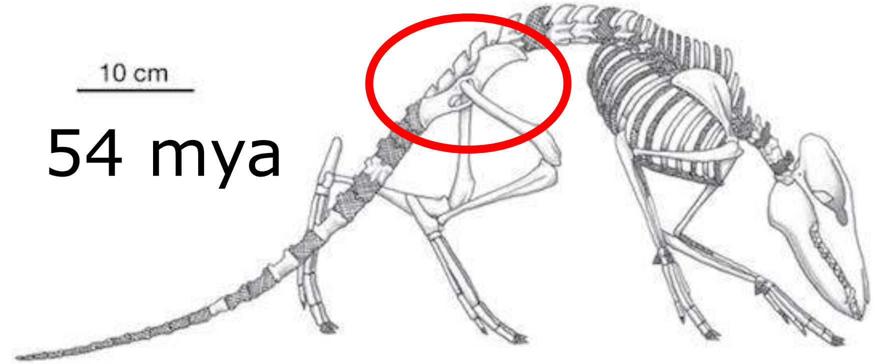
Homology: similarity that results from descent from common ancestor.

<u>Anatomical</u> homology example: radius and ulna play different roles in different creatures, but have similar structures.



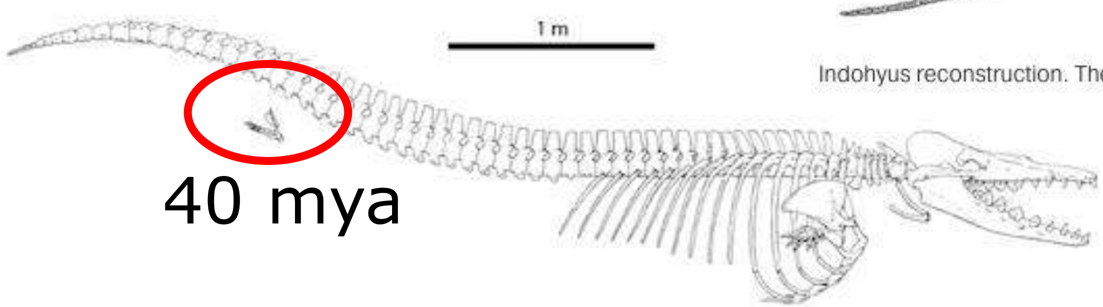
Anatomical homologies: vestigial hip bones of whales

54 mya

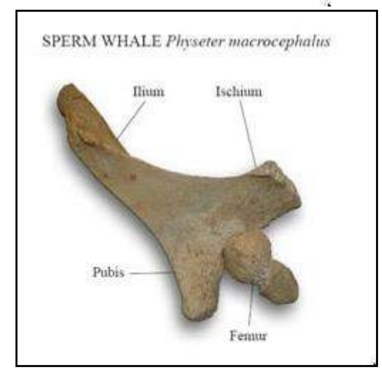


Indohyus reconstruction. Thewissen et al. Nature 2007. 450, 1190-1194

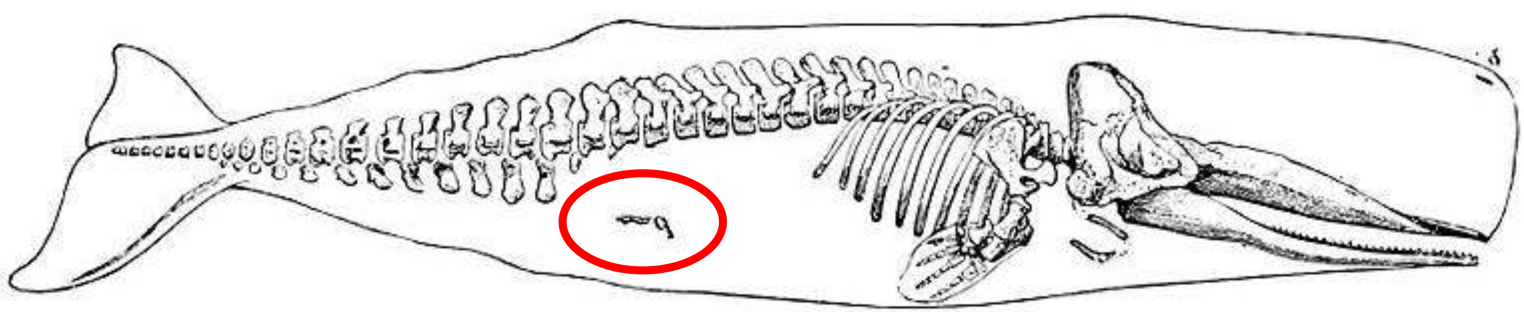
40 mya



Dorudon. From M. Uhen, Annu. Rev. Earth Planet. Sci. 2010. 38:189–219



Today



Carl Zimmer, National Geographic, undated, http://phenomena.nationalgeographic.com/2014/09/05/the-erotic-endurance-of-whale-hips/. Hip bone photo: http://um.uib.no/fagsider/osteologi/hvaler/e_bekken.htm

<u>Molecular</u> homology: Amino acid sequences. Human sequence most similar to similar species.

Human (*Homo sapiens*)	Val	Pro	Ser	Gln	Lys	Thr	Tyr	Gln	Gly	Ser	Tyr	Gly	Phe	Ar
Rhesus monkey (*Macaca mulatta*)	Val	Pro	Ser	Gln	Lys	Thr	Tyr	His	Gly	Ser	Tyr	Gly	Phe	Ar
Green monkey (*Cercopithecus aethiops*)	Val	Pro	Ser	Gln	Lys	Thr	Tyr	His	Gly	Ser	Tyr	Gly	Phe	Ar
Rabbit (*Oryctolagus cuniculus*)	Val	Pro	Ser	Gln	Lys	Thr	Tyr	His	Gly	Asn	Tyr	Gly	Phe	Ar
Dog (*Canis familiaris*)	Val	Pro	Ser	Pro	Lys	Thr	Tyr	Pro	Gly	Thr	Tyr	Gly	Phe	Ar
Chicken (*Gallus gallus*)	Val	Pro	Ser	Thr	Glu	Asp	Tyr	Gly	Gly	Asp	Phe	Asp	Phe	Ar
Channel catfish (*Ictalurus punctatus*)	Val	Pro	Val	Thr	Ser	Asp	Tyr	Pro	Gly	Leu	Leu	Asn	Phe	Th
European flounder (*Platichthys flesus*)	Val	Pro	Val	Val	Thr	Asp	Tyr	Pro	Gly	Glu	Tyr	Gly	Phe	Gl
Congo puffer fish (*Tetraodon miurus*)	Val	Pro	Val	Thr	Thr	Asp	Tyr	Pro	Gly	Glu	Tyr	Gly	Phe	Ly

Amino acids are the building blocks of proteins

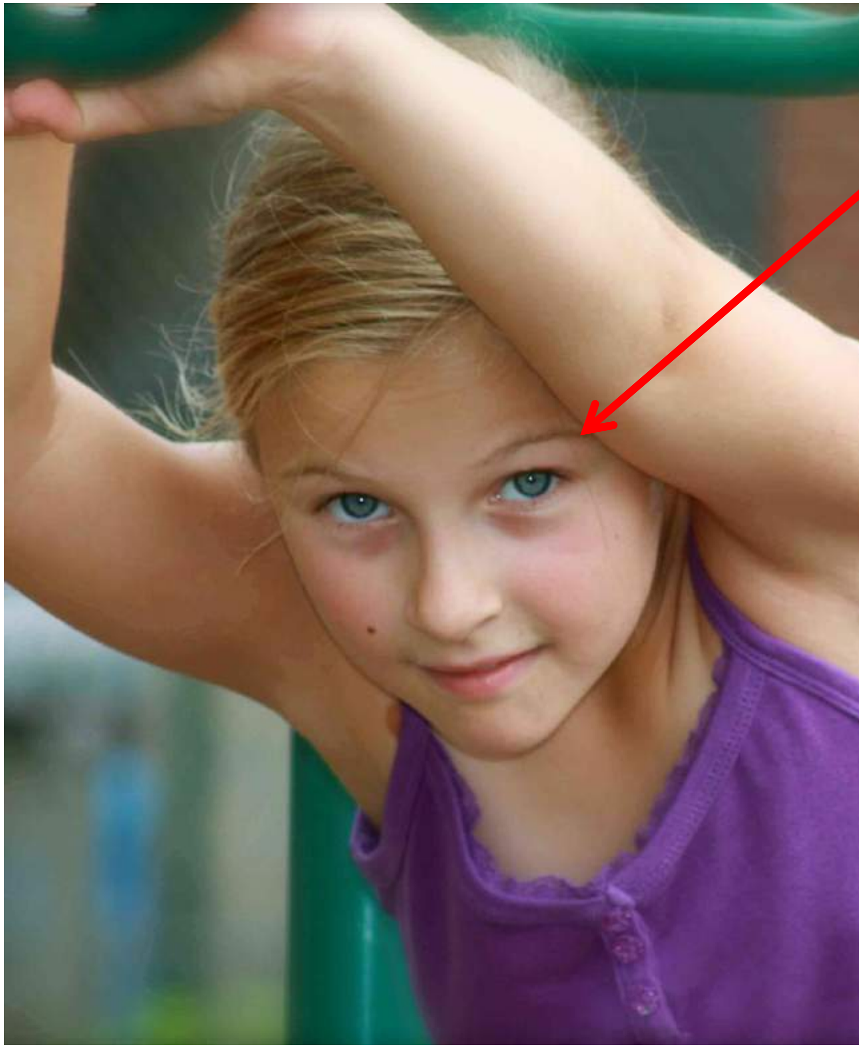
Convergent evolution: dissimilar organisms (without a recent common ancestor) subjected to similar selective forces develop similar adaptations.

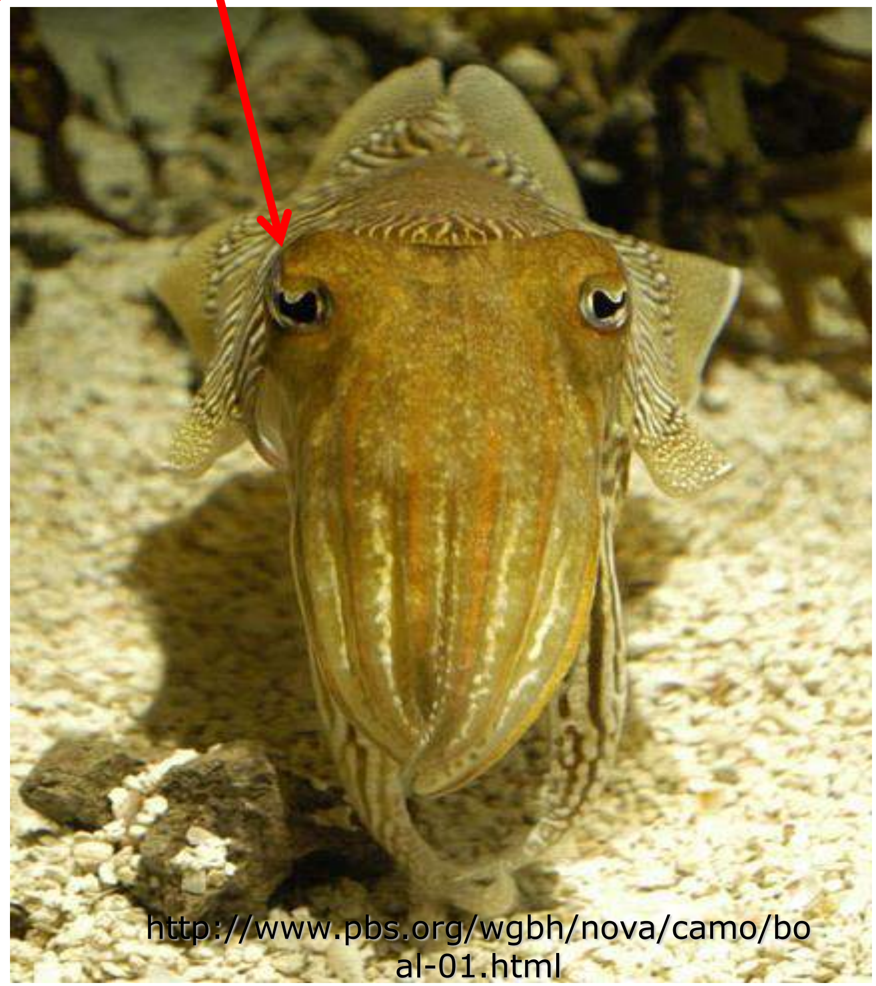
Similar overall shape (because convergent), but not similar internal anatomy (because different ancestors)

http://whaleswimming.com/
http://www.mirror.co.uk/news/world-news/video-swimmer-riding-shark-ocean-1744125

Convergent Evolution: eyes

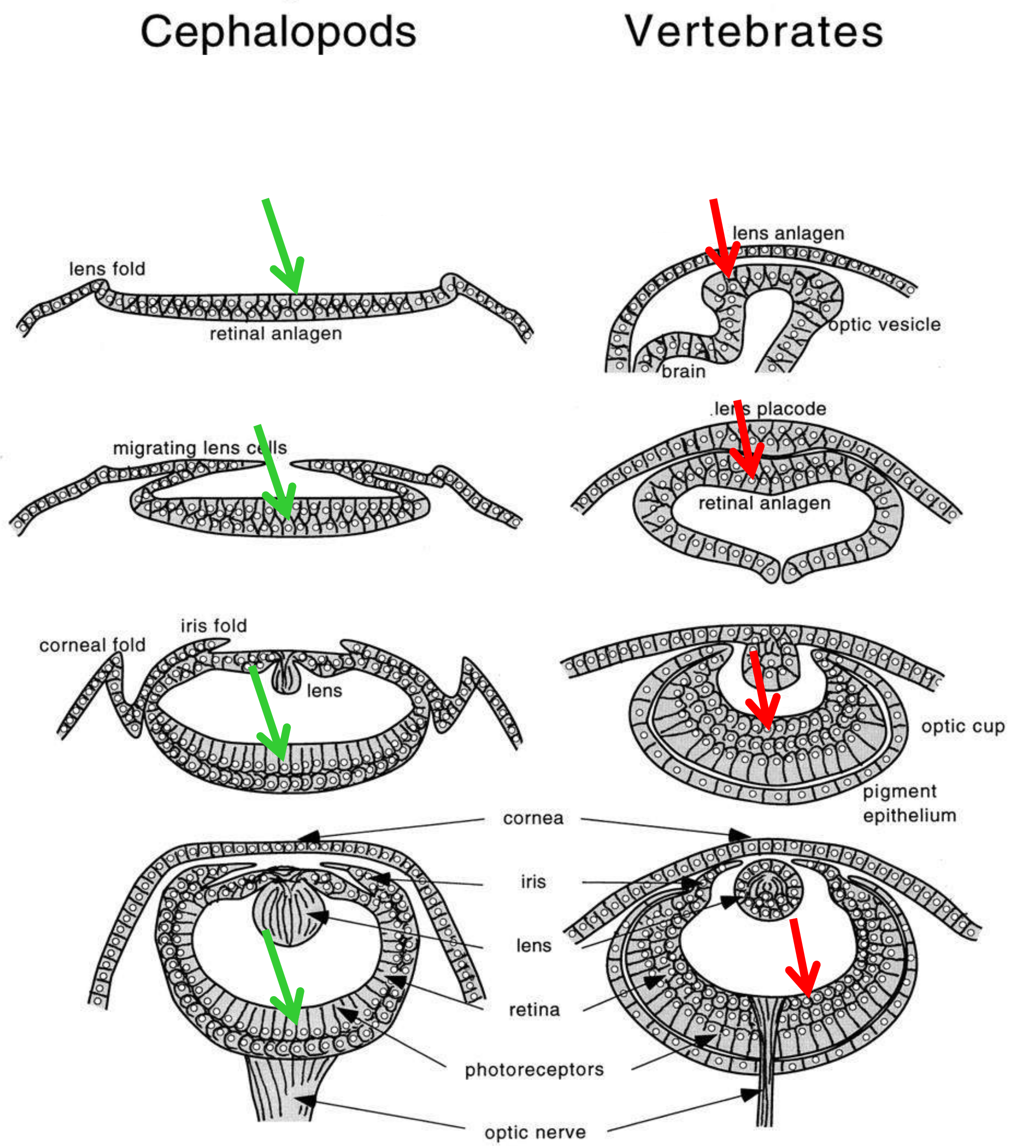
Similar adaptations independently evolved





Eye Formation in

Octopus
retina forms from
epidermis
(eventual skin,
outer layer)



Vertebrate
retina forms from
neural tissue
(eventual nervous
system, inner
layer)

Harris W A PNAS 1997;94:2098-2100

Historical evidence consistent with evolution by natural selection

Fossils

Molecular homologies

Anatomical homologies

Convergent evolution

Species diversity on archipelagos

Study carefully: different aspects of the same pair of species can provide examples of both

Bat

Bird

Anatomical homologies: bone structure (distant, non-flying ancestors)

Convergent evolution: wings (skin vs. feathers – more recent evolution)

http://upload.wikimedia.org/wikipedia/commons/3/38/Homology.jpg

Species diversity on archipelagos

http://www.birdsofoklahoma.net/images/HouseFinch0709-1.jpg

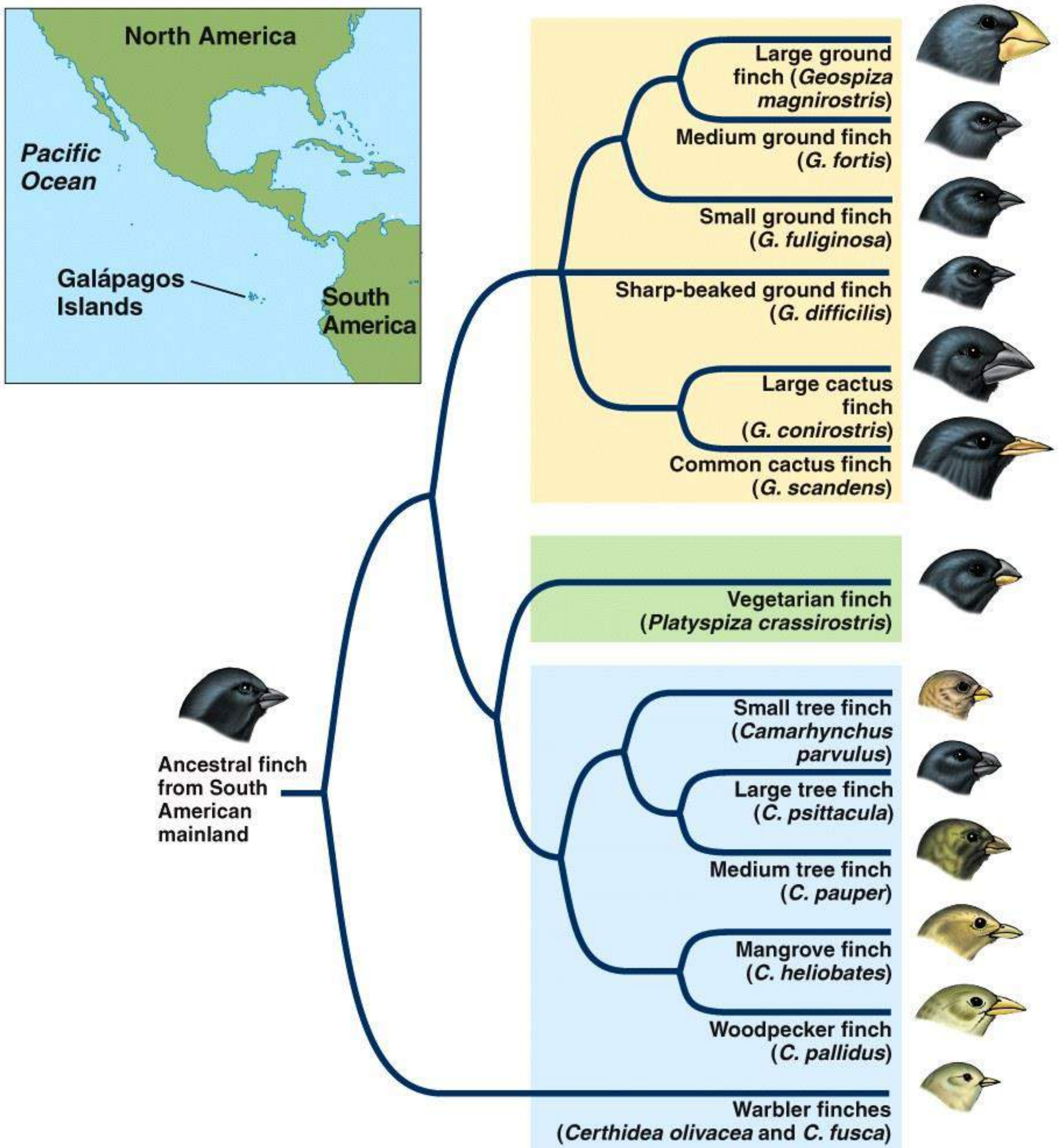
Galapagos Islands
Isla Isabela
Puerto Ayora
almost 1000 km
Manta
Quito
Ibarra
Pasto
Popa
Ecuador
Guayaquil
Salinas
Cuenca
Loja
Piura
Chiclayo
Cajamarca


Isla Santiago
Isla Fernandina
Puerto Ayora
Puerto
Baquerizo
Moreno
25km
Isla Isabela
Puerto Villamil

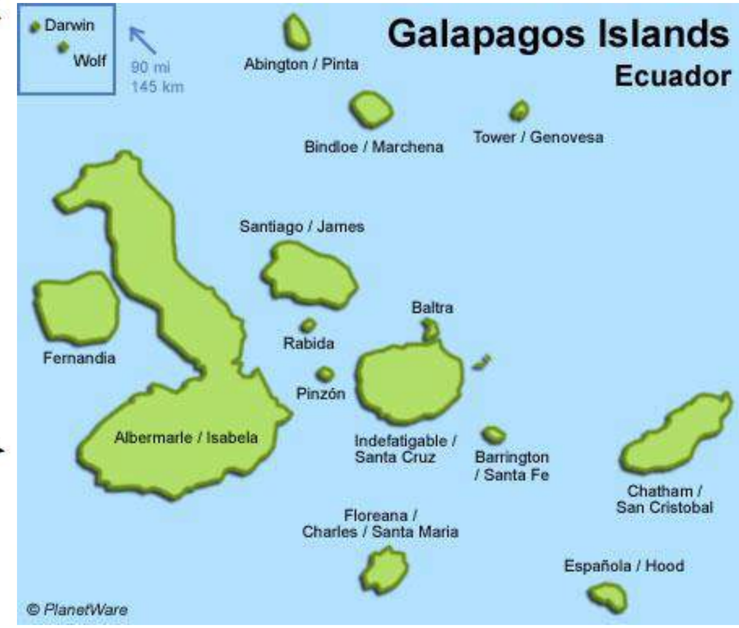
Galapagos habitat variation:
Different ecological circumstances (selective forces) on different islands led, eventually, to enough different evolution to give rise to different species

Igor Starukha, https://commons.wikimedia.org/wiki/File:Floreana_Island_of_Galapagos.jpg

Galapagos finch diversity



PRINCIPLES OF LIFE, Figure 17.7



http://houstonzooblogs.org/zoo/tag/galapagos-islands/

Consistent with hypothesis that a few finches made it to the archipelago and then diversified into different species on different islands with different conditions.

Three Circumstances

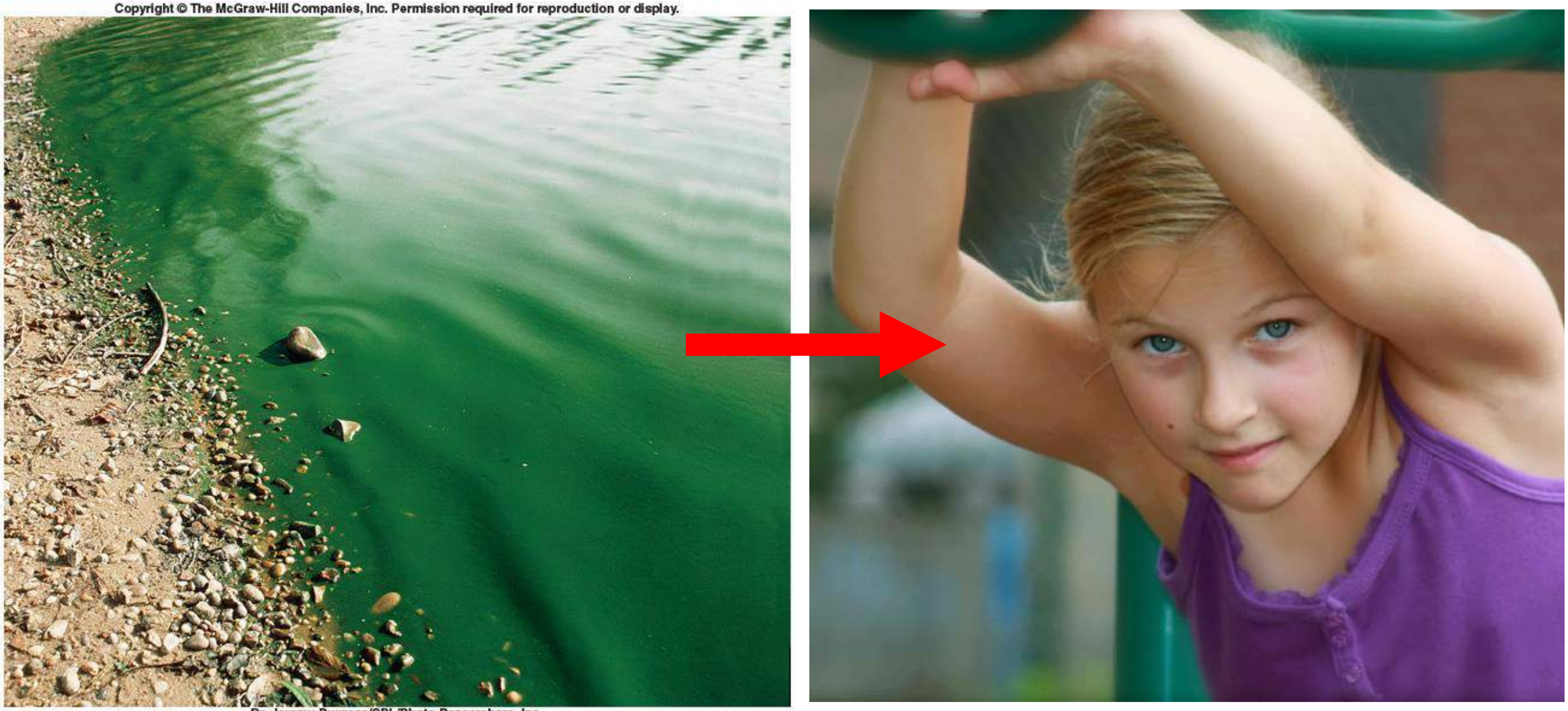
1. More born than environment can support.
2. Individuals not identical.
3. Some differences genetic).

Two Consequences

1. Result 1: Individuals best suited to their environment tend to leave most offspring (natural selection).
2. Result 2 (consequence of result 1): the relative abundance of different gene variants change (evolution).

Two factors that are nearly impossible to comprehend

1. the amount of time involved - billions of years
2. the number of opportunities for adaptive mutations.



Dr. Jeremy Burgess/SPL/Photo Researchers, Inc.

An inconceivable amount of time for evolution to occur

If width of this room = period of life on Earth

4 billion years = 10 meters

1 mm = 350,000 yr

1 mm = thickness of 10 sheets of paper

Industrial revolution (200 yr)
= 1 micrometer = 1/20 the diameter of a hair

Inconceivable # of opportunities for beneficial genetic changes

10^{-8} mutations (copying errors) per DNA base pair per generation

10^{6} base pairs perbac terium

Thus, 1 mutation per 100 bacterial cell divisions

10^{6} bacteria per milliiter of ocean water

10^{4} mutations per generation per milliliter

1 generation per day

10^{27} ml of ocean water

10^{31} bacterial mutations per day in the ocean

Outline

Evolution - 3 circumstances & 2 consequences

Observations of evolution in progress

- intentional artificial selection
- unintentional artificial selection
- Beak depths of Galapagos finches
- Stickleback armor

Evidence of past evolution

- fossils
- molecular homologies
- anatomical homologies
- convergent evolution
- species diversity on archipelagos

Review: Evolution is:

A. the adaptations that make species able to survive in their environment.

B. Survival of the fittest

C. Just a theory

D. A change in the composition of a gene pool.

A. None of the above.

Review: Which of the following is difficult for the most freshman college students?

A. Understanding course material.

B. Managing time.

C. Adjusting to academic demands.

D. Developing effective study skills.

The next level of understanding evolution:

Mutations,
inbreeding depression,
common patterns of evolution,
gene flow,
& genetic drift

Outline

- Basic genetics of inheritance
- Fitness – formal definition
- Processes that alter allele frequencies
    - mutation
        - problem for individuals
        - benefits for populations
    - natural selection – typical patterns
        - directional selection
        - stabilizing selection
        - disruptive selection
        - sexual selection
    - non-adaptive evolution
        - gene flow (non-adaptive change)
        - genetic drift (non-adaptive change)
- Why selection does not eliminate genetic variation
- Why selection does not lead to perfect organisms
- Genetic problems of small populations

Population: a group of individuals of the same species with opportunities to interbreed.

Species: a set of individuals with the potential to interbreed in nature.

Gene – a unit of heredity made of DNA

Allele – a variant of a gene – e.g. a length of DNA that codes for a particular genetic trait, such as black hair

Fitness

The relative contribution an individual makes to the gene pool of the next generation.

"Survival of the fittest"

(not the strongest individuals, but rather the individuals best suited to the environment)

Processes that alter allele frequencies
(”alter allele frequency” = “cause evolution”)

- Mutation

  (creates new alleles = new genetic varieties = new possibilities)

- Evolution by natural or artificial selection

  (adapts populations to current conditions)

- Gene flow
- Genetic drift

Mutation – a change in a DNA sequence.

Mutations occur randomly, not because they would be beneficial or for any other reason.

Mutations often create new genetic variants.

Any specific mutation is extremely unlikely.

Most mutations are inconsequential or harmful (random change to functional system)

Rarer, beneficial mutations enable populations to develop genetic diversity & adapt to new circumstances.

The problem with mutations for individuals
Slide 1 - <u>background</u>

2 copies of most genes – one from each parent

Thus 2 alleles – same or different

Phenotype = the expression of an individual’s genotype
(genotype = individual’s complete set of alleles)

Natural selection acts upon phenotype, not genotype

One allele may be dominant over another, recessive to another, or related in a more complicated manner

(Dominant does not mean selected for.)
(Dominant does not mean “better.”)

Figure 12.15

- The child in the photo expresses albinism, a recessive trait.

Dominant trait:

individual produces melanin (skin pigment)

Recessive trait:

individual does not produce melanin

The problem with mutations for individuals
Slide 2 - background

Dominant mutant – expressed, affects phenotype

Recessive mutant – usually only expressed in phenotype if an individual has 2 copies of same recessive allele (homozygous) – one from each parent

Dominant harmful alleles are rapidly eliminated from populations.

Recessive harmful alleles inherited from only one parent do not affect heterozygotes (2 different alleles for a gene), & thus are not eliminated from populations. Rather, they accumulate in heterozygous individuals.

We are all heterozygous for many recessive, harmful alleles.

The problem with mutations for individuals
Slide 3 – inbreeding depression

Most mutations (random changes to a product of natural selection) are harmful or have no consequence.

Carrying one copy of a recessive harmful mutant allele does not affect fitness.

Carrying two copies of a recessive harmful mutant allele reduces fitness.

The problem with mutations for individuals
Slide 4 – inbreeding depression continued

How could an individual inherit 2 copies of the same rare, recessive, harmful allele?

Must get one from each parent.

When would both parents carry the same harmful (and thus rare) mutation?

When both parents are descended from the same individual in whom the mutation occurred.

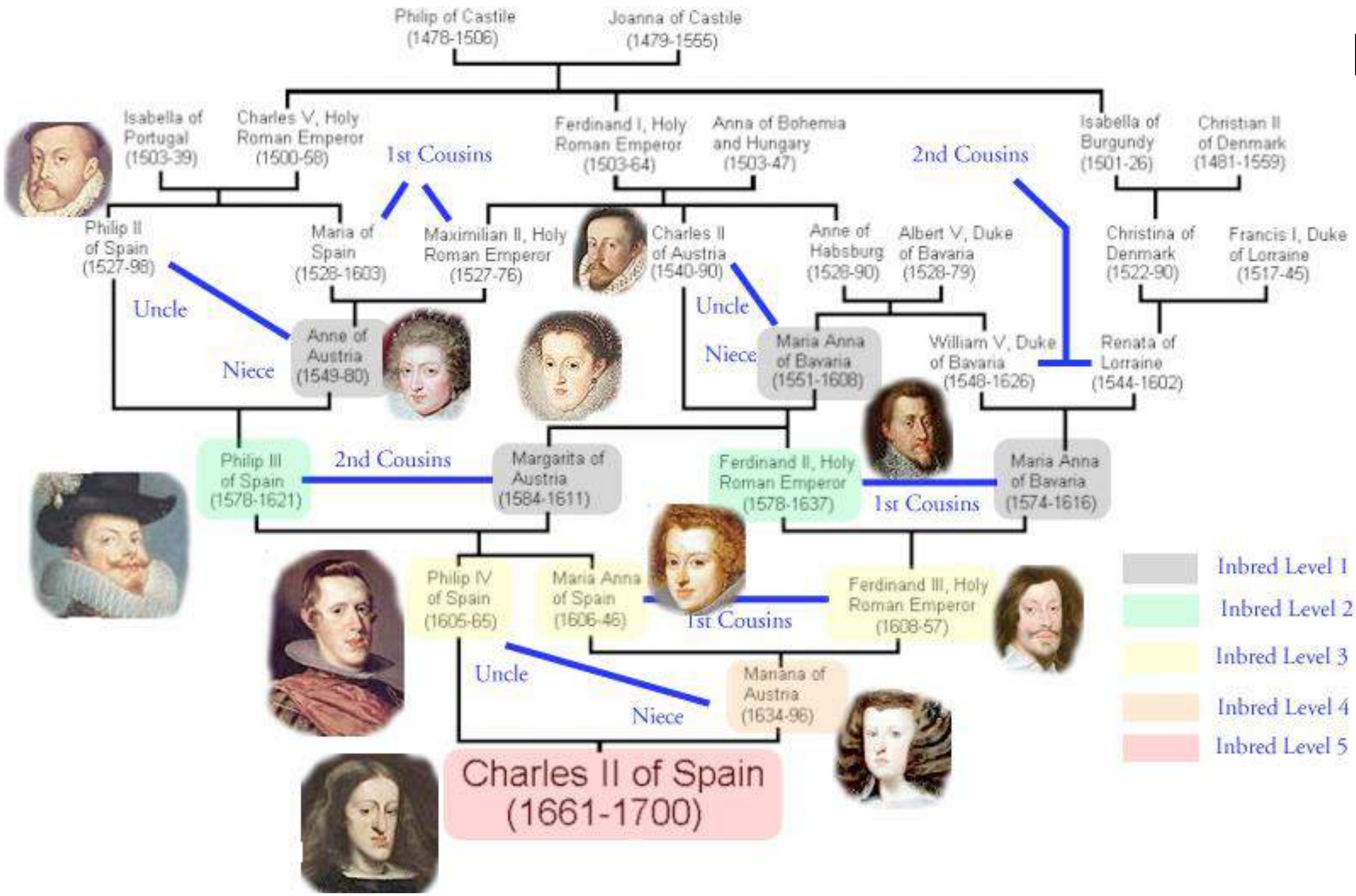
= When the parents are close relatives

(Inbreeding = mating among close relatives)

Inbreeding depression = low fitness due to phenotypic expression of homozygous, recessive, harmful (deleterious) alleles.

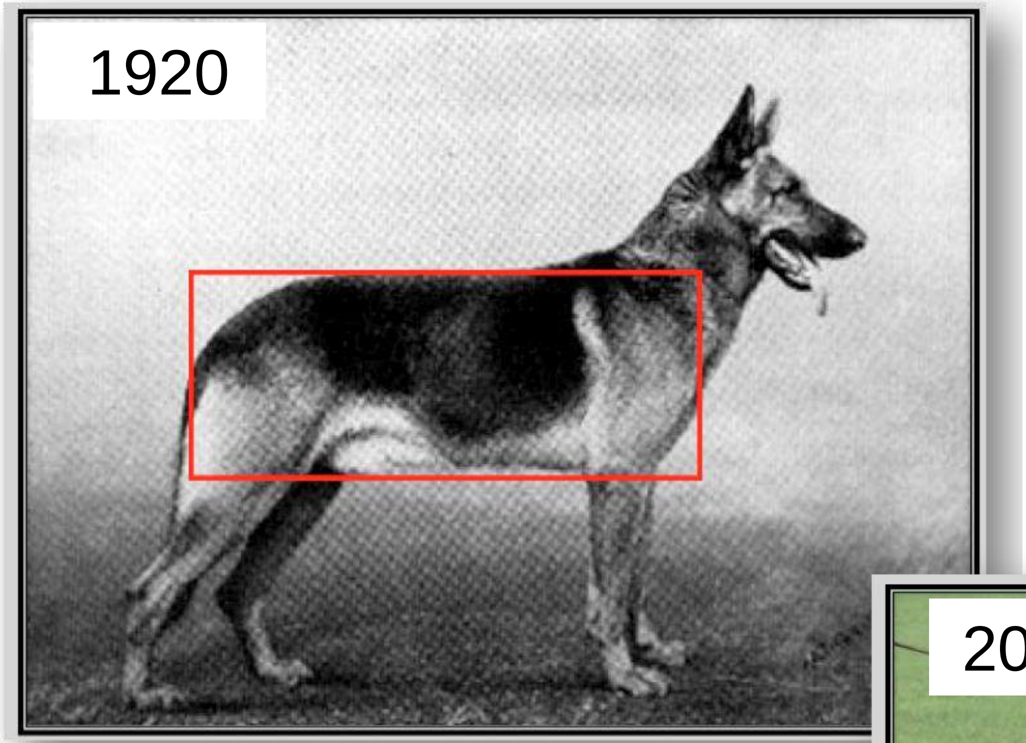
Deleterious recessive alleles are common but have no effect on fitness in outbred populations because they are not expressed.

Inbreeding of Charles II of Spain

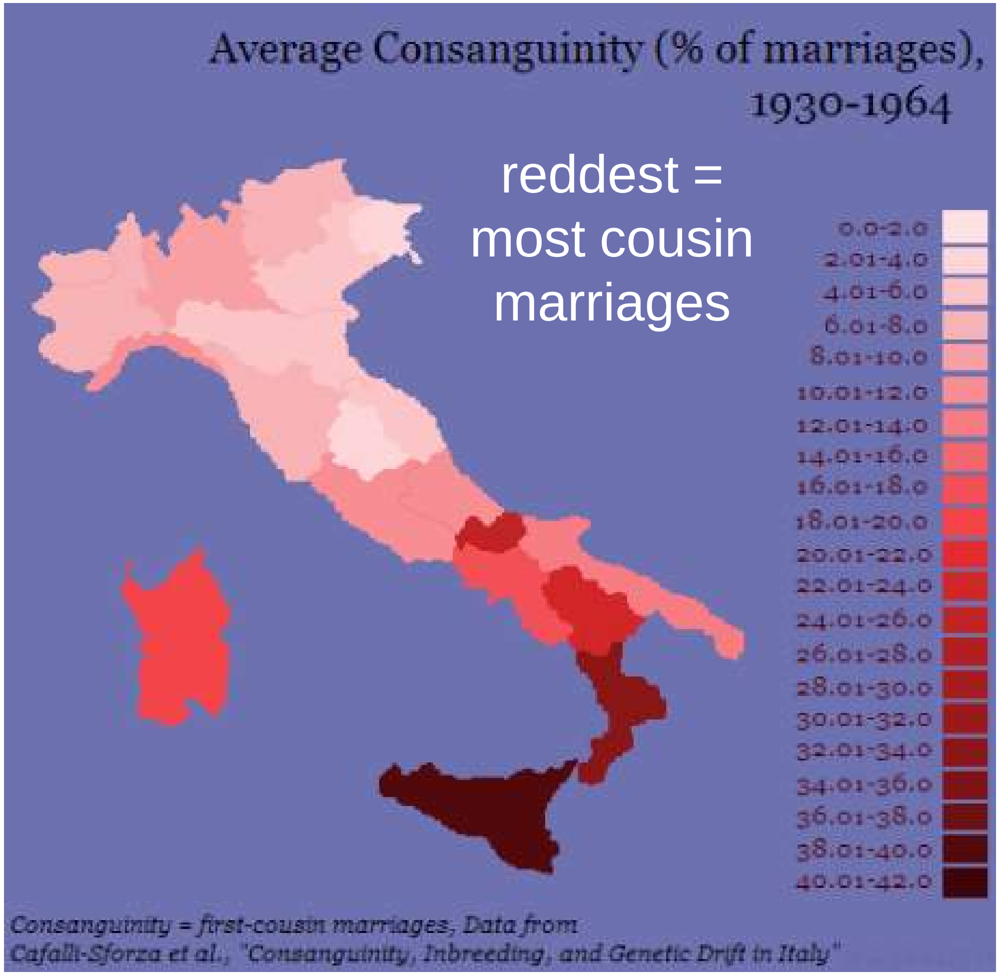


"Generations of royal intermarriage had culminated in Charles [II of Spain] … He was not weaned until he was five, could not walk until he was ten, and was considered to be too feeble for … education. In Charles, the famous Hapsburg chin reached such massive proportions that he was unable to chew, and his tongue was so large that he was barely able to speak."

From: Age of Kings, New York, Time-Life Books, 1967, pg. 168. A family trait of the 16th and 17th-century Hapsburgs was an oversized jaw, commonly called the Hapsburg lip, quoted at http://xenohistorian.faithweb.com/europe/eu11b.html



http://www.louisdonald.com/the-evolution-of-the-back-of-the-gsd.html



% of marriages among relatives

Cavalli-Sforza et al. 2004

Standardized test scores

(Programme for International Student Assessment)
https://reluctantapostate.wordpress.com/2011/08/18/comparing-pisa-with-gdp-per-capita-in-spain-and-italy/

The importance of mutations to populations

Mutations are the only source of new genetic variation.

Natural selection acts on variations in phenotypes.

- favoring some, selecting against others.

Mutations cause populations to contain genetic and phenotypic variation.

Thus, mutations provide the genetic variety that allows populations to evolve.

Populations with lots of genetic variation have potential to adapt to new circumstances. The alternative is extinction.

Processes that alter allele frequencies (= change the composition of gene pools) (= cause evolution)

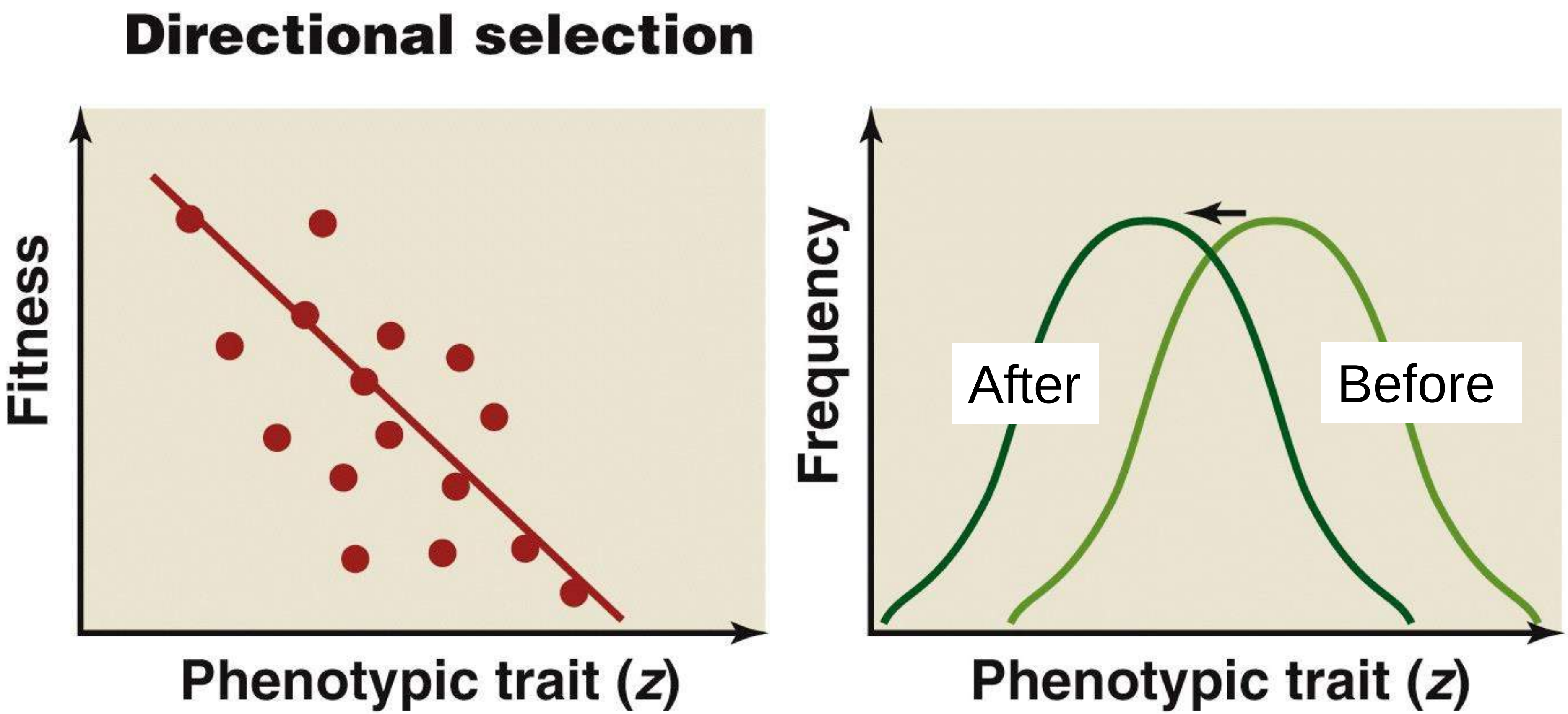
- **Mutation** (random, thus not usually adaptive)
- **Natural selection (**not random, **adaptive)**
- Gene flow (not usually adaptive)
- Genetic drift (not usually adaptive)
- [Artificial selection (not usually adaptive)]

Common patterns of evolution by natural selection

- Directional selection
- Stabilizing selection
- Diversifying selection
- Sexual selection

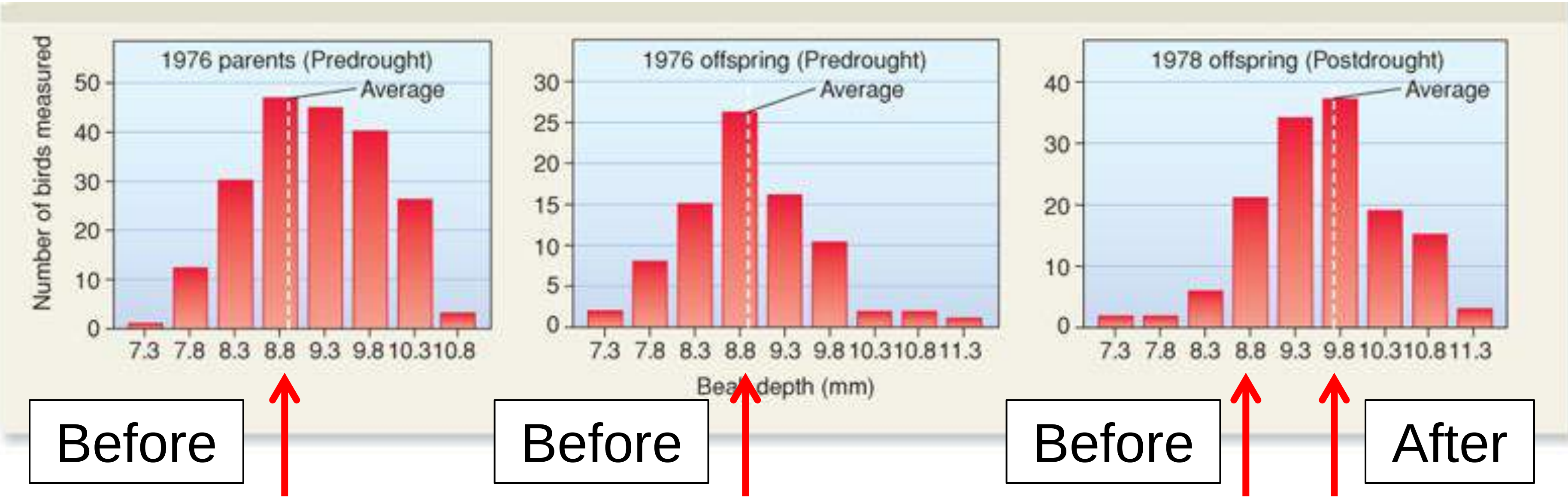
Directional (natural) selection

– one extreme phenotype selected for

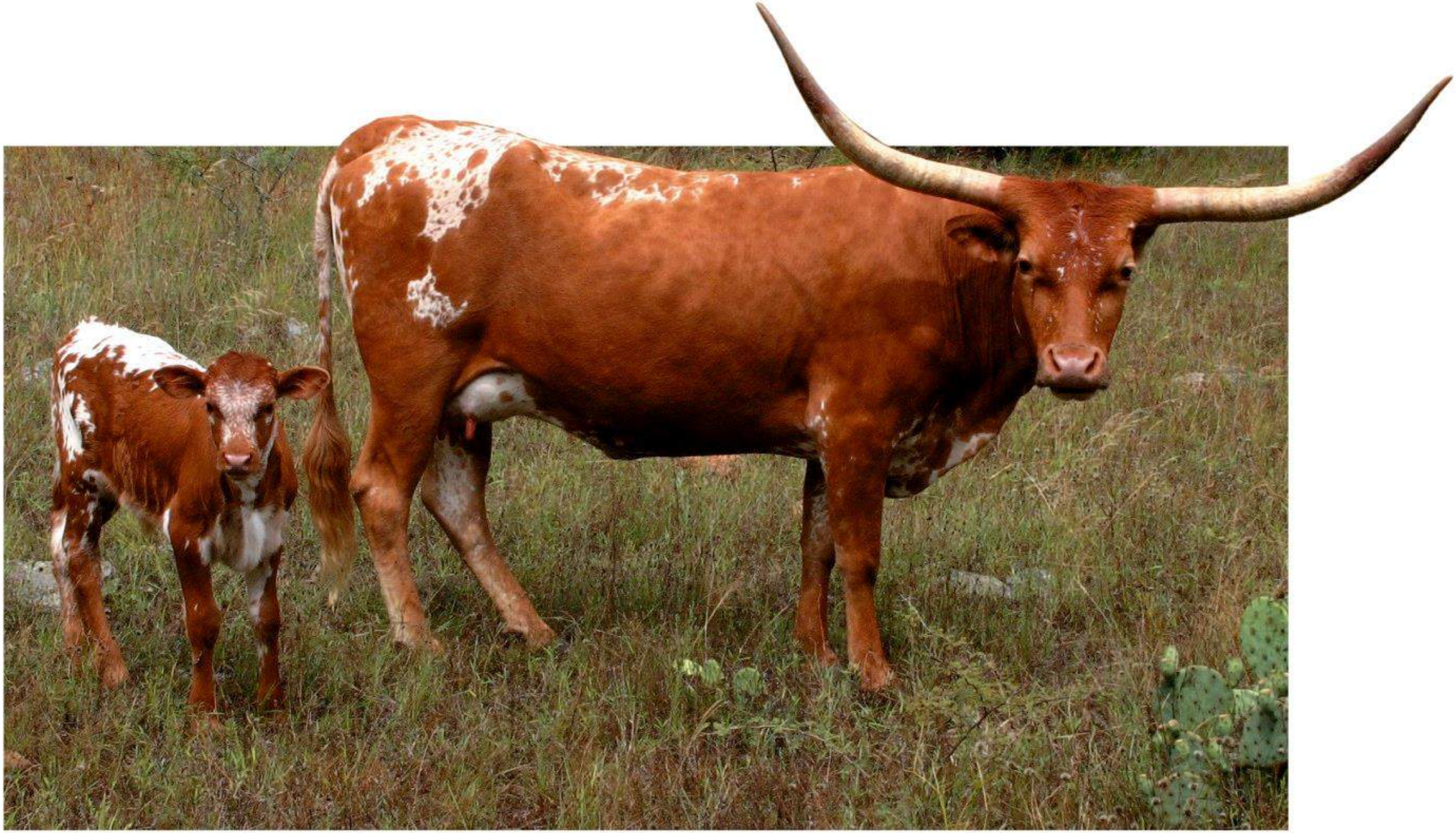


PRINCIPLES OF LIFE, Figure 15.12 (Part 2)

Previously seen example of directional selection



Product of former directional selection

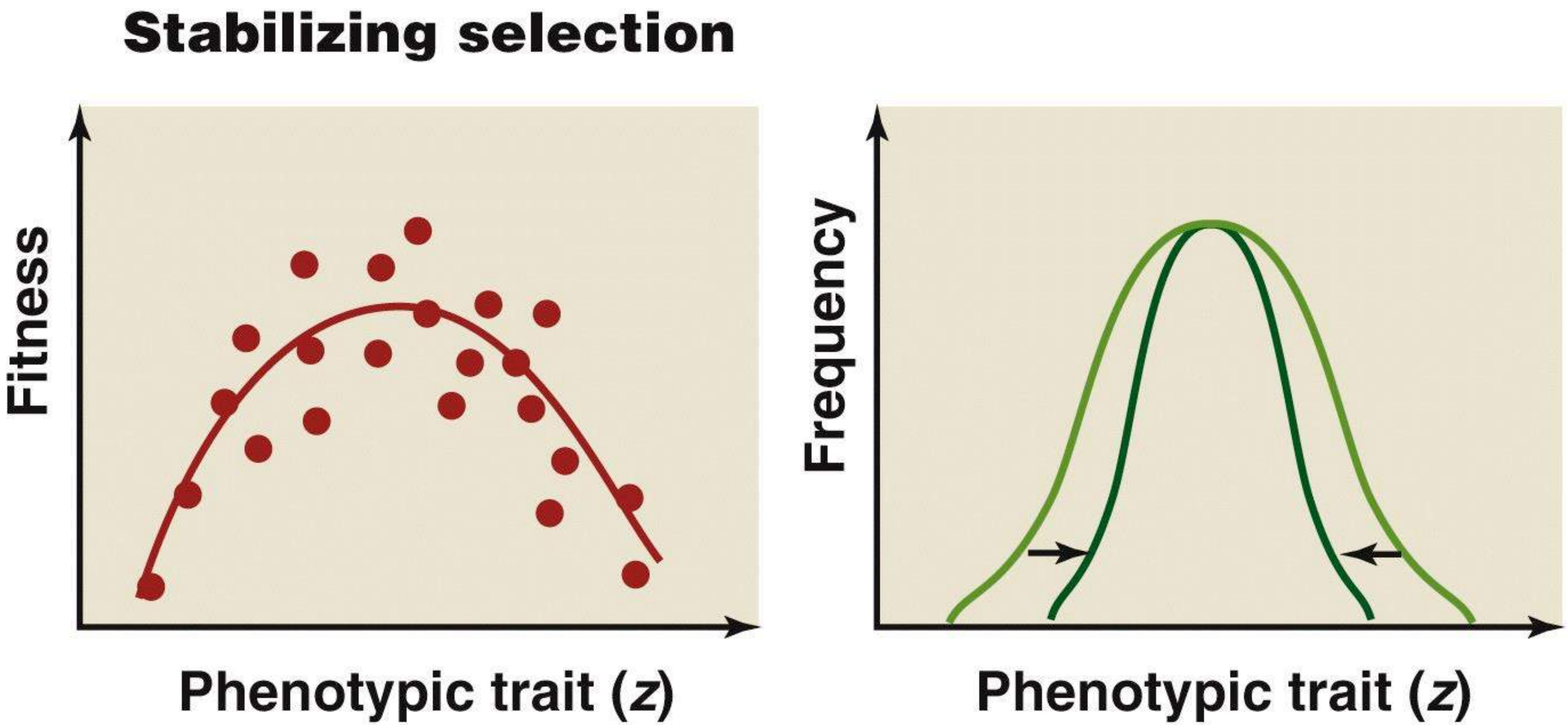


PRINCIPLES OF LIFE, Figure 15.14

Would you expect directional selection to continue indefinitely?

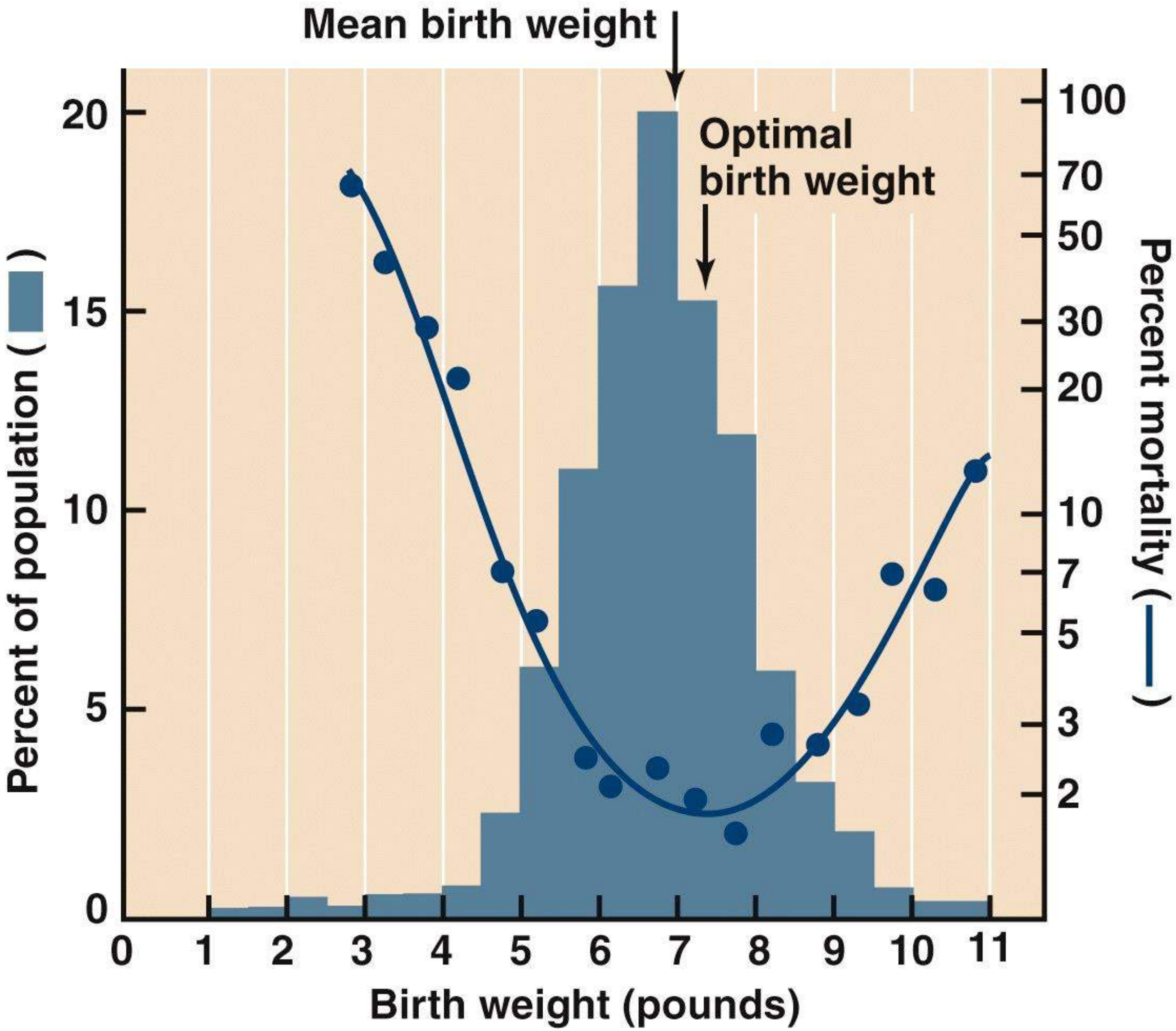
Stabilizing selection

- intermediate phenotype selected for



PRINCIPLES OF LIFE, Figure 15.12 (Part 1)

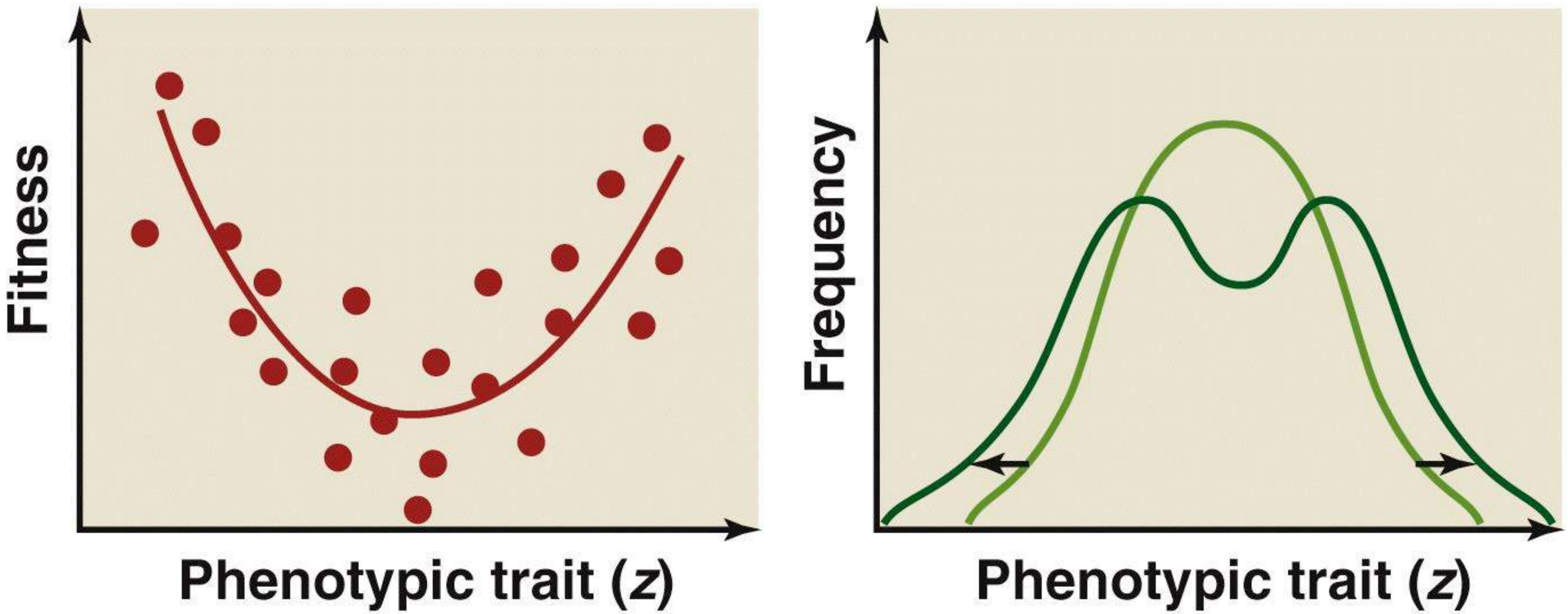
Stabilizing Selection for Intermediate Human Birth Weight



PRINCIPLES OF LIFE, Figure 15.13

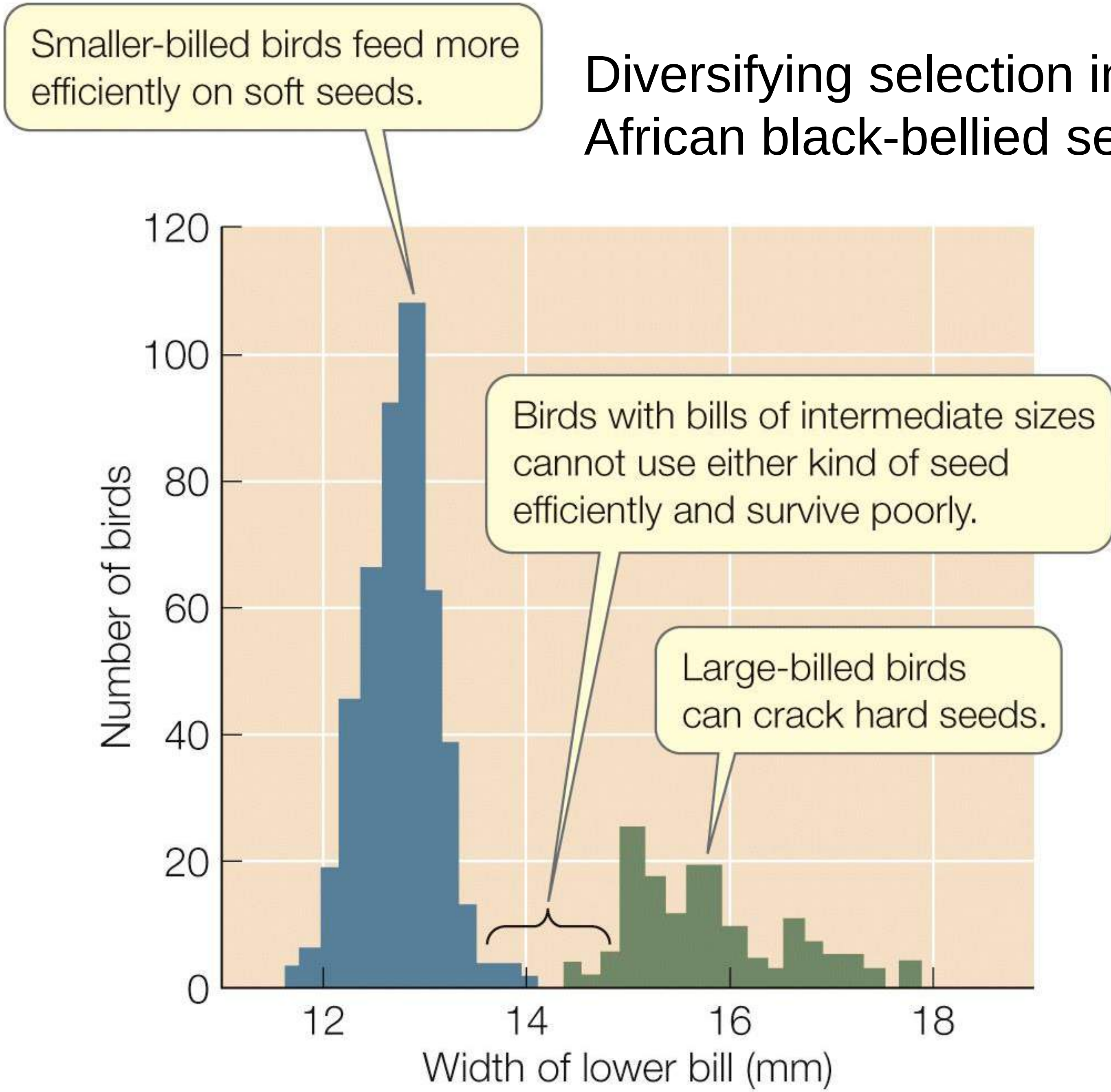
Diversifying selection (rare)

– both extremes favored over intermediates



PRINCIPLES OF LIFE, Figure 15.12 (Part 3)

Diversifying selection in West African black-bellied seedcracker



PRINCIPLES OF LIFE, Figure 15.15

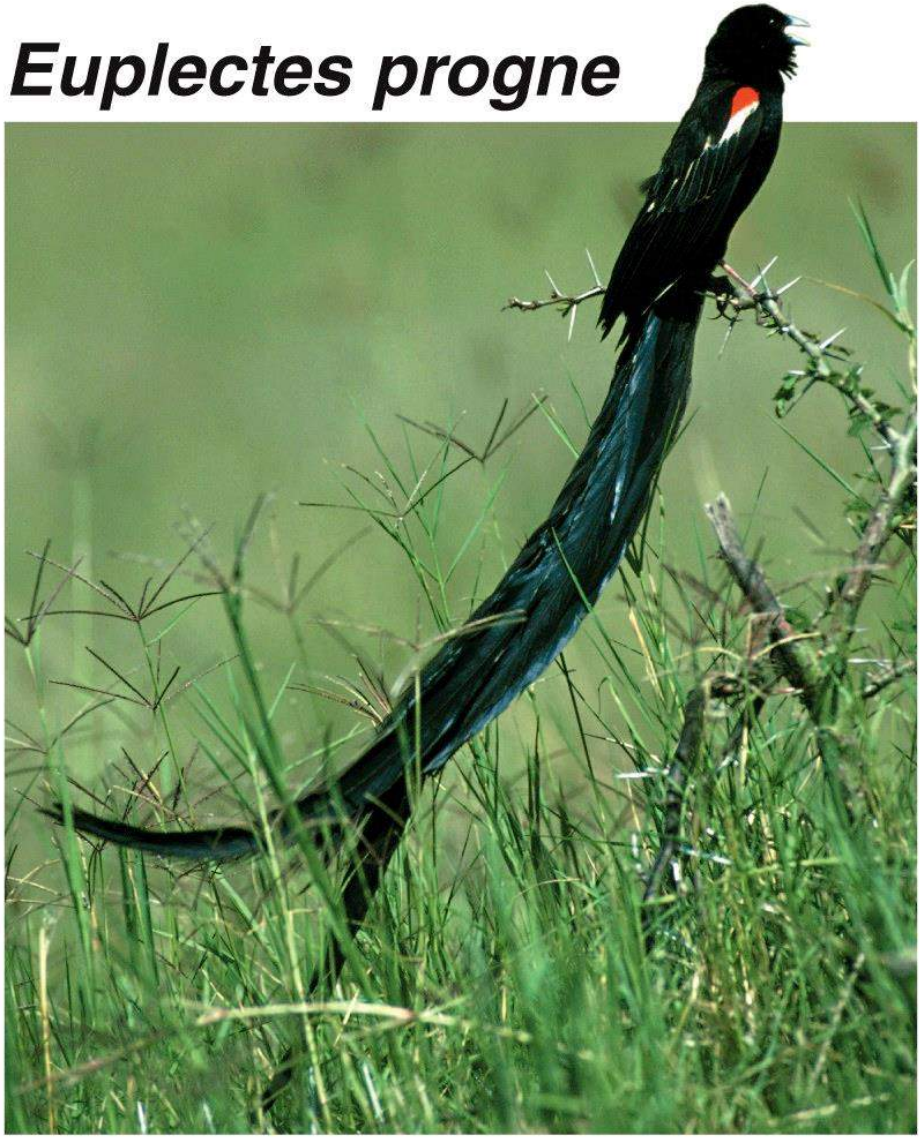
Sexual Selection – Mate Choice

How would natural selection drive choices of mates?

https://www.youtube.com/embed/REP4S0uqEOc
(bird of paradise video)

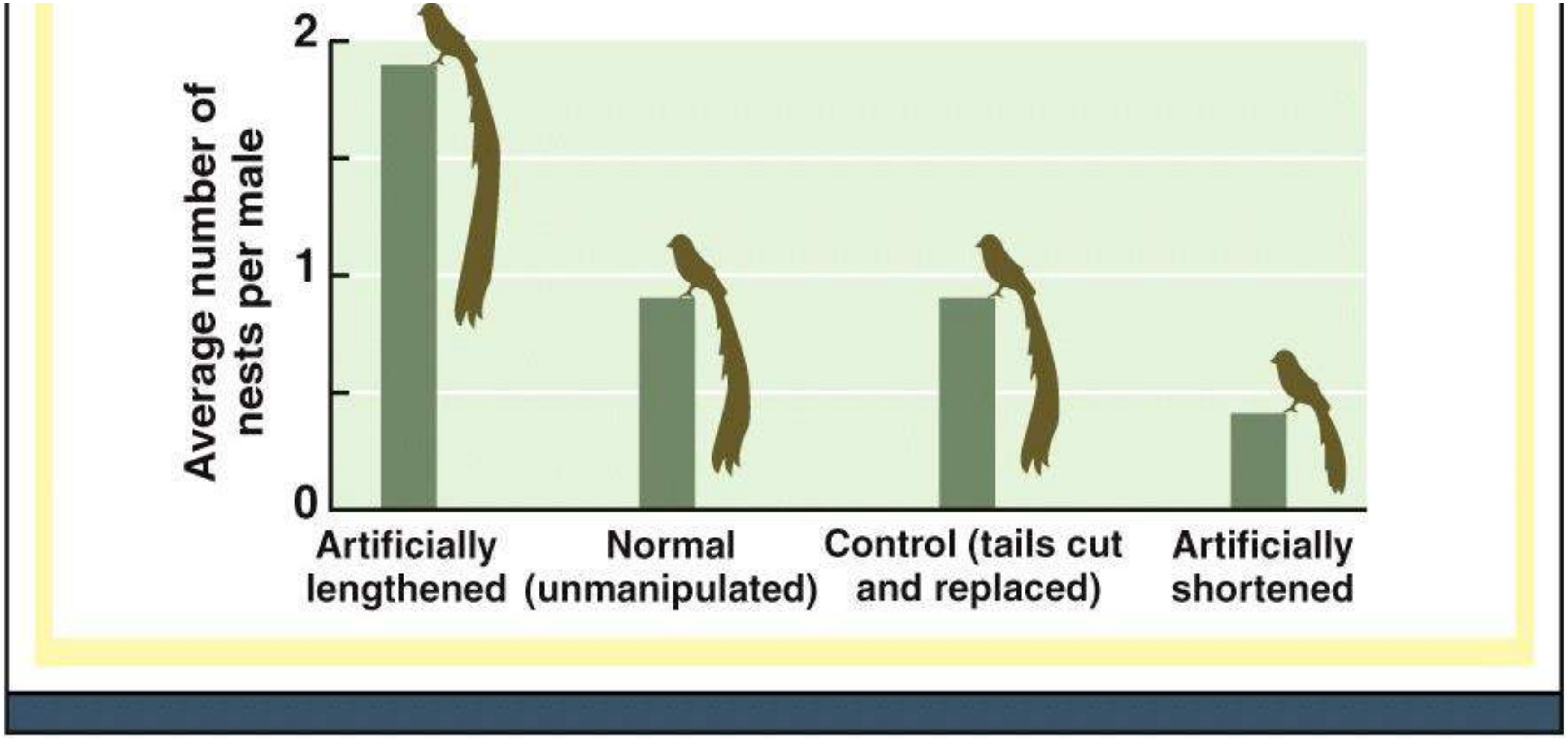
Sexual selection

Euplectes progne



PRINCIPLES OF LIFE, Figure 15.8

African long-tailed widowbird



PRINCIPLES OF LIFE, **Figure 15.9 (Part 1)**

Females choose individuals with the longest tails

Sexual Selection – Mate Choice

One sex is generally (in most species) choosier about mates

- Usually females (why?)
  - Female fitness depends more on genotype of individual offspring than does male fitness
    - - because females cannot reproduce as often
  - If a male makes a bad mate choice he can mate again
    - - little impact of one bad choice on fitness

- Exceptions
  - In species where males raise young, males are the choosier sex.
  - In other species only one or a few males mate.
    - - females have no choice.

What would happen to alleles that cause females to choose poorly?

Offspring would have low fitness.

Alleles that led to such choices would be selected against.

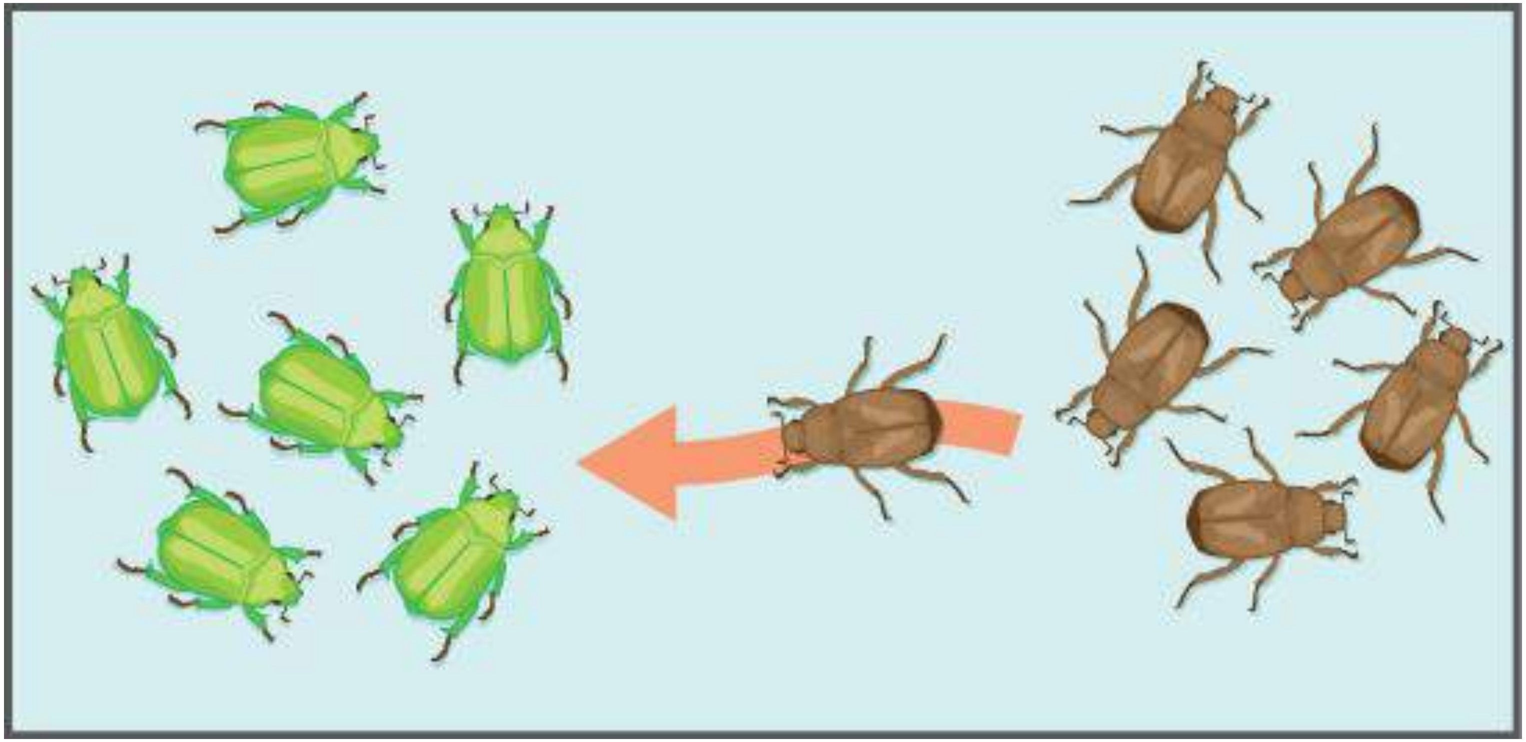
Mate choice criteria (of wild species) <u>must</u> lead to high fitness or the alleles that lead to those choices would have been selected against.

(Just because we don't know how choices work to maximize fitness doesn't mean they don't work.)

Processes that alter allele frequencies

- Mutation
- Natural selection
- Gene flow – movement of genes from one population to another
- Genetic drift

Gene flow (Figure 19.6)



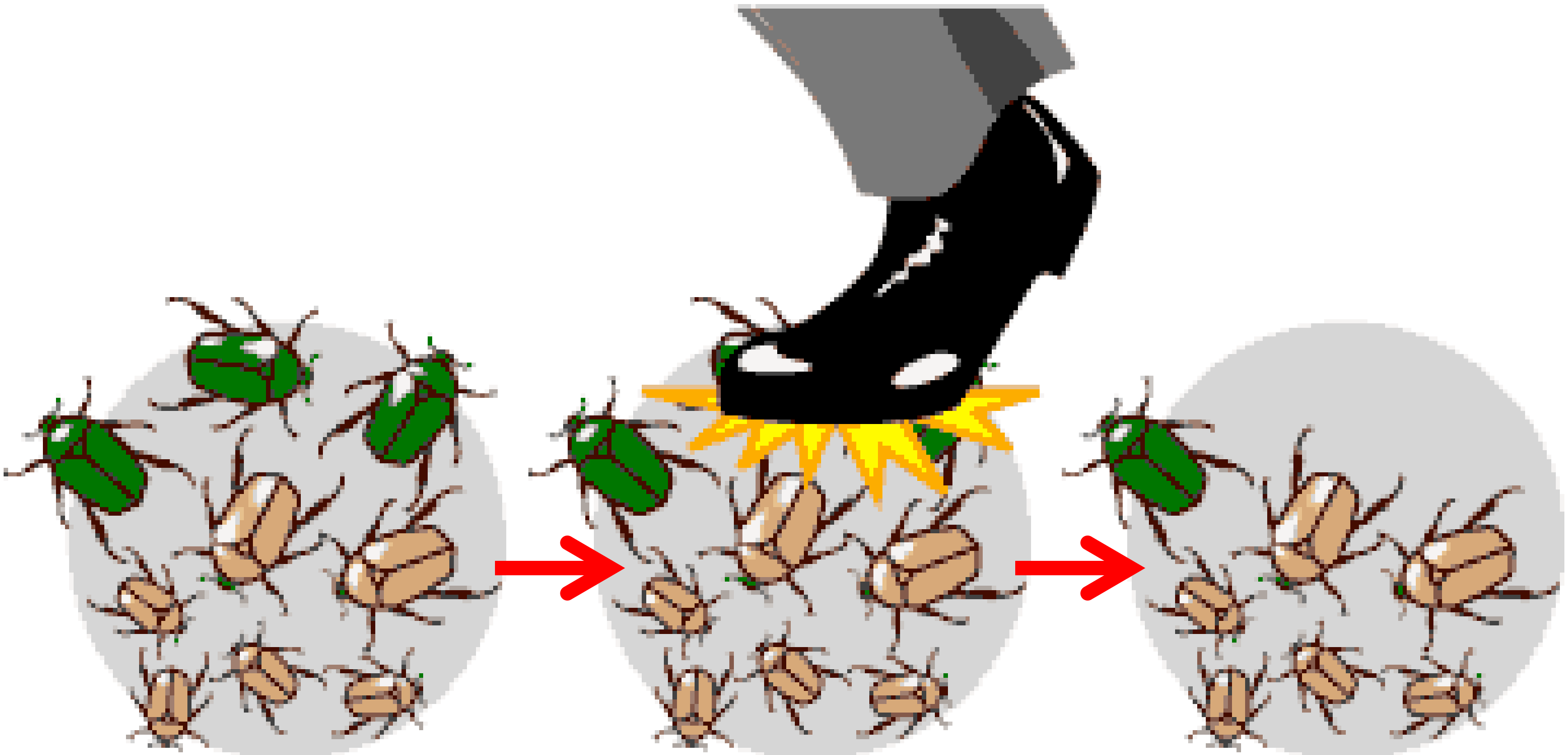
Critically important to prevent inbreeding depression in small populations (e.g. endangered spp.)

Processes that alter allele frequencies

- Mutation
- Natural selection
- Gene flow
- Genetic drift – <u>chance</u> change in allele frequency – individuals with some alleles just happen to leave more offspring other individuals (not adaptive)

Genetic drift

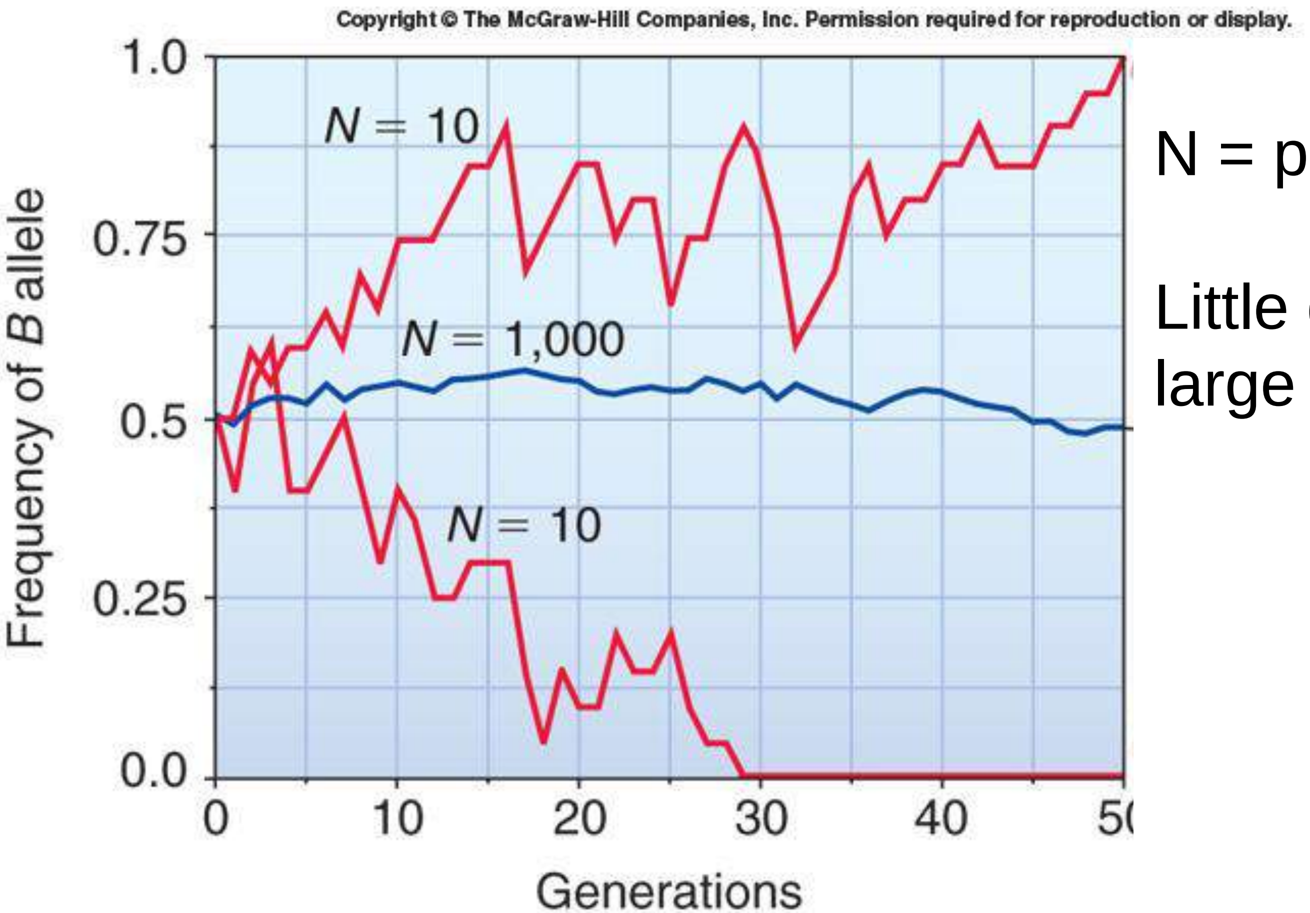
– chance event alters allele frequencies



http://evolution.berkeley.edu/evosite/evo101/IIIDGeneticdrift.shtml


Blue abundant by chance

Genetic drift can be important in very small populations but chance changes in allele frequencies are unlikely in large populations.



N = population size.

Little genetic drift in large populations.

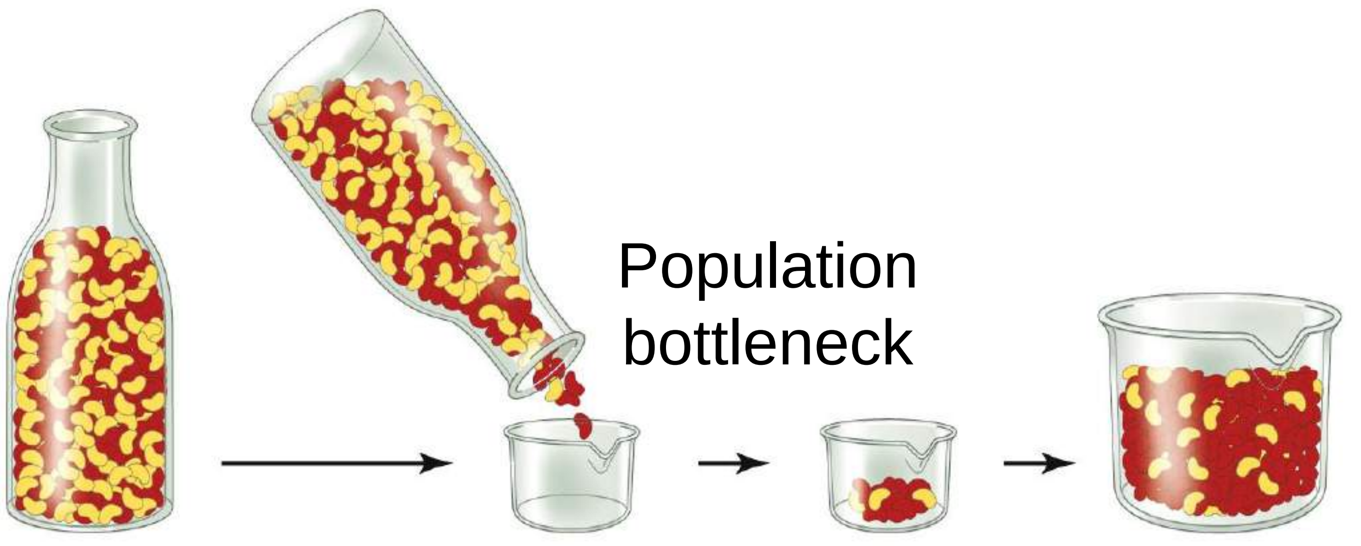
Genetic drift often results from

population <u>bottlenecks</u>

(almost all individuals die, after which the population regrows)

& <u>founder</u> <u>events</u>

(a few individuals found a new population in a new location)



PRINCIPLES OF LIFE, Figure 15.7

Red allele becomes more abundant due to chance (genetic drift).

Processes that alter allele frequencies

- Mutation
- Natural and artificial selection
- Gene flow
- Genetic drift

5 reasons why natural selection does not eliminate genetic variation?

Diploidy = 2 alleles for most genes so recessive alleles are “hidden” in heterozygotes (not selected against)

Variable selection pressure (different alleles favored in different times and places)

Heterozygotes sometimes have higher fitness than either homozygote

Neutral variation (variation with no fitness consequence)

Mutations continually add new variants.

Does evolution lead to perfect organisms?

No.

Natural selection involves trade-offs (e.g. faster or stronger)

Natural selection can act only upon existing genetic variation.

Mutations occur randomly, not because they would be adaptive.

Delay between when selective forces change and when allele frequencies change. Natural selection always playing catch up.

Gene regulation problems (epigenetic processes) interfere with fitness.

Some imperfections of humans

Pharynx used for both breathing & eating - risks choking.

We can’t synthesize vitamin C due to a deficient gene. Other species can.

Fertilized eggs can implant in the wrong locations, causing ectopic pregnancies.

Babies’ heads so large delivery is difficult. Why not born between ribs and pelvis where no bones are in the way.

Babies’ skulls deform during birth. Umbilical cords can tangle. Tremendous hazards of childbirth prior to modern medicine.

“Inside-out” retina with nerves & blood vessels blocking light to light receptors.

Birth defects.

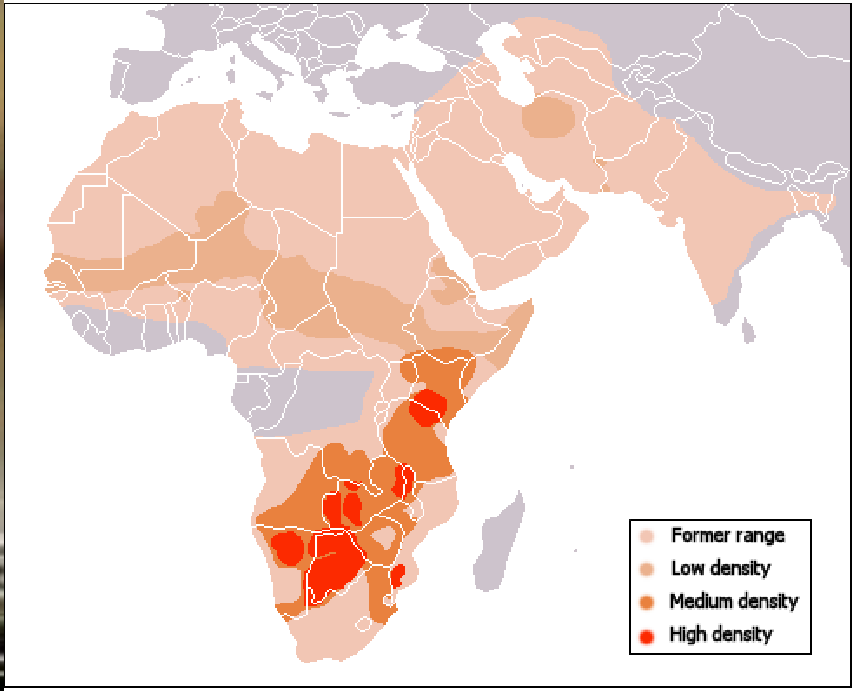
Limited mental ability.

Illnesses and mortality.

Knees, memory, hairline, etc. etc. etc.

Genetic Risks to Small Populations

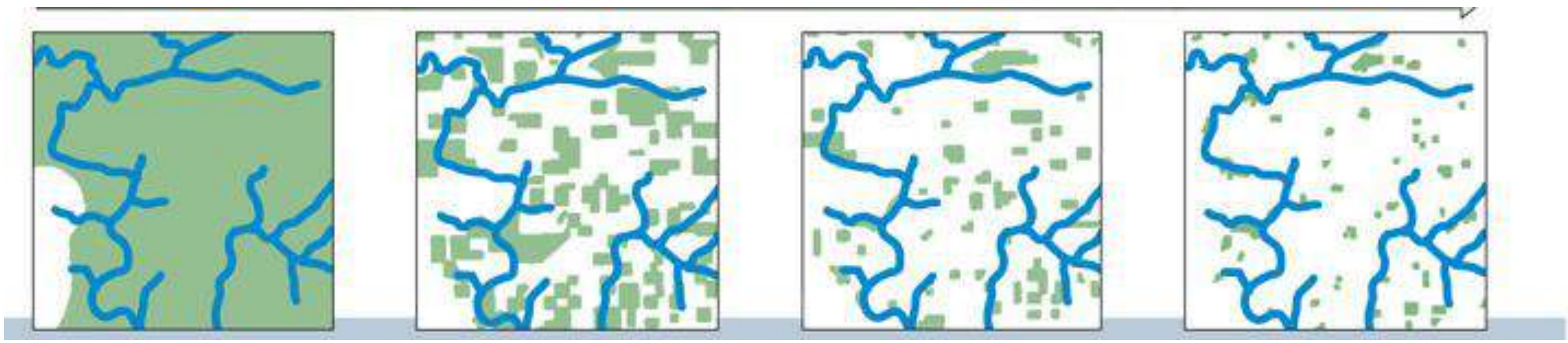
-Low genetic diversity due to extreme bottlenecks
-Risk of inbreeding depression



http://www.thebigcats.com/news/
2005_0204_cheetah_cubs.htm

http://animals.y2u.co.uk/Animal_Kingdom
_Cheetah.htm

Many cases of small, endangered populations because habitat loss is widespread



1830 1950

Wisconsin Forests

Outline

- Basic genetics of inheritance
- Fitness – formal definition
- Processes that alter allele frequencies
  - mutation
    - problem for individuals
    - benefits for populations
  - natural selection – tyical patterns
    - directional selection
    - stabilizing selection
    - disruptive selectionp
    - sexual selection
  - non-adaptive evolution
    - gene flow (non-adaptive change)
    - genetic drift (non-adaptive change)
- Why selection does not eliminate genetic variation
- Why selection does not lead to perfect organisms
- Genetic problems of small populations

Speciation

formation of new species

***PRINCIPLES OF LIFE,* Chapter 17 Opener**

Outline

- Species definition
- Species identification
- Origin of new species
    - Allopatric speciation
    - Sympatric speciation
- Mechanisms that prevent hybridization between species
- Major changes due to evolution of genes that regulate development

A species is a group of individual organisms that have the potential to interbreed and produce fertile offspring under natural circumstances.

If members of 2 different species breed they do not produce fertile offspring.

Thus, members of separate species are <u>reproductively isolated</u>.

Looks can be deceiving

Figure 18.9

All one species

(a) (c)

Figure 18.10

Different species

(a) (b)

In practice – it is often impossible to test whether two individuals can breed & produce fertile offspring, so...

Species identified on basis of

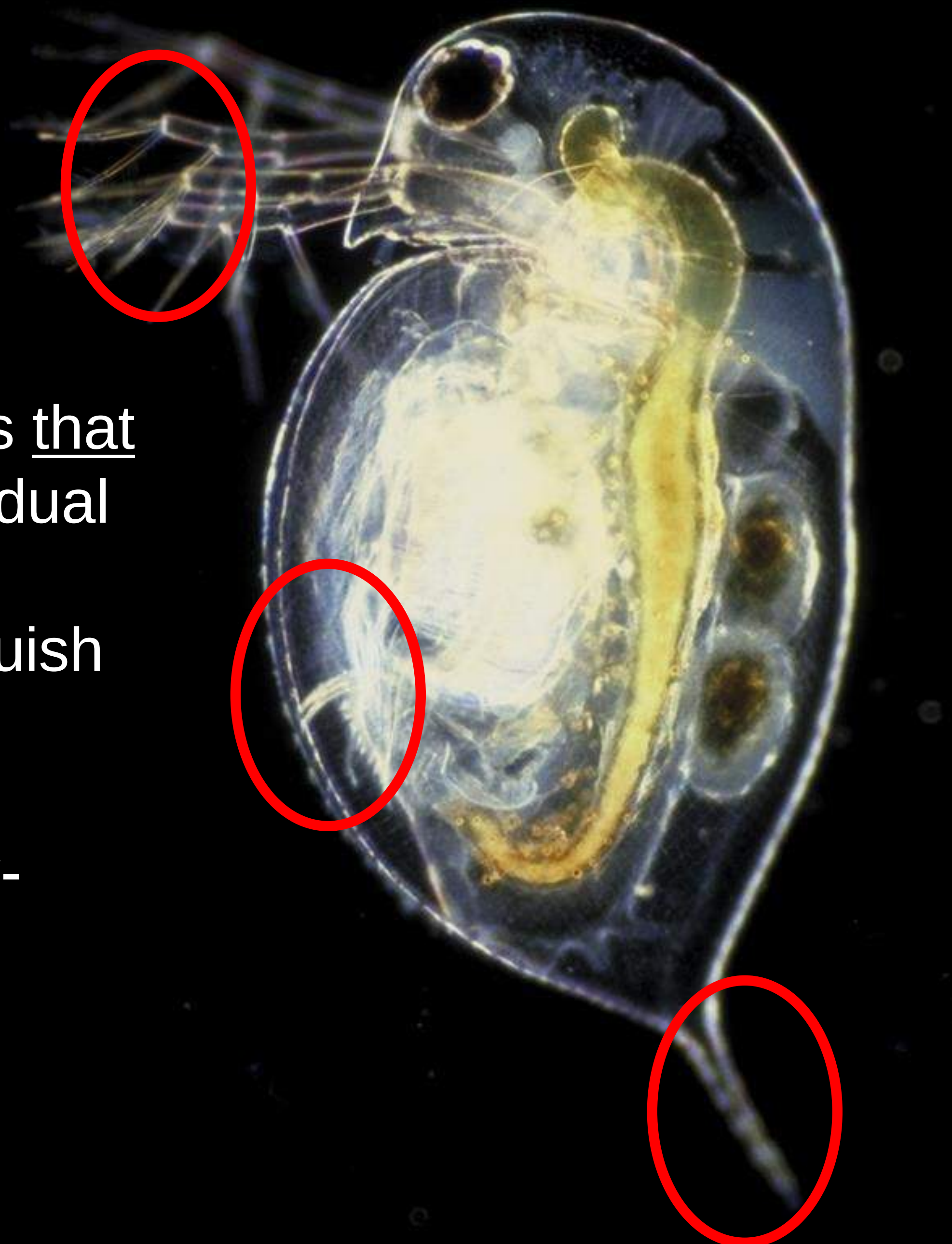
- morphology (unique features or combinations thereof)

or

- genetics (unique DNA sequences)

Suggest unique features imply reproductive isolation.

Morphological features that do not vary from individual to individual within a population *and* distinguish populations with those features from other populations (of closely-related species).



Functional Genomics Thickens the Biological Plot. Gewin V, PLoS Biology Vol. 3/6/2005, e219.
http://dx.doi.org/10.1371/journal.pbio.0030219

In some cases biochemical data, such as DNA sequences, must be used to identify species with any certainty.

“barcoding” species

1 25002 74135 0

http://ceoworld.biz/ceo/2009/11/14/best-barcode-label-design-software-barcode-label-printing-image-applications

Thus, 2 methods for distinguishing species

1. Reproductive isolation

2. Distinctive morphological or biochemical features

Problems with these methods:
#1 often cannot be tested.
#2 can confuse long-isolated populations and
actual separate species.

Meanwhile: no method should always “work”to distinguish species because speciation may be in progress. Two populations may be isolated and diverging but not yet different species.

Outline

- Species definition
- Species identification
- Origin of new species
    - Allopatric speciation
    - Sympatric speciation
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How do new species arise?

1. Separate populations experience different selective conditions that favor different alleles.

    Changes accumulate until 2 populations of one species become 2 different species.

or

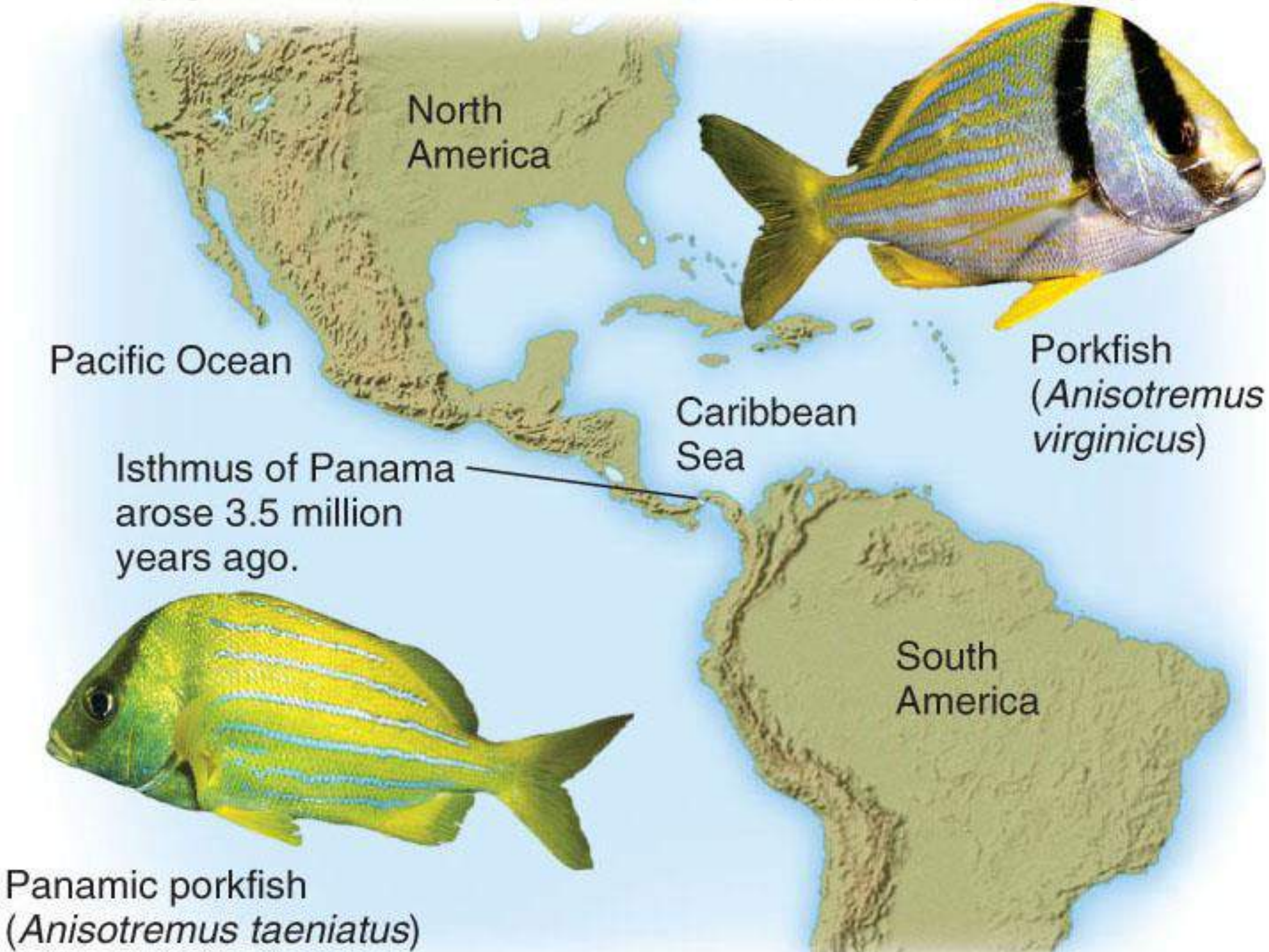
2. Much rarer butcommon in plants: Reproduction “error” produces a new species in one generation.

For two populations to diverge into separate species they must be sufficiently reproductively isolated that their gene pools can diverge.

If there is substantial gene flow between populations, they will not diverge genetically.

<u>Allopatric speciation</u> – speciation involving geographic isolation

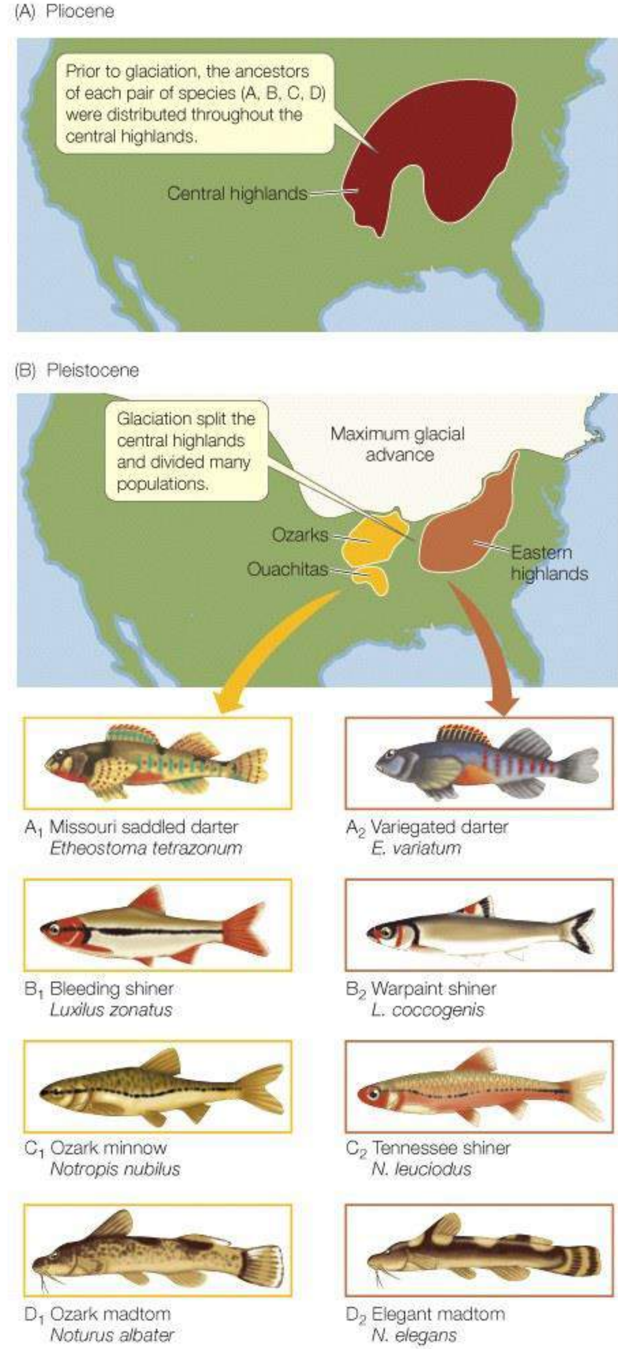
<u>Sympatric speciation</u> - two populations become isolated even though they occur in the same area.



Allopatric speciation

due to Isthmus of Panama - formed 3.5 mya

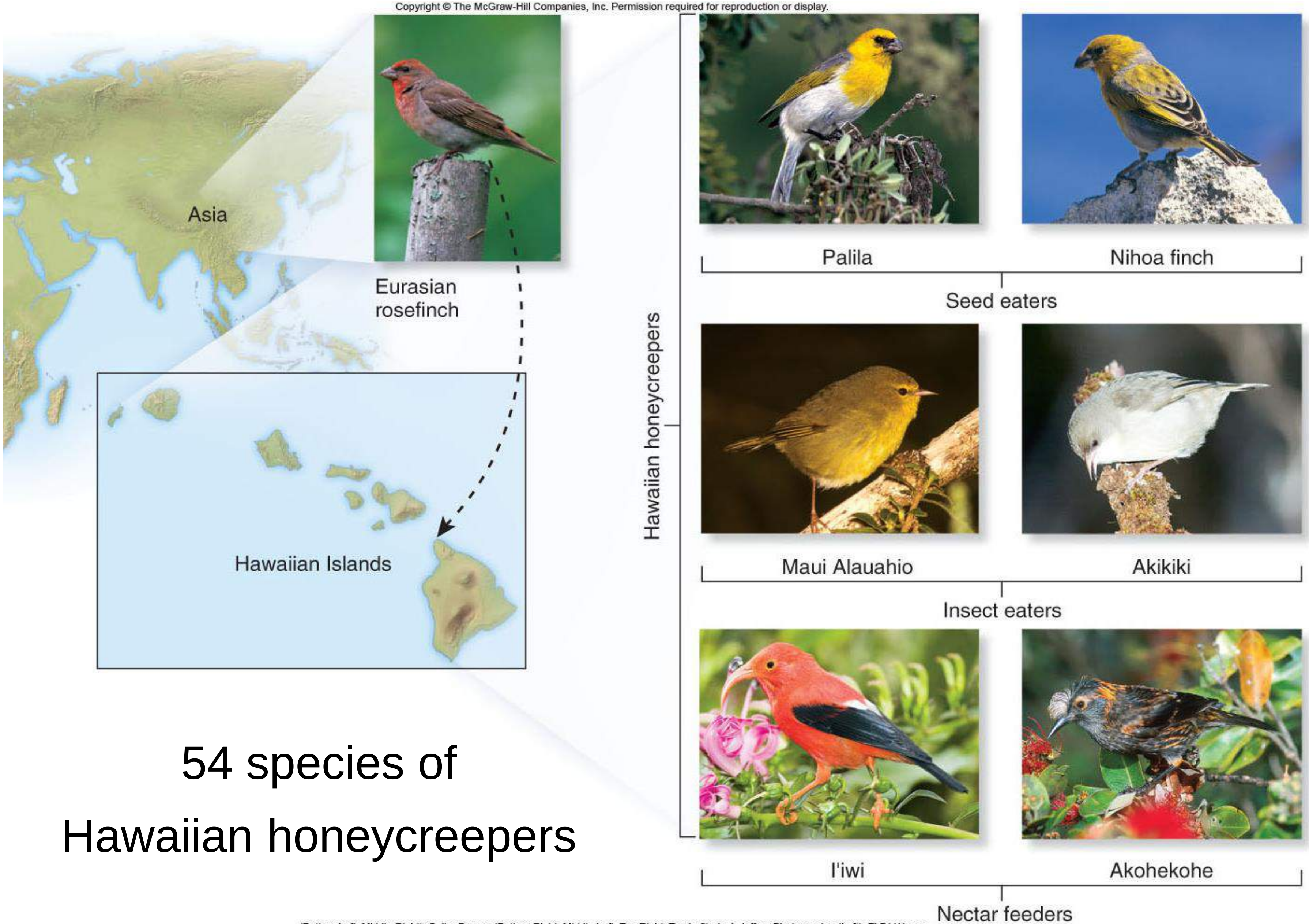
Allopatric speciation in stream fishes during geographic isolation due to glaciation



PRINCIPLES OF LIFE, Figure 17.6

Factors that increase likelihood of allopatric speciation

1. Different selective pressures in different locations
2. Many different populations
3. Initial allele frequency differences among populations



54 species of
Hawaiian honeycreepers

(Bottom Left, Middle Right): © Jim Denny; (Bottom Right, Middle Left, Top Right, Top Left): Jack Jeffrey Photography; (Left): FLPA/Alamy

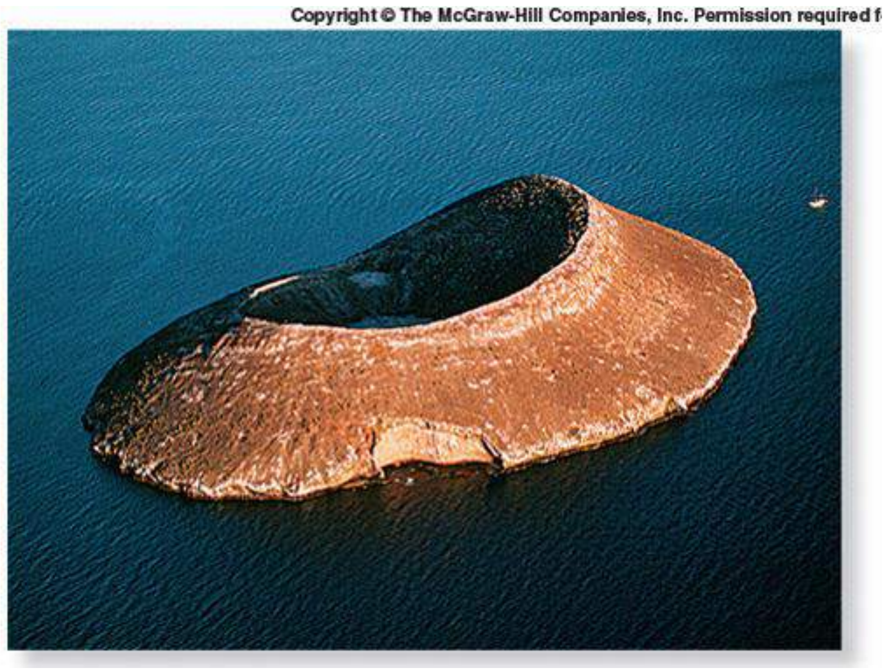
Island chains are often sites of adaptive radiation

Isolation from mainland

Small founder populations.

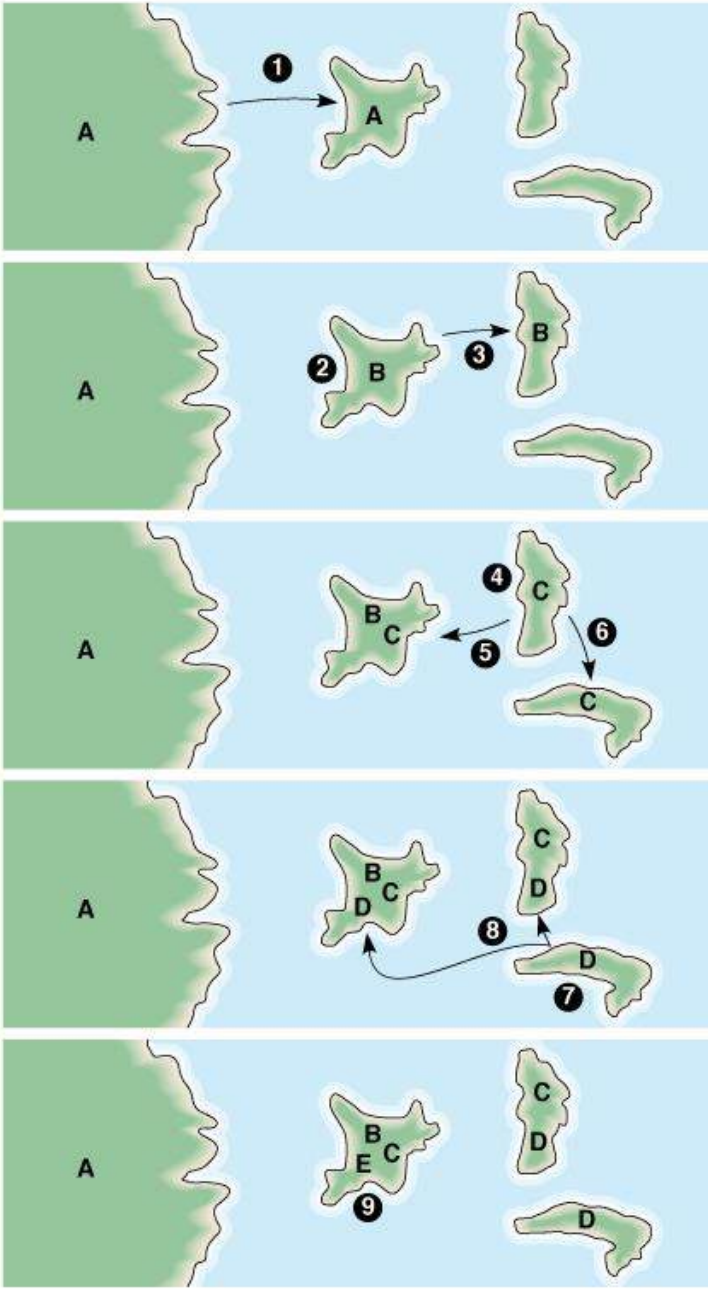
Different selective pressures on different islands.

Infrequent movement from island to island.



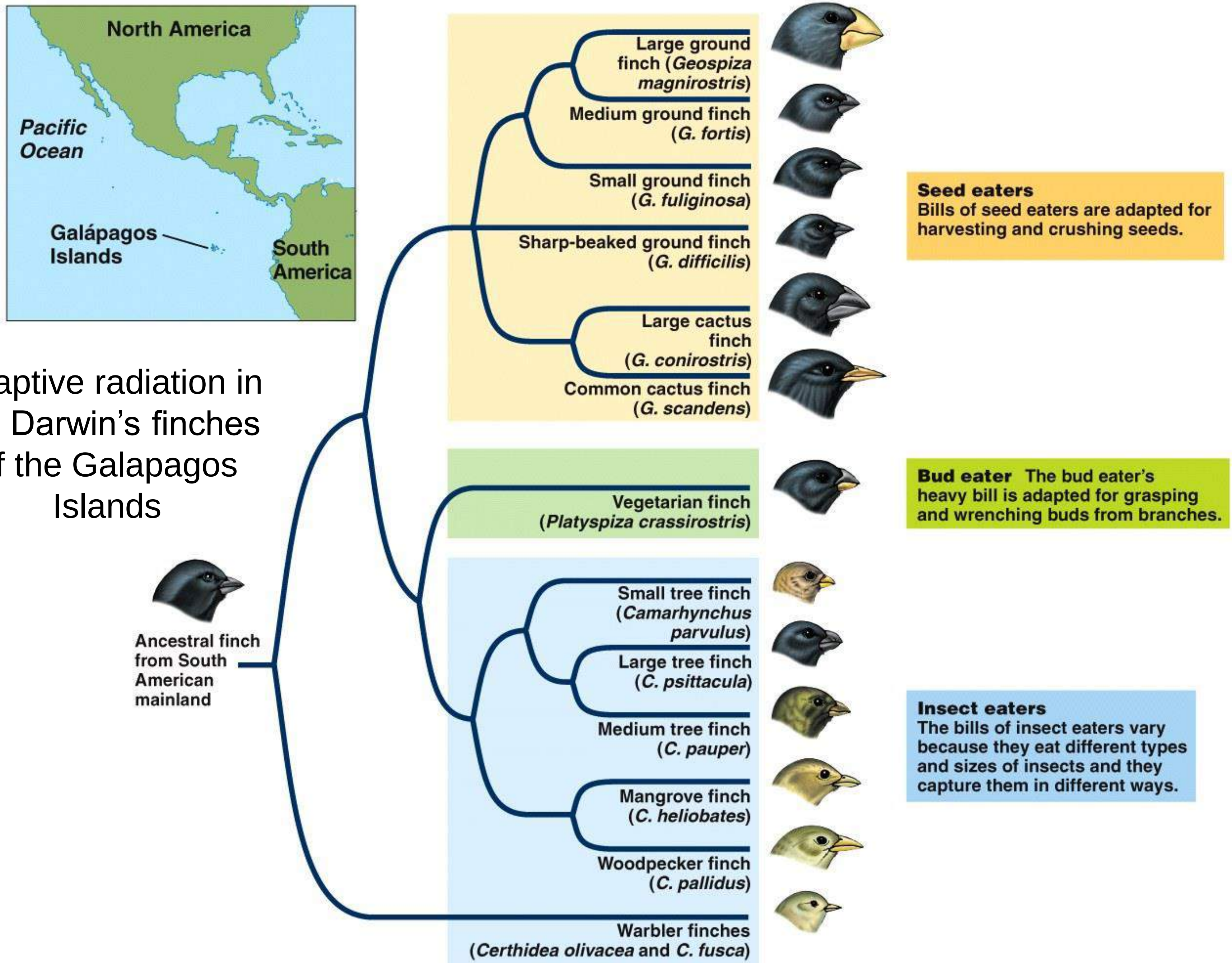
http://en.wikipedia.org/wiki/File:Ecuador_landscapenear_Banos.JPG

Adaptive radiation on an island chain




Galapagos
Islands
Isla Isabela
Puerto Ayora
Pasto
Ibarra
Quito
Manta
Ecuador
Guayaquil
Salinas
Cuenca
Loja
Piura
Chiclayo
Cajamarca

Adaptive radiation in the Darwin's finches of the Galapagos Islands



***PRINCIPLES OF LIFE*, Figure 17.7**

Sympatric speciation

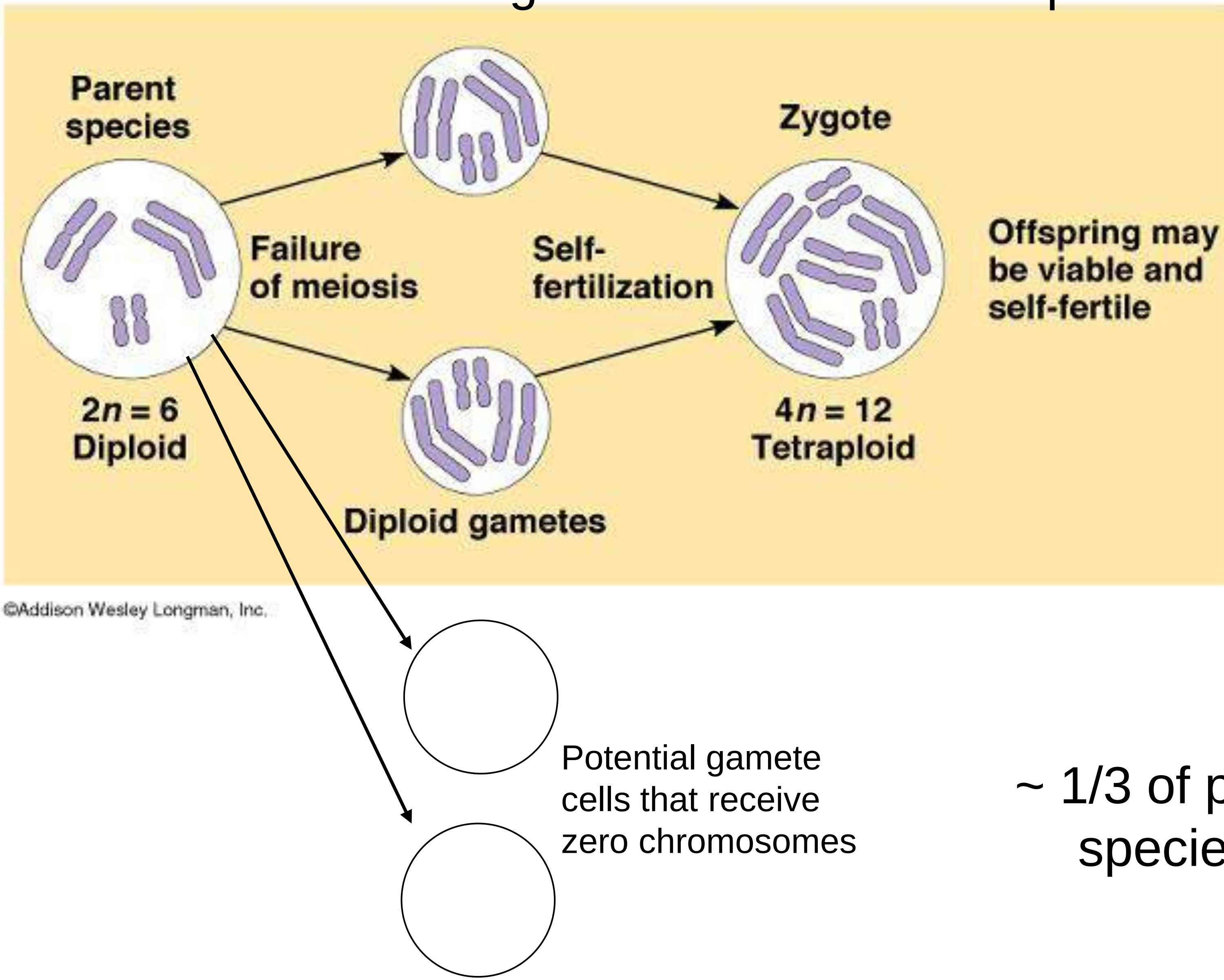
- speciation without geographic isolation
- possibly common, difficult to detect
- (ambiguity of “geographic” isolation?)

Figure 18.18

(a) *Gryllus pennsylvanicus* prefers sandy soil.

(b) *Gryllus firmus* prefers loamy soil.

Sympatric speciation due to nondisjunction of chromosomes during meiosis - common in plants



~ 1/3 of plant species

Outline

- Species definition
- Species identification
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- Mechanisms that prevent hybridization between species
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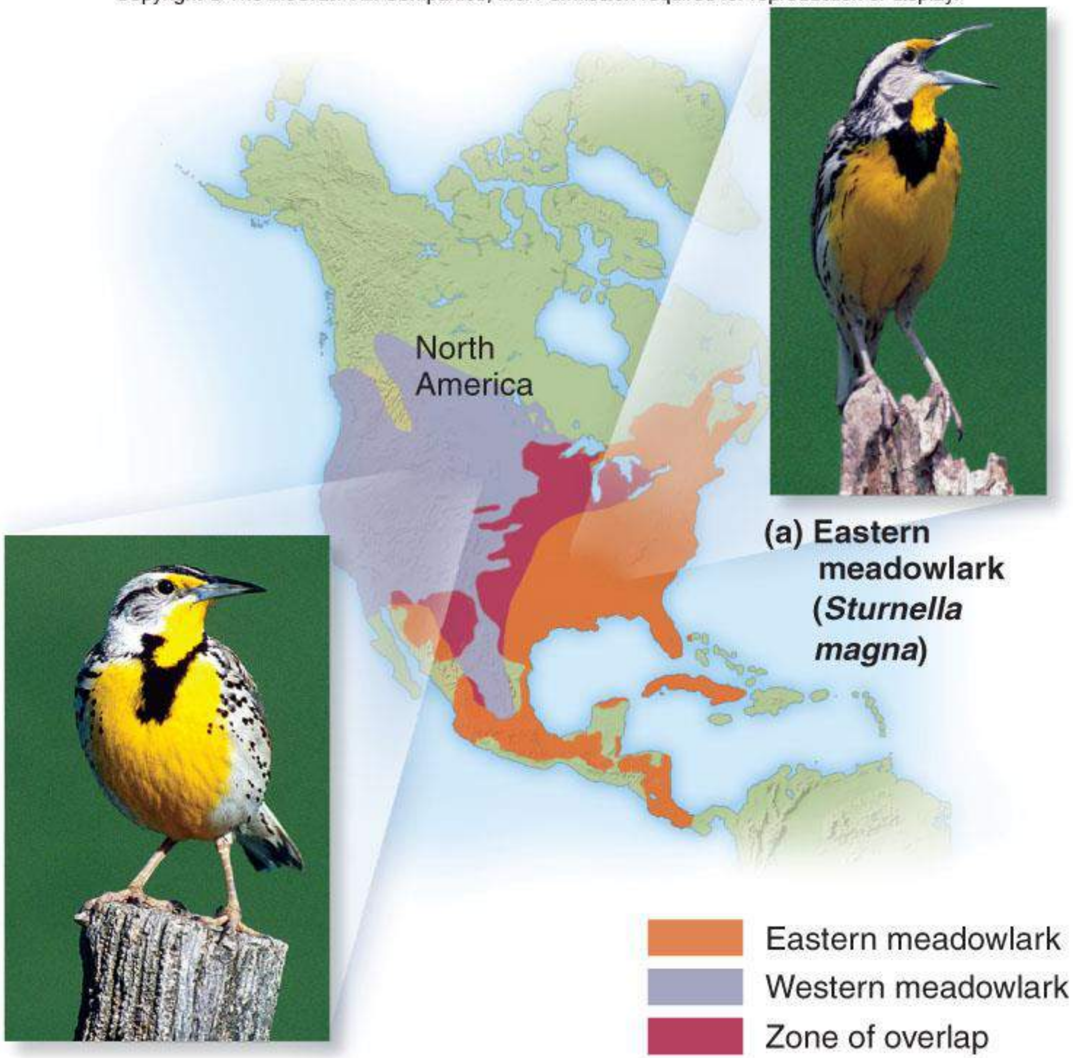
Recall that the species concept involves grey areas.

When are diverging populations truly separate species?

Can they form viable hybrids?

Do they form viable hybrids?

Behavioral isolation - birds not recognized as potential mates.



(a) Eastern meadowlark (*Sturnella magna*)

(b) Western meadowlark (*Sturnella neglecta*)

a: Ron Austing/Photo Researchers, Inc; b: Rod Planck/Photo Researchers, Inc

Eastern Meadowlark song
http://www.youtube.com/watch?v=vDpydv6VbtU

Western Meadowlark song
http://www.youtube.com/watch?v=lvAUgFb1cLY

Temporal isolation

– mate at different times of year

Figure 18.17

(a) (b)

- These two related frog species exhibit temporal reproductive isolation. (a) *Rana aurora* breeds earlier in the year than (b) *Rana boylii*. (credit a: modification of work by Mark R. Jennings, USFWS; credit b: modification of work by Alessandro Catenazzi)

Outline

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Evolution of Development

Small genetic changes (e.g. single mutations) that affect the development of embryos can cause tremendous morphological changes.

In other words, a small genetic change sometimes causes a major phenotypic change.

Evolution of Development

2 genes determines whether a bird’s foot is webbed (by changing whether web cells die during development).

(c) Comparison of a chicken and a duck foot

Courtesy of Dr. J.M. Hurle (Originally published in Development. 1999 Dec; 126(23):5515-22.)

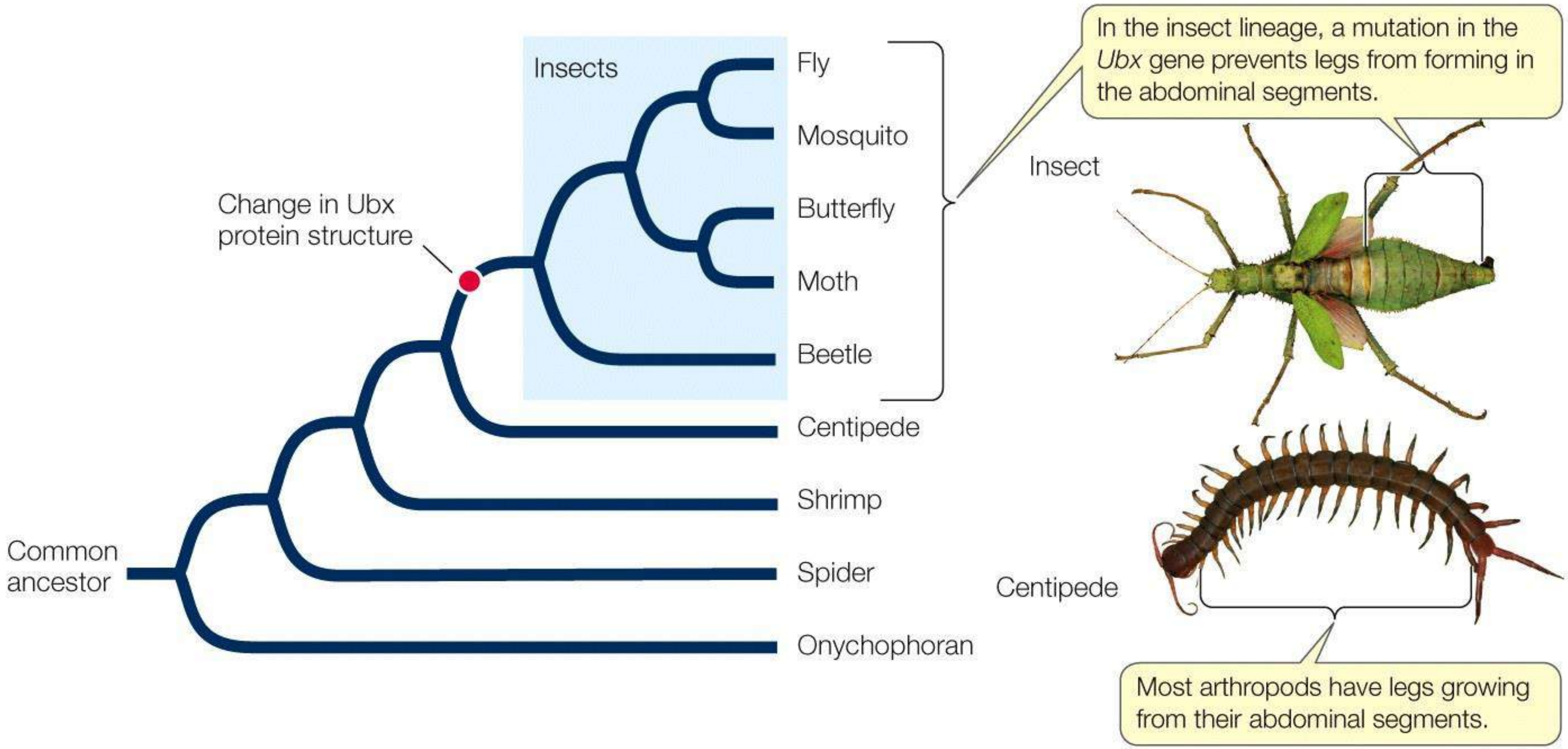
Intermediates with a bit of webbing need not ever occur for both foot morphologies to exist among bird species.

Evolution of Development

A single mutation prevents armor formation in sticklebacks.

Evolution of Development

One mutation prevents legs from forming on insect abdomens.



PRINCIPLES OF LIFE, Figure 14.19

Evolution of Development

Upshot:

Small genetic changes that affect development can have huge evolutionary implications.

Intermediate forms are not always necessary to get from one form to a distinctly different form.

Outline

- Species definition
- Species identification
- Origin of new species
    - Allopatric speciation
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History of life

George Bernard/Photo Researchers, Inc.

Outline

- Common ancestry
- Domains of life
- Past conditions on planet
- Historical mass extinctions
- Present mass extinction

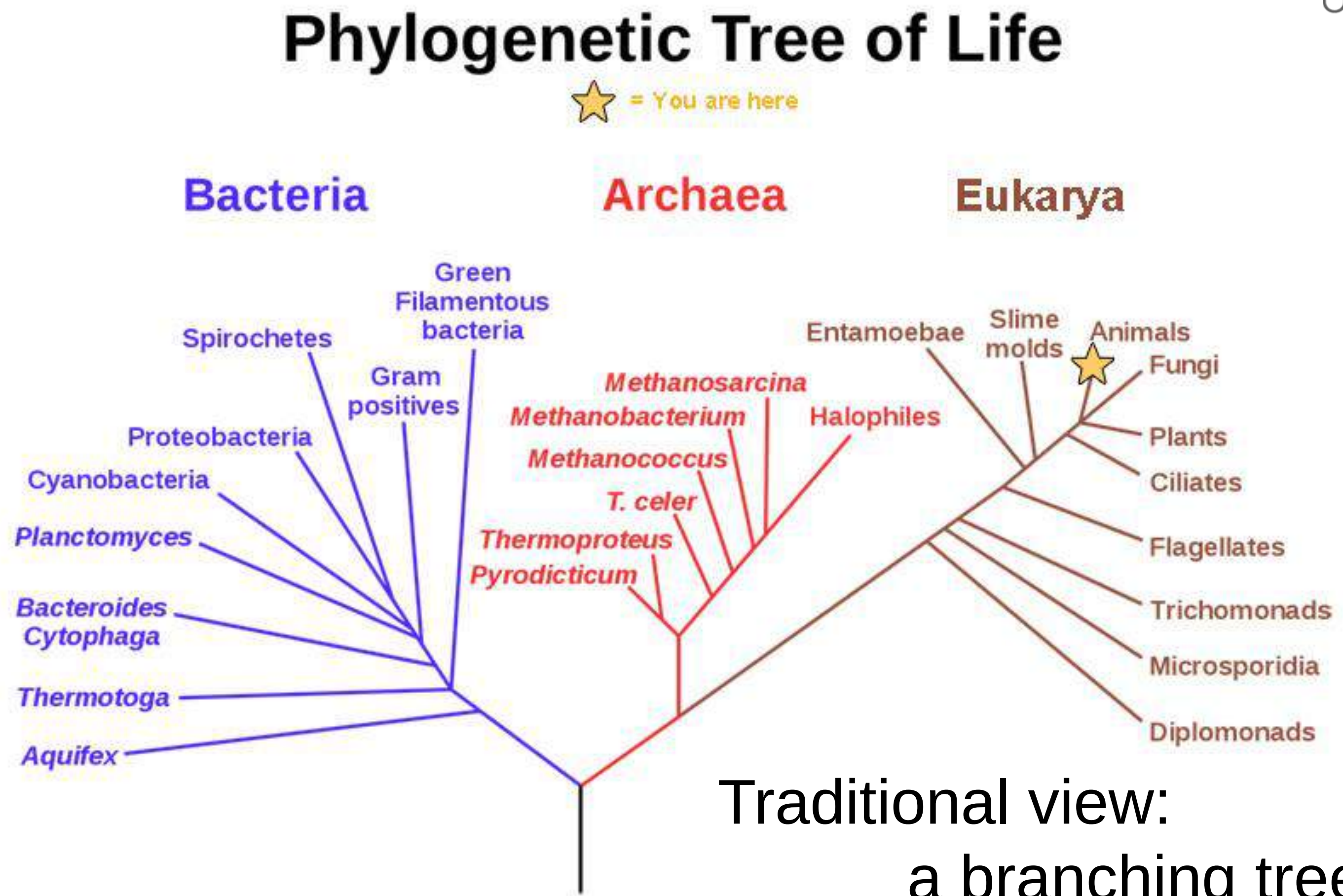
Some reasons all creatures are thought to be related:

All composed of same biochemicals, such as DNA and amino acids

Sequence similarities among fundamental genes

Evolve through gradual changes in genetic information

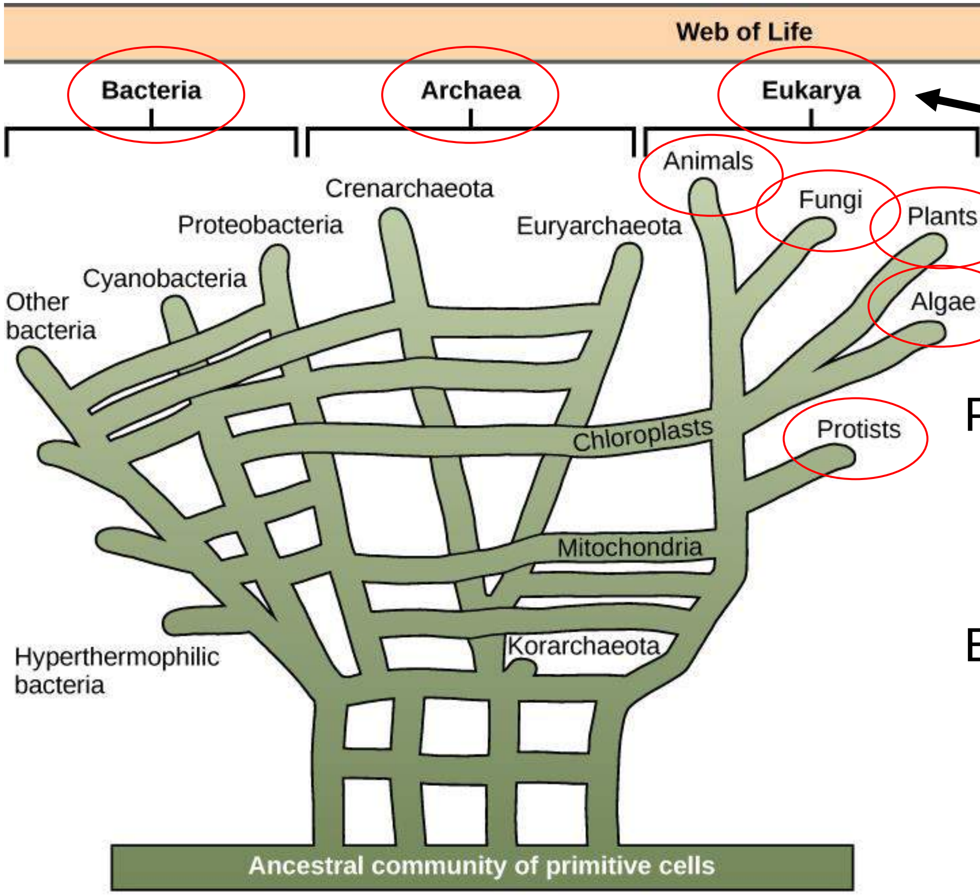
FIGURE 1.17



Traditional view:
a branching tree

This phylogenetic tree was constructed by microbiologist Carl Woese using data obtained from sequencing ribosomal RNA genes. The tree shows the separation of living organisms into three domains: Bacteria, Archaea, and Eukarya. Bacteria and Archaea are prokaryotes, single-celled organisms lacking intracellular organelles. (credit: Eric Gaba; NASA Astrobiology Institute)

Figure 20.16



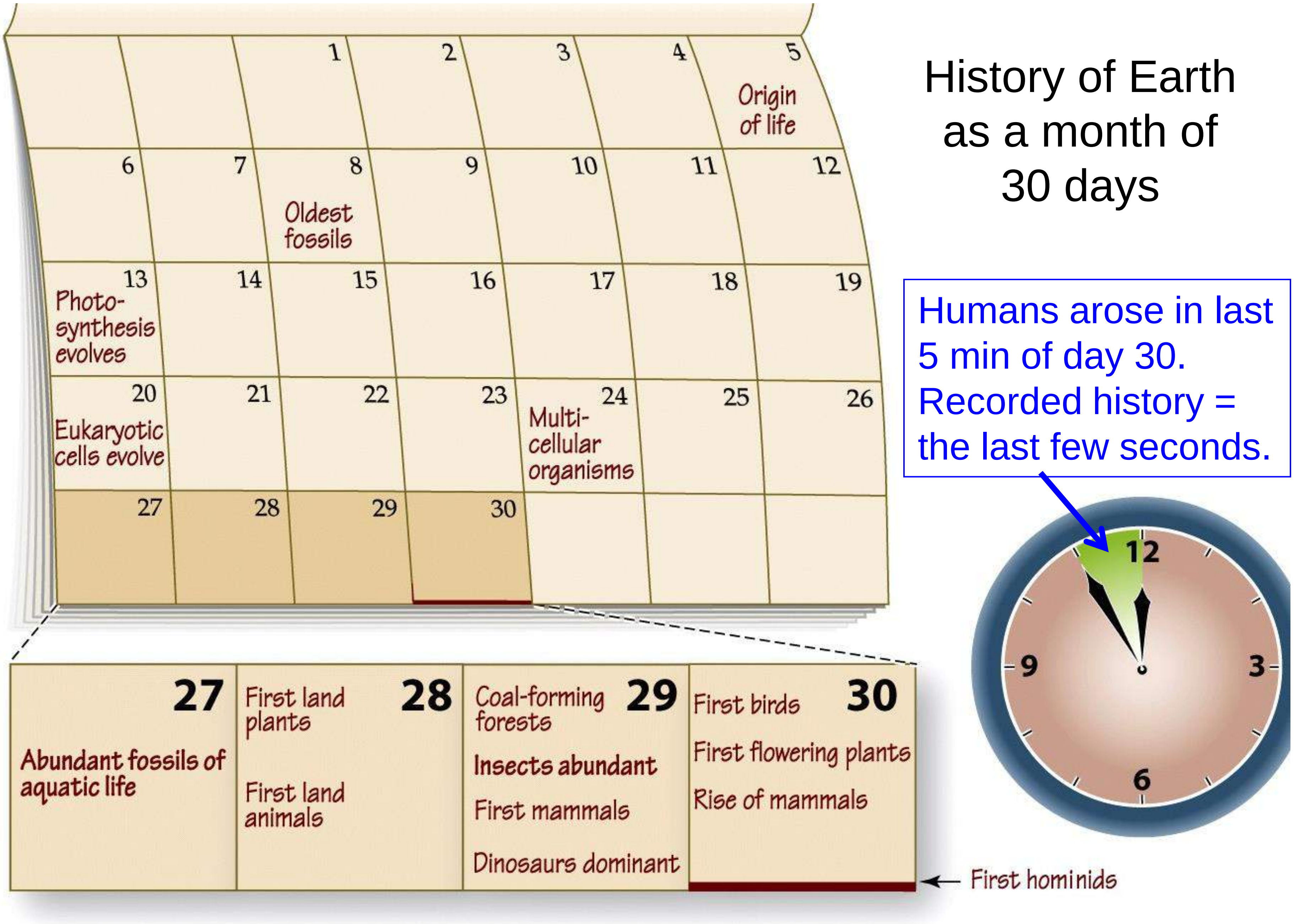
3 domains

Prokaryotes:
no cell nuclei
(archaea & bacteria)

Eukaryotes:
cell nuclei
(fungi, animals, plants, protists, algae)

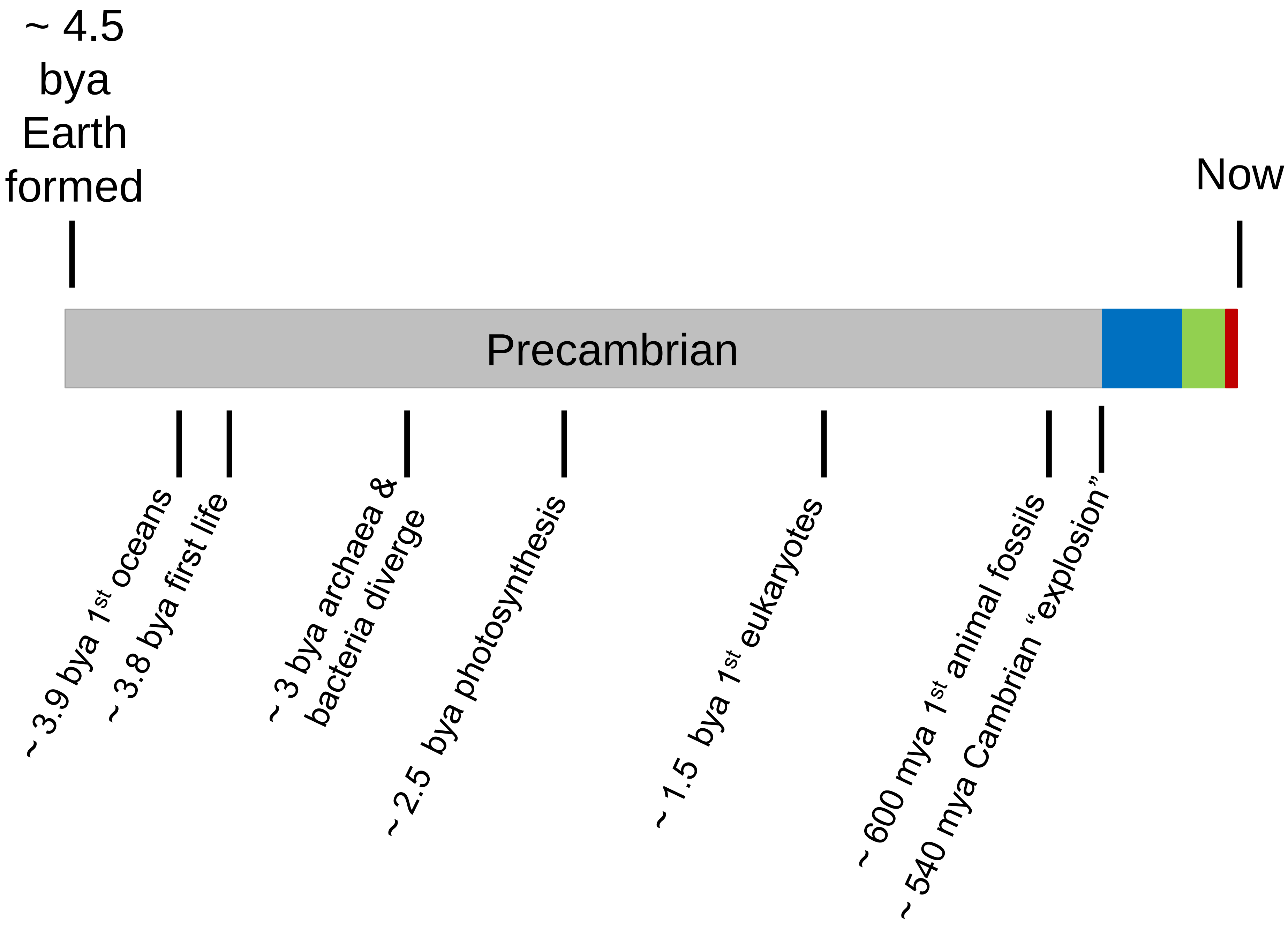
- In the (a) phylogenetic model proposed by W. Ford Doolittle, the "tree of life" arose from a community of ancestral cells, has multiple trunks, and has connections between branches where horizontal gene transfer has occurred.

History of Earth as a month of 30 days



Humans arose in last 5 min of day 30. Recorded history = the last few seconds.

PRINCIPLES OF LIFE, Figure 1.1



~ 4.5 bya Earth formed
Now
Precambrian
~ 3.9 bya 1st oceans
~ 3.8 bya first life
~ 3 bya archaea & bacteria diverge
~ 2.5 bya photosynthesis
~ 1.5 bya 1st eukaryotes
~ 600 mya 1st animal fossils
~ 540 mya Cambrian “explosion”

The earliest cells: Archaea

Age of Earth: 4.5 billion years

First life occurred > 3.8 bya, descendants still around

Archaea & bacteria diverge 3 bya

Today's Archaea occur in "harsh" environments.

Methanogens, halophiles, thermophiles
(Methane generators, salt lovers, heat lovers)

Grand Prismatic Spring, Yellowstone NP

http://en.wikipedia.org/wiki/File:Grand_prismatic_spring.jpg

https://en.wikipedia.org/wiki/Grand_Prismatic_Spring#/media/File:Grand_Prismatic_Spring_and_Midway_Geyser_Basin_from_above.jpg

Bacteria

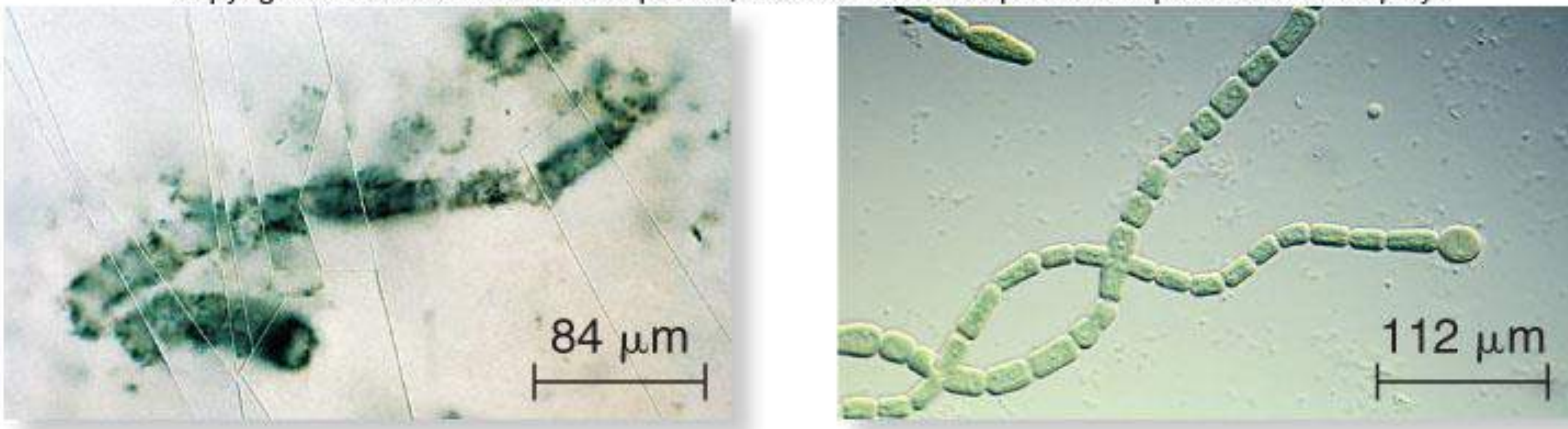
First evidence 3 bya, ~1 billion years after Archaea

Peptidoglycan in cell walls (unlike Archaea)

Includes the cyanobacteria

- photosynthesizers (give off O_2)
- responsible for O_2 in atmosphere
- enabled formation of stratospheric ozone layer
- stratospheric ozone layer blocks ultraviolet light
- no life on land until the ozone layer formed
- so, we owe our lives to pond scum

http://mareinet.com/2011/08/23/pond-scum-in-missouri-next-big-farmland-crop/



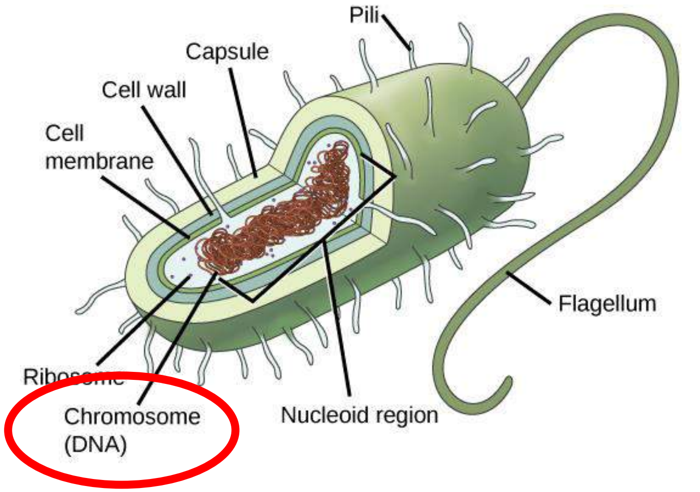
(a) Fossil prokaryote (b) Modern cyanobacteria

Prokaryotes (organisms whose cells lack nuclei, archaea, bacteria) had the planet to themselves for more than 1 billion years.

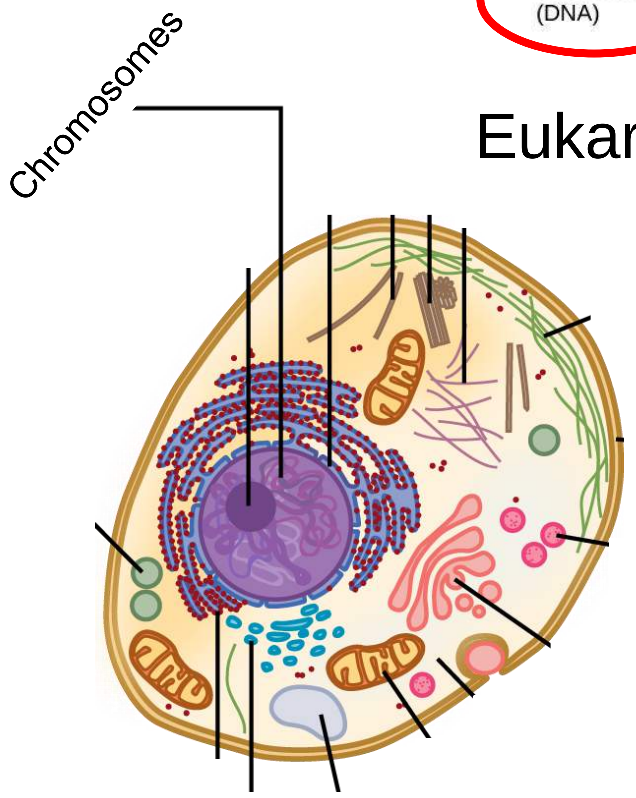
Eventually the first eukaryotes arose (organisms with chromosomes enclosed inside the membranes of cell nuclei. How?

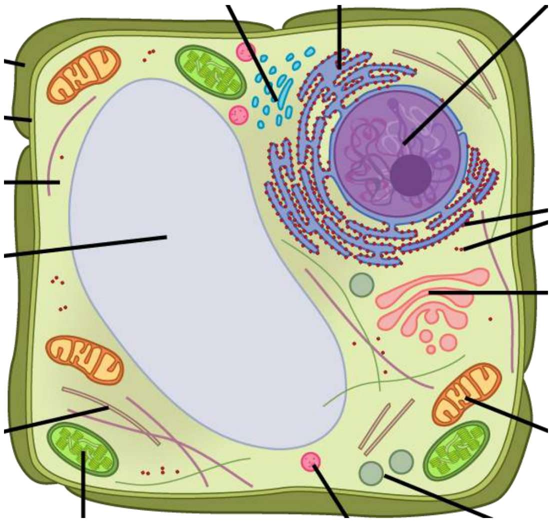
Prokaryote (Archaea & Bacteria)

Open Stax text figures 4.5 & 4.8

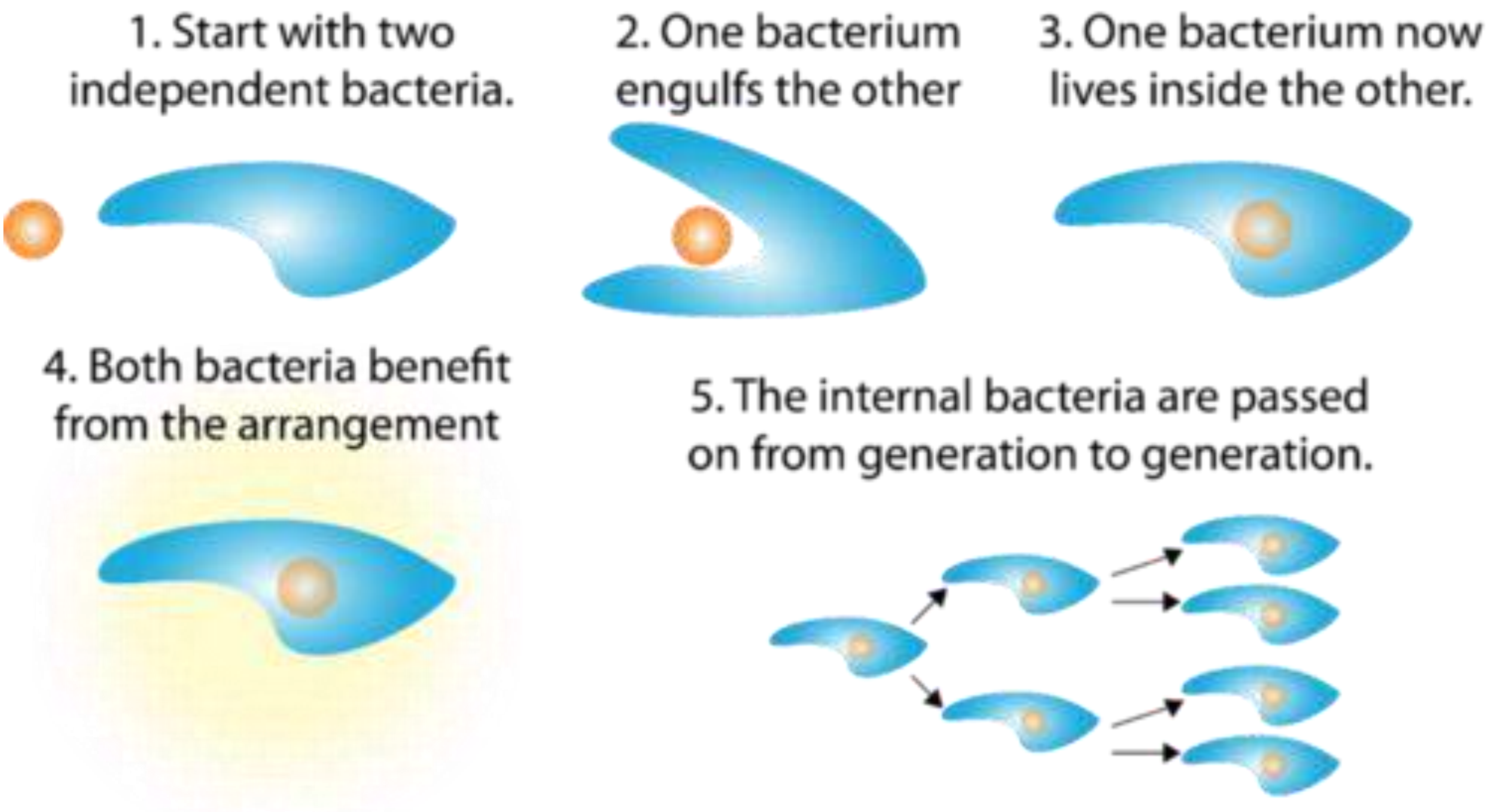


Eukaryotes (everything else)





Endosymbiont hypothesis for the origin of Eukaryotes



http://www.freelearningchannel.com/l/Content/Materials/Sciences/Biology/textbooks/CK12_Biology/html/9/ck12_1_files/20130303115913997916.png

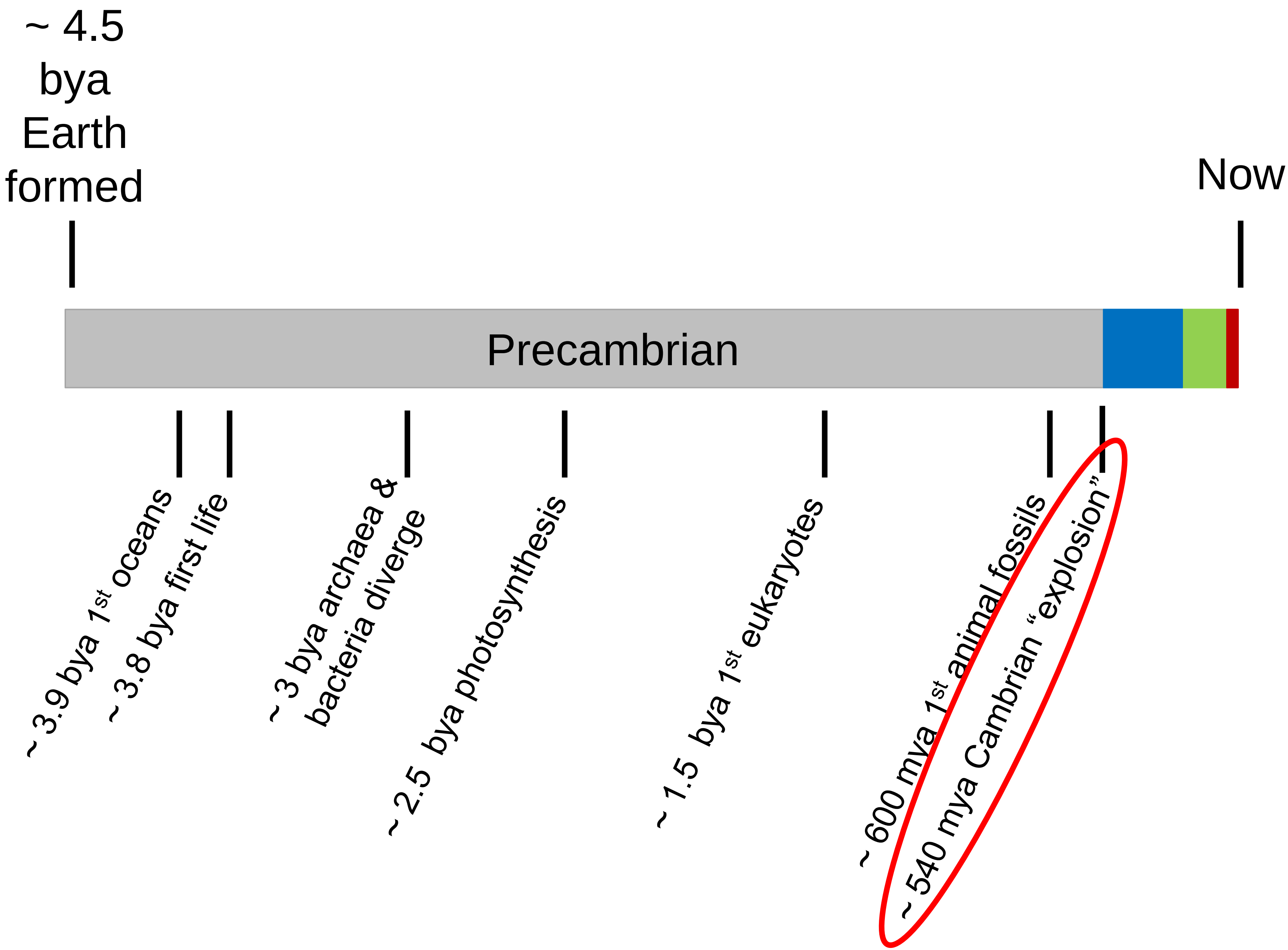
Evidence for endosymbiont hypothesis

Chloroplasts & mitochondria are similar in size to bacteria

Chloroplasts & mitochondria reproduce by splitting, like bacteria

Chloroplasts & mitochondria have their own circular DNA, like bacteria

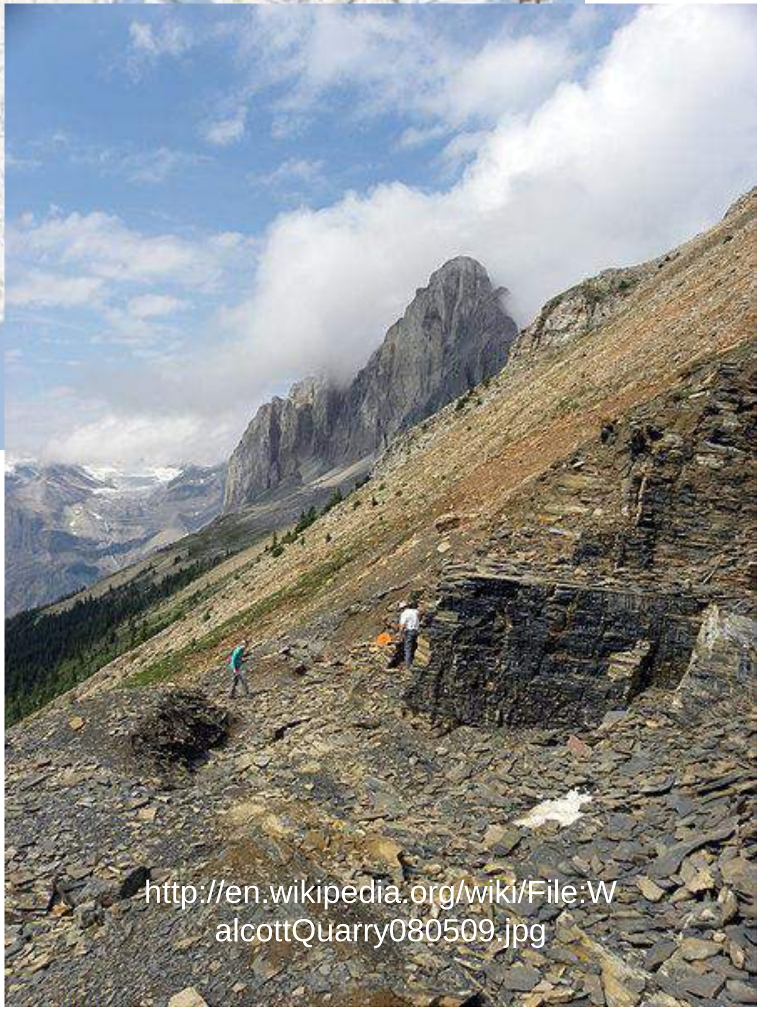
Chloroplast DNA include sequences very similar to cyanobacterial DNA.



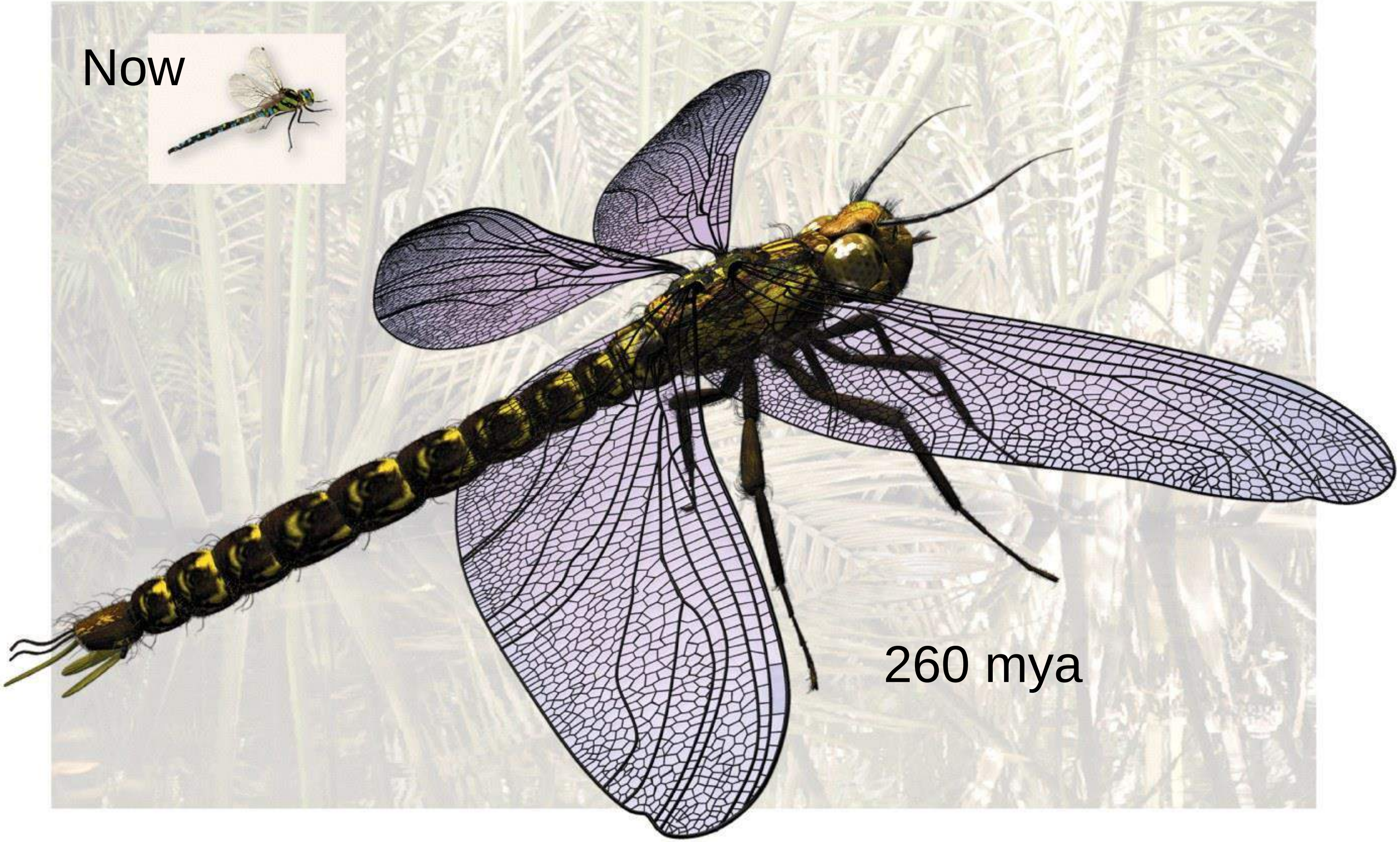
~ 4.5 bya Earth formed
Now
Precambrian
~ 3.9 bya 1st oceans
~ 3.8 bya first life
~ 3 bya archaea & bacteria diverge
~ 2.5 bya photosynthesis
~ 1.5 bya 1st eukaryotes
~ 600 mya 1st animal fossils
~ 540 mya Cambrian "explosion"

Figure 27.16


Google Maps
AB
MB
BC
SK
NL
ON
QC
Gulf of St
Lawrence
WA
MT
ND
MN
NB
OR
ID
WY
SD
NE
NV
UT
CO
KS
CA
OK
AZ
NM
TX
Gulf of
California
México

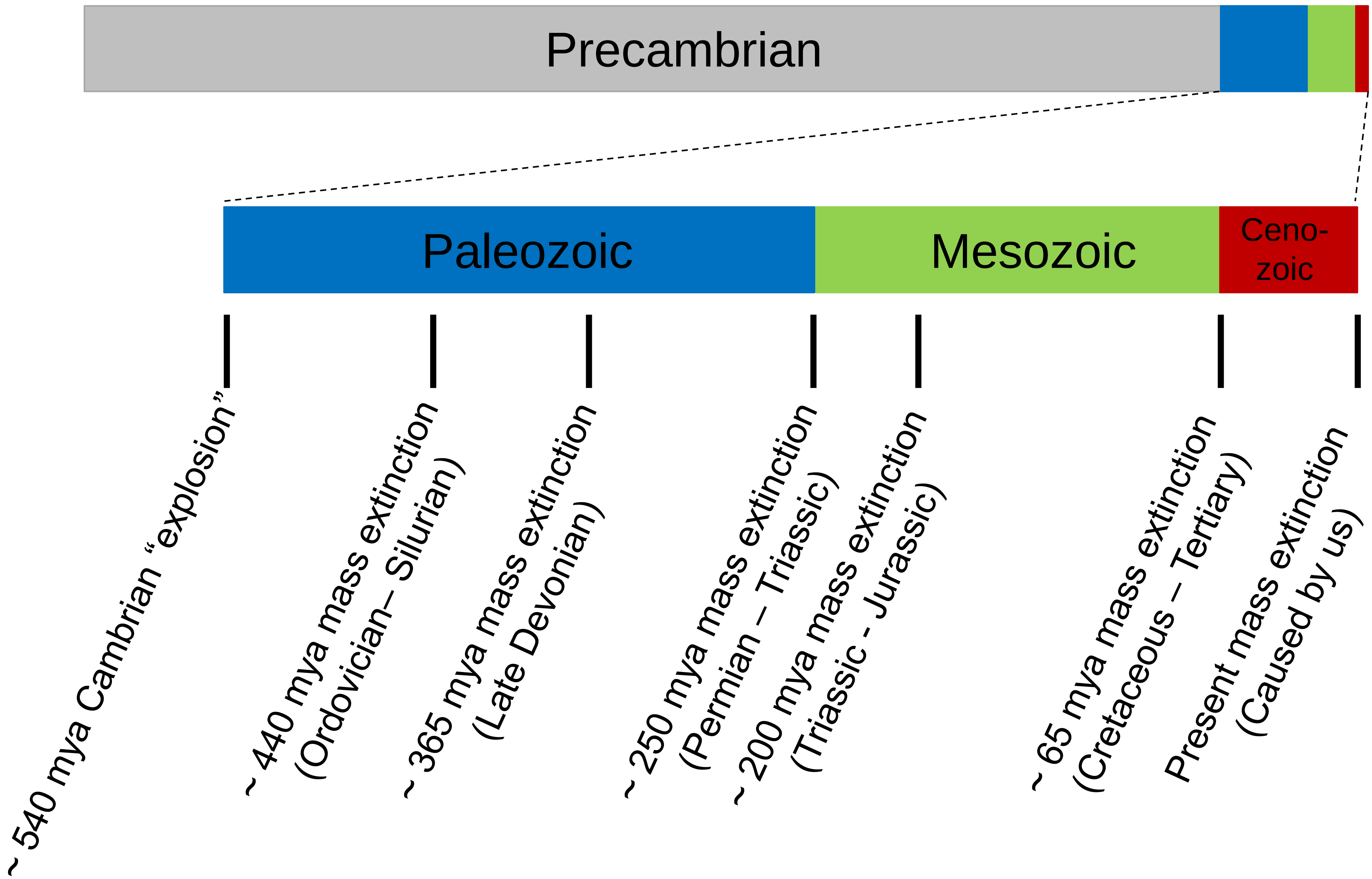

http://en.wikipedia.org/wiki/File:W
alcottQuarry080509.jpg

Conditions on the planet have been very different at some times in the past



PRINCIPLES OF LIFE, Chapter 18 Opener

Mass extinctions



Magnitude of mass extinctions

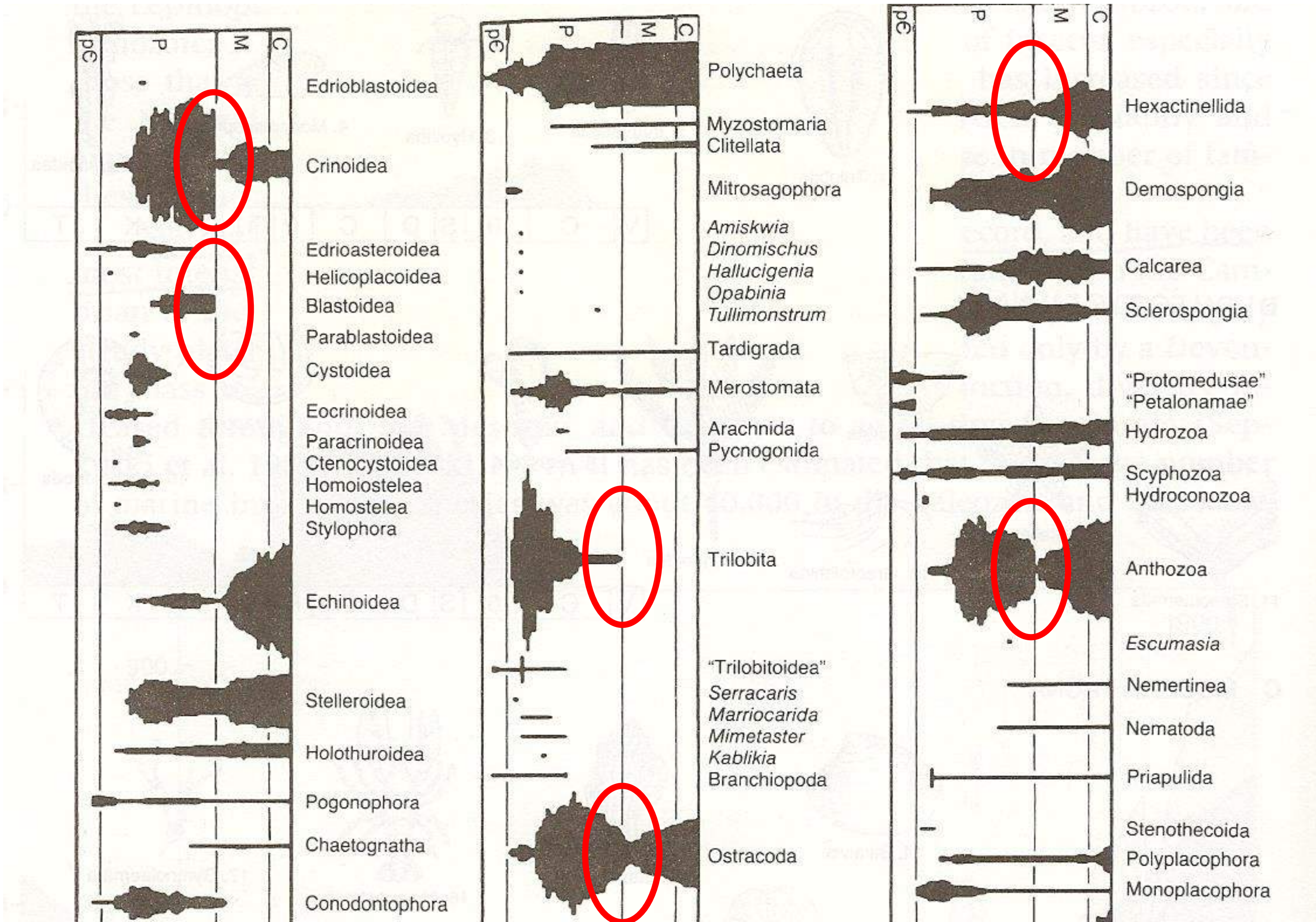
440 mya Ordovician – Silurian extinction
75% of all animals extinct

365 mya Late Devonian extinction
75% of marine species extinct

250 mya Permian – Triassic extinction
98% of species extinct. O_2 levels drop.

65 mya Cretaceous – Tertiary extinction
Dinosaurs extinct. Mammals radiate.

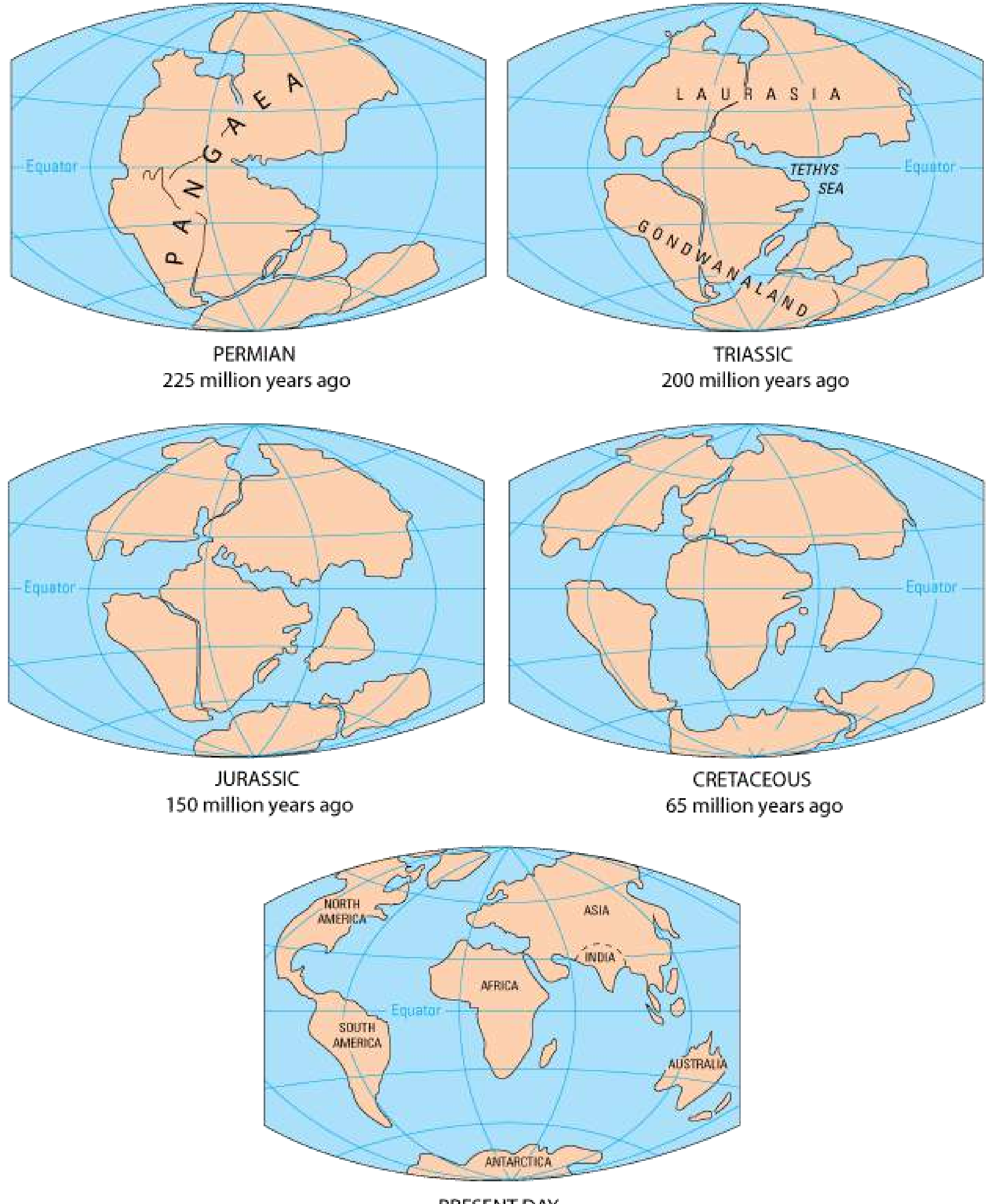
Diversity of families of marine animals in fossil record
(family extinct if all species & genera in family extinct)



Mass extinctions tend to be associated with climate change.

Several factors can cause climate change.

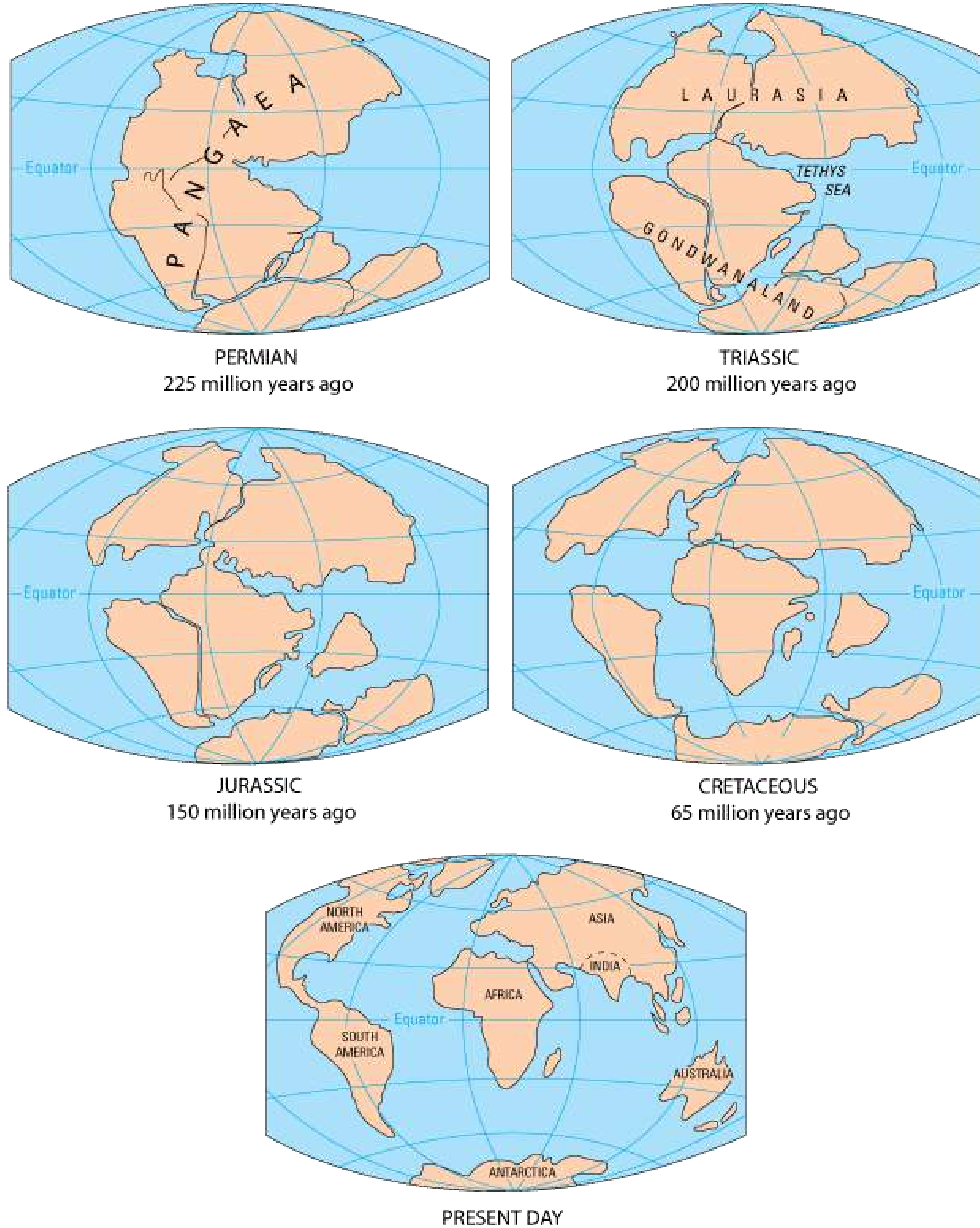
(1) Movement of continents.



http://pubs.usgs.gov/gip/dynamic/historical.html

Movement alters ocean currents, amount of land near poles, depths of oceans, and ocean currents

These changes can alter climates.



http://pubs.usgs.gov/gip/dynamic/historical.html

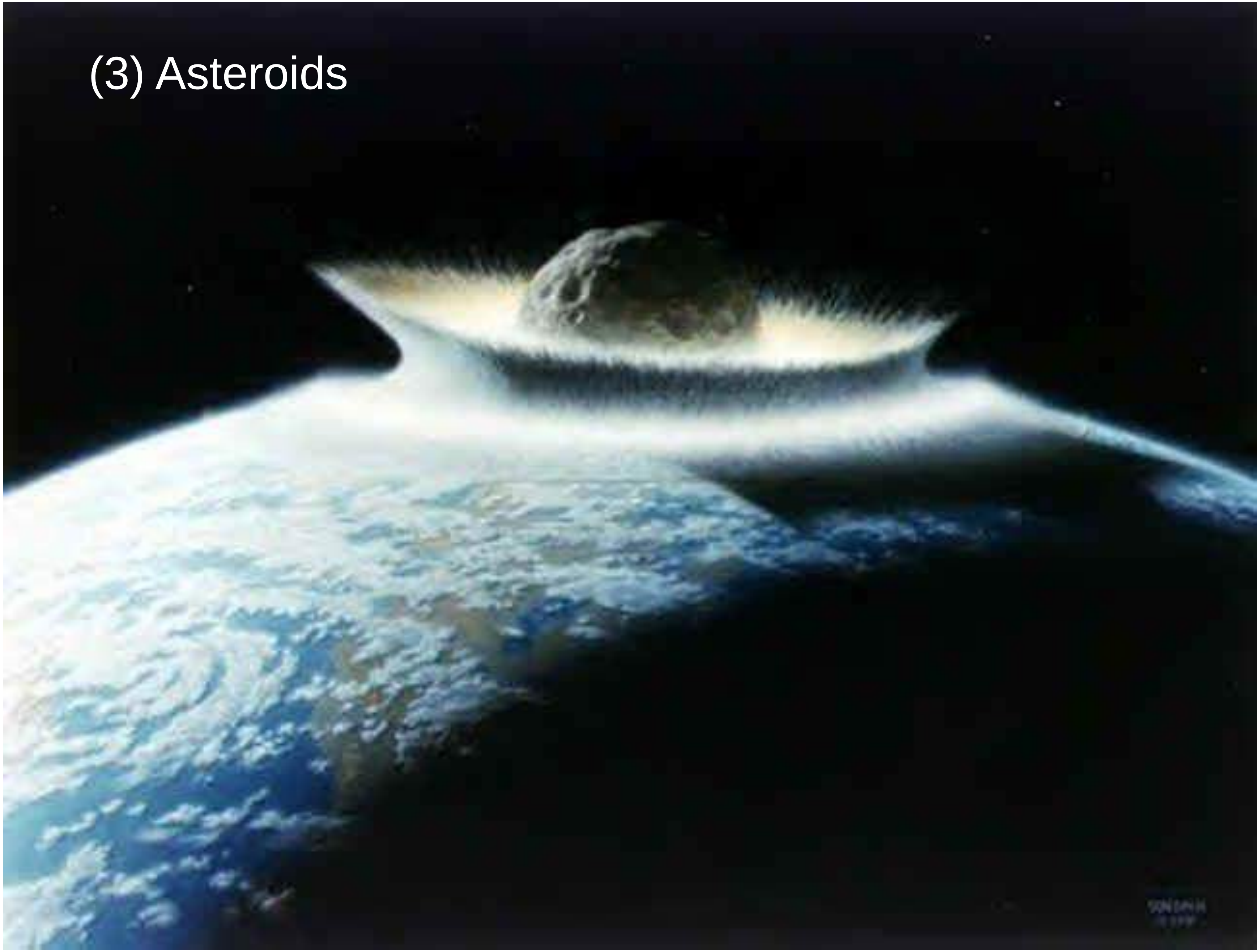
Tectonic plate movement can also cause (2) massive volcanism

Ash from volcanic eruptions blocks light & thus initially cools the climate, but ash eventually settles,

while carbon dioxide from volcanism can cause warming over longer periods.

PRINCIPLES OF LIFE, **Figure 18.4**

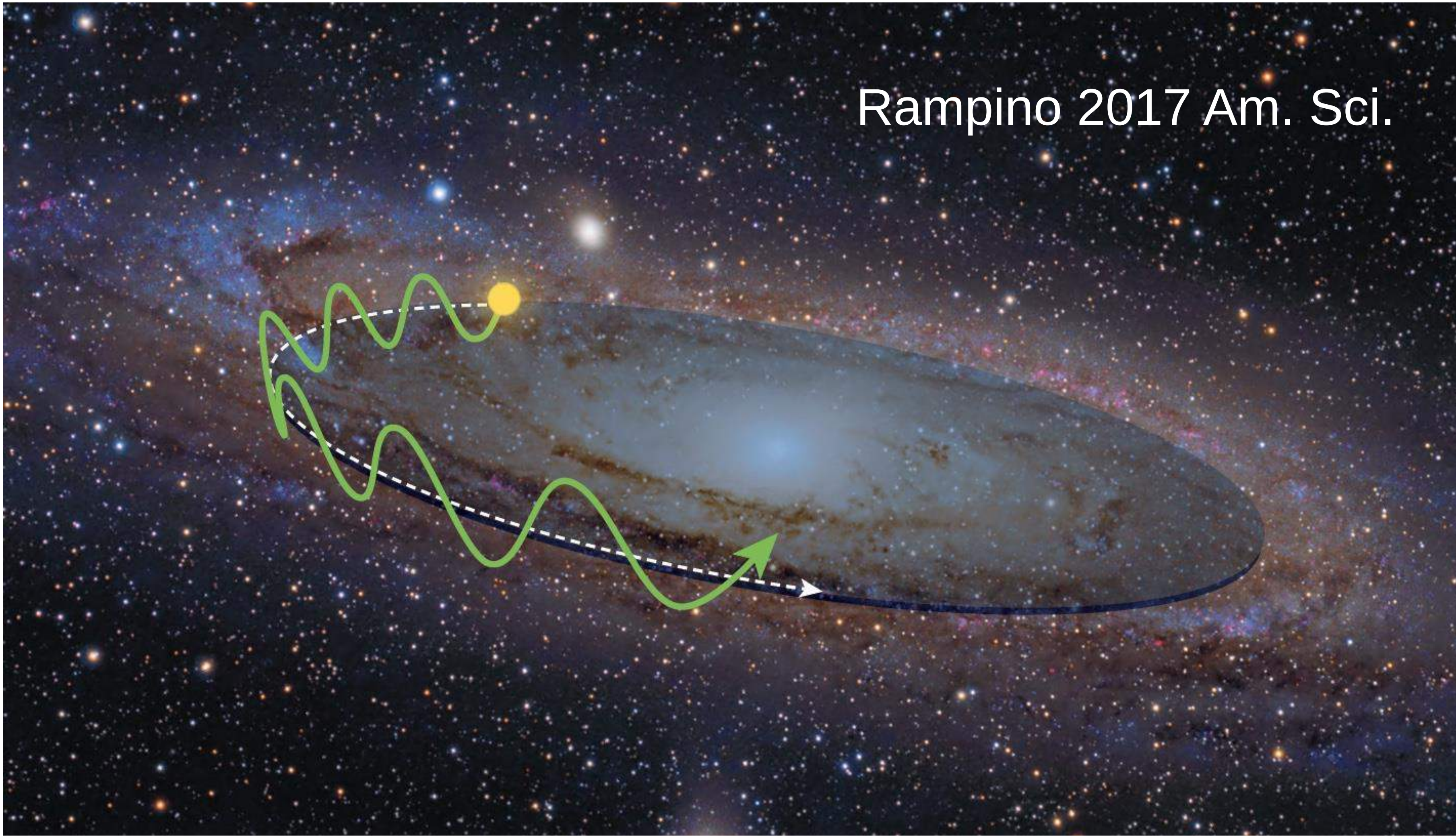
(3) Asteroids



http://palaeo.gly.bris.ac.uk/Palaeofiles/Triassic/bolide.htm www.earthchangestv.com

Figure 47.6

- In 1980, Luis and Walter Alvarez, Frank Asaro, and Helen Michels discovered, across the world, a spike in the concentration of iridium within the sedimentary layer at the K–Pg boundary. These researchers hypothesized that this iridium spike was caused by an asteroid impact that resulted in the K–Pg mass extinction. In the photo, the iridium layer is the light band. (credit: USGS)



Our Solar System moves through our galaxy, as depicted by the green line above. New evidence suggests that the 30-million-year cycle of the Solar System crossing through the galaxy's mid-plane corresponds with large-scale cataclysms on Earth, such as asteroid and comet impacts or large volcanic eruptions. These findings could upend the long-standing doctrine of geology set forth by Charles Lyell in the mid-1800s and replace it with a new, catastrophic geology.

craters found	extinction event (millions of years ago)	age of crater (million years)	fossils	expected 26-million-year cycle
none	11 mya			12 mya
9	36 mya	36 mya	some Eocene mammals	38 mya
8	66 mya	66 mya	Cretaceous dinosaurs, marine life	64 mya
7	94 mya	91 mya	Late Cretaceous marine life	90 mya
6	116 mya	115 mya	Early Cretaceous marine life	116 mya
5	145 mya	145 mya	Jurassic dinosaurs	142 mya
4	168 mya	168 mya	Jurassic marine life	168 mya
3	201 mya	201 mya	Late Triassic reptiles	194 mya
2	225 mya	228 mya	Late Triassic marine life	220 mya
1	252 mya	254 mya	more than 90 percent of life	246 mya

Rampino 2017 Am. Sci.

If no asteroid then dinosaurs probably not extinct, then no radiation of mammals, then no evolution of humans.

http://palaeo.gly.bris.ac.uk/Palaeofiles/Triassic/bolide.htm www.earthchangestv.com

5 greatest mass extinctions of the past all apparently associated with unusually rapid climate change.

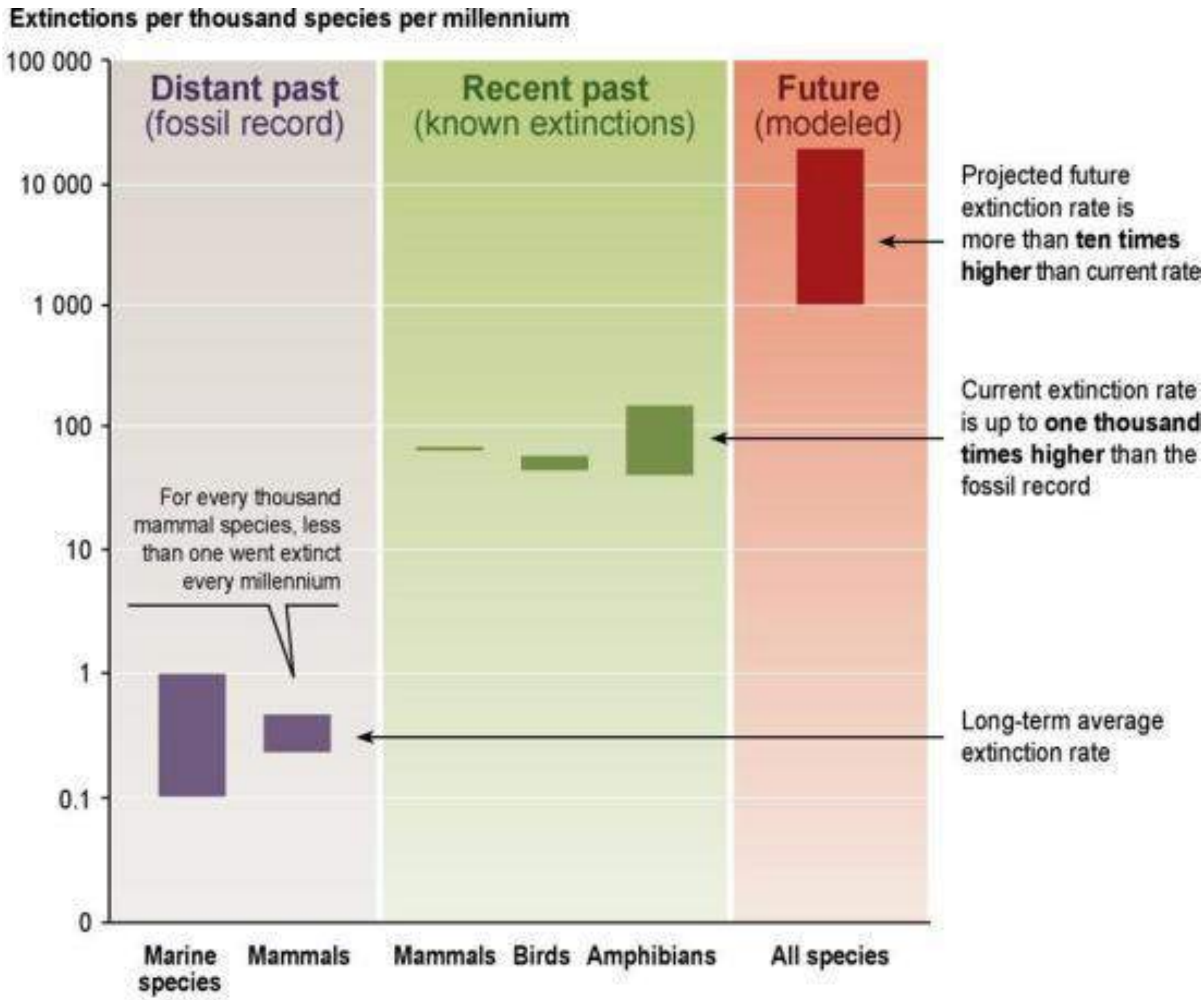
“Those who do not remember the past are condemned to repeat it.”

George Santayana
Spanish philosopher

6th Mass Extinction

http://www.chicagotribune.com/features/lifestyle/green/chi-endangered-threatened-species-080515-pg,0,2716741.photogallery

Extinction Rate Projections



http://maps.grida.no/go/graphic/species-extinction-rates

Habitat destruction due to agriculture, pollution, and urbanization has been responsible for most recent extinctions.

Henceforth, anthropogenic climate change may be most responsible for extinctions.

ART FOR SCIENCE RISING

With an innovative project, UCS enlists artists to help remind voters that science matters.

BY PAMELA WORTH

In 2018, UCS took every opportunity before the midterm elections to reach prospective voters with the message that science and evidence are crucial to our democracy. As part of that effort, we launched Science Rising, a national mobilization of thousands of scientists and science enthusiasts who hosted more than 100 events emphasizing the importance of science to our health and safety. Then, in order to draw even broader attention, we thought outside the lab.

The resulting project, *Art for Science Rising*, began with a UCS call to artists around the country to create visible, bold work in outdoor public spaces that would communicate the vital role science plays in our lives. We received dozens of inspiring proposals that were evaluated by a team of artists, art curators, and science communicators. Six artists and collectives made the cut, and we awarded them grants to develop and install their works.

With their distinct and indelible messages, these works of public art have reached hundreds of thousands of people and garnered media attention from print and television outlets. UCS is proud to have facilitated this unique exchange among scientists, artists, and the public.

Here are the projects (which are also on the UCS website at *www.ucsusa.org/art-science-rising*. And stay tuned for more *Art for Science Rising* projects in 2020.

WE ARE THE ASTEROID II

Justin Brice Guariglia, Chicago, IL

Artist and environmental activist Justin Brice Guariglia's unusual inspiration was something many of us see every day: a large LED sign on the side of the highway, flashing traffic-related alerts.

"I thought, this is the perfect metaphor," he says. "It's a great way to get people to slow down and think more about the unprecedented changes taking place in the natural world around us." Working with Rice University professor and author Timothy Morton, Guariglia refurbished a solar-powered message board and programmed it with text Morton drafted. He then installed the sign at Chicago's Navy Pier, where hundreds of thousands of passersby watched it flash a series of aphorisms:

WARNING: HIGH CO2 • TRIASSIC WEATHER AHEAD
GLOBAL WARMING AT WORK • GOODBYE ARCTIC ICE
DON'T ECO SHOP ECO VOTE • WE ARE THE ASTEROID

Artist: Justin Guariglia

Tropical rainforest
Enables us to breathe

Car motor
Enables us to travel fast

I don’t know how all the parts work.

Foolish to pull some out and throw them away.

Some species are more susceptible to extinction than others

Small populations due to

- limited habitats (endemics, island species)
- large area/individual (top carnivores)

Hunted or otherwise valuable to humans (esp in past)

Migratory species (need many appropriate habitats)

Species with specialized requirements

- e.g. hole nesting birds

History & Future of Life on the Planet: summary

Life began about 3.5 bya, precisely how is unknown

Bacteria and Archaea were alone for more than 1 by

Photosynthesis evolved about 2.5 bya

Eukaryotes evolved about 2 bya

Massive radiation of eukaryotes 540 mya (“Cambrian Explosion”)

5 mass extinctions since then (due to climate change associated with tectonic plate movement & at least one asteroid)

K-T extinction 65 mya wiped out dinosaurs & led to radiation of mammals

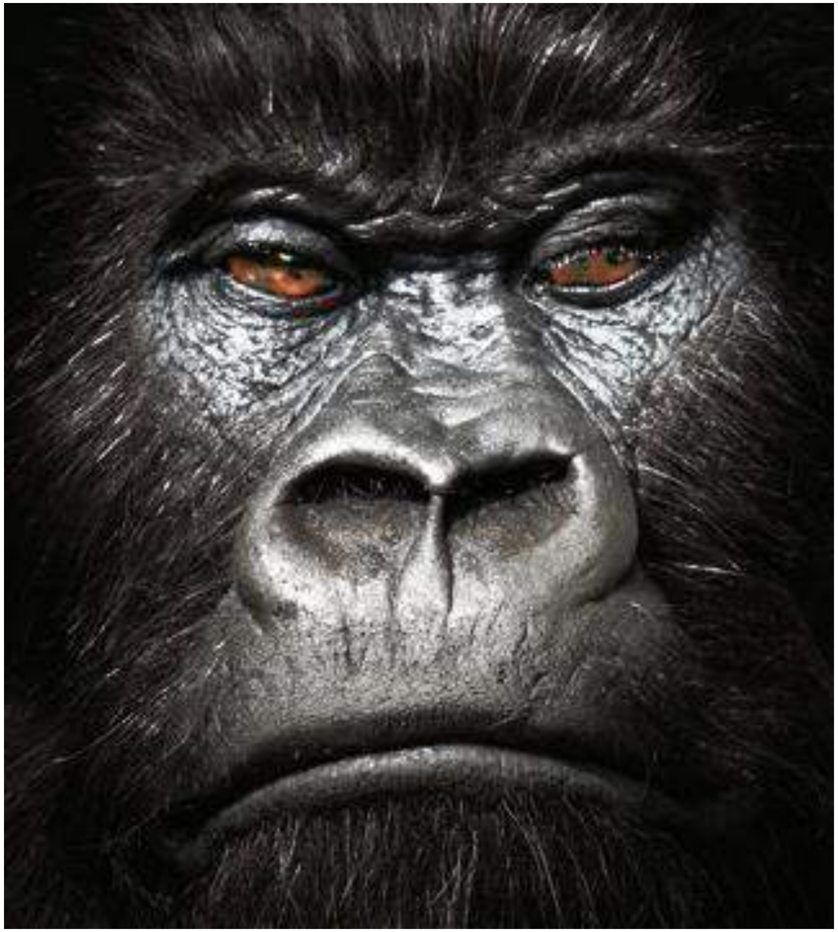
Present mass extinction due to habitat transformation

Future extinctions likely due to climate change


Grizzly bears are like golden retrievers now. – Bill McKibben
http://www.chicagotribune.com/features/lifestyle/green/chi-endangered-threatened-species-080515-pg,0,2716741.photogallery

Human Ancestry

Primates
- Monkeys & apes
  - Humans
    - Modern humans



http://ijustlovemonkeys.blogspot.com/2007/11/orangutan.html

http://www.roumazeilles.net/news/en/wordpress/category/digital-photography/wildlife-photo/gorilla/

Primates

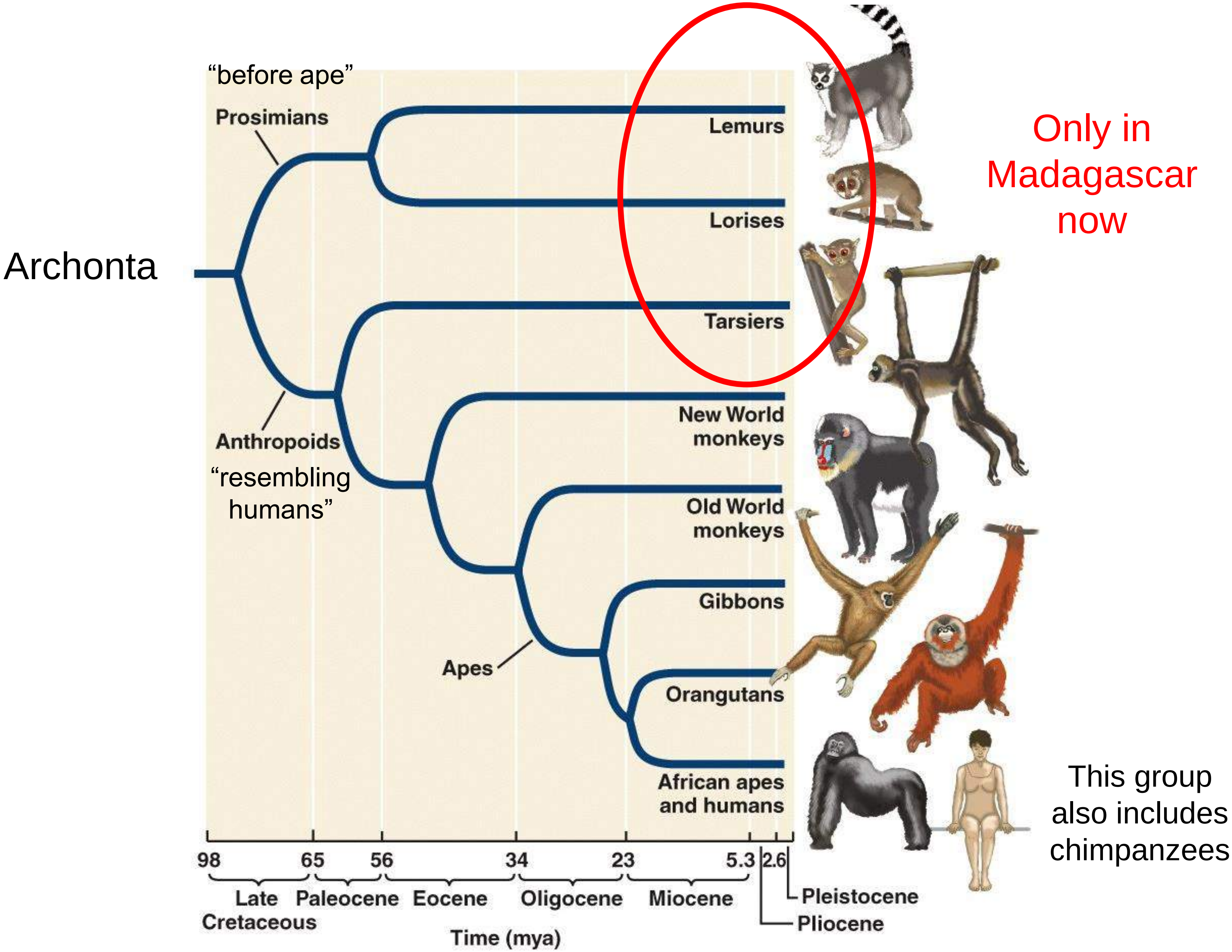
(Left): Michael Dick/Animals Animals; (Middle): © Lacz, Gerard/Animals Animals; (Right): © Martin Harvey/CORBIS

Tarsier Monkey us

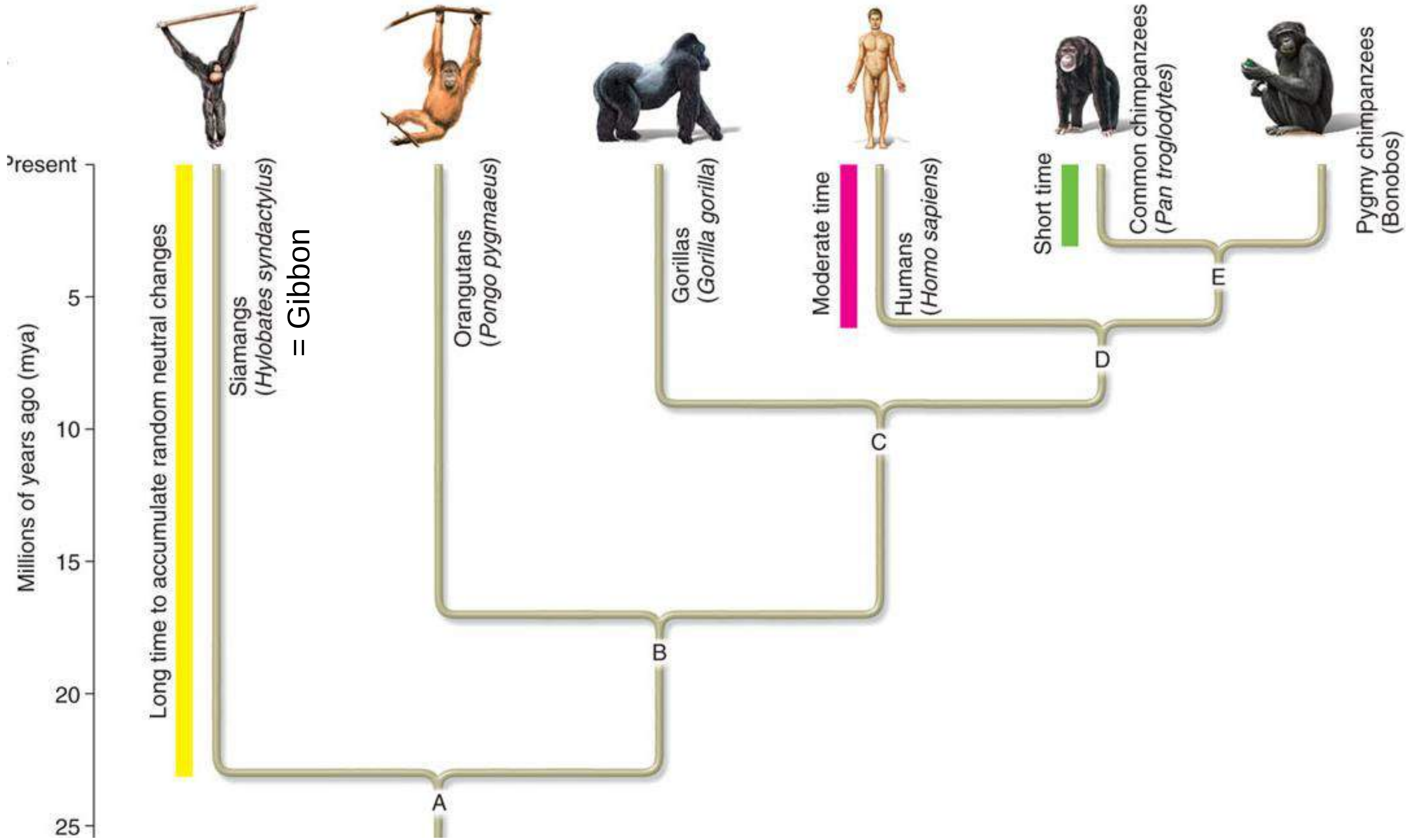
All *primates* have

1. Binocular vision &
2. Grasping fingers & toes

(No other mammal has both)



PRINCIPLES OF LIFE, **Figure 23.51**

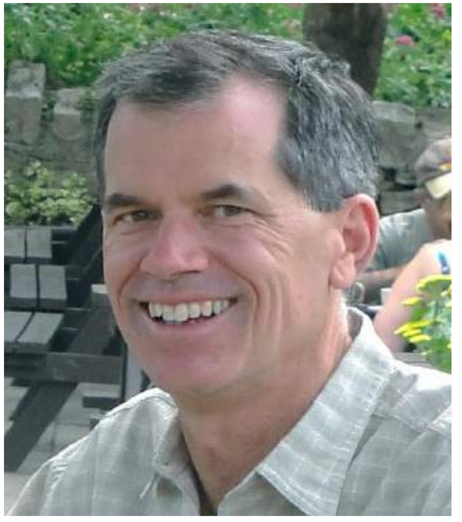


Present
5
10
15
20
25
Millions of years ago (mya)
Long time to accumulate random neutral changes
Siamangs
(Hylobates syndactylus)
= Gibbon
Orangutans
(Pongo pygmaeus)
Gorillas
(Gorilla gorilla)
Moderate time
Humans
(Homo sapiens)
Short time
Common chimpanzees
(Pan troglodytes)
Pygmy chimpanzees
(Bonobos)
A
B
C
D
E

1 gibbon 2 orangutan 3 gorilla 4 chimpanzee 5 human

humanhttp://www.nhc.ed.ac.uk/index.php?page=493.504.508.505

http://www.zooborns.typepad.com/zooborns/chimpanzee/




1% difference in DNA

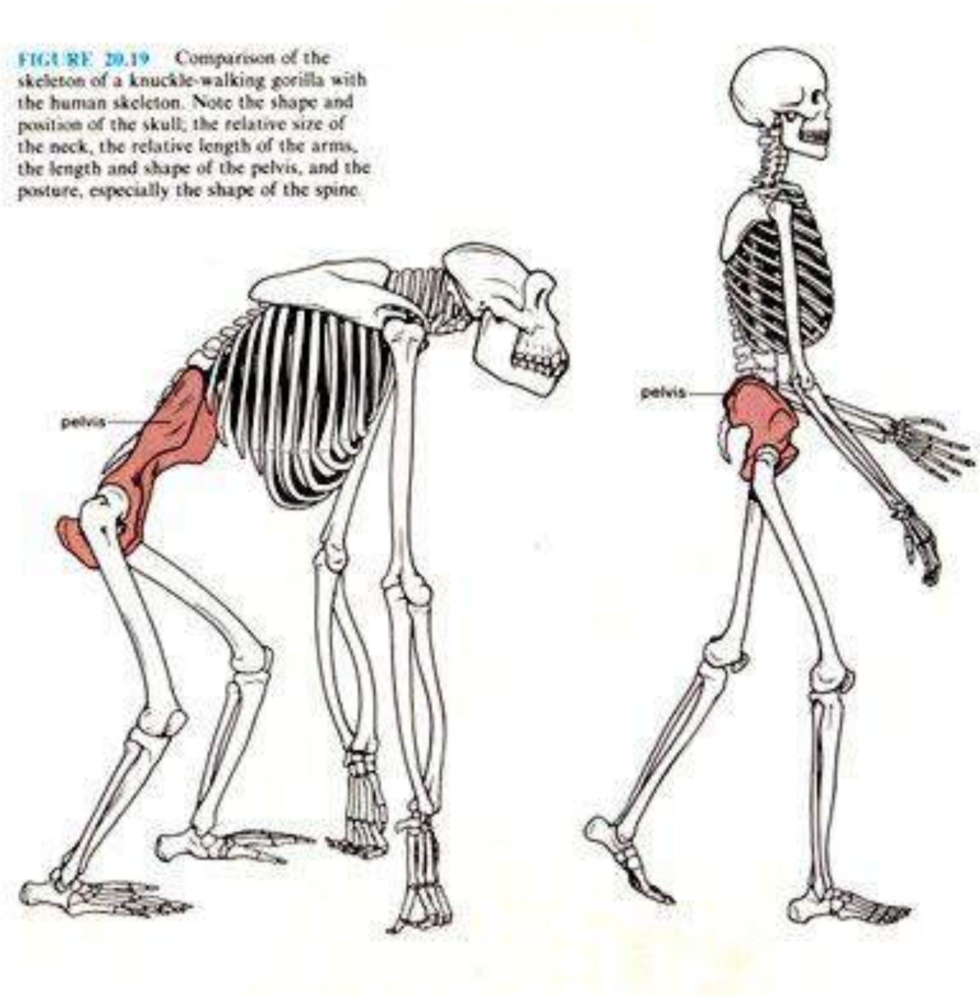

4% difference in DNA

Katherine Pollard, UC Davis, http://www.youtube.com/watch?v=sHwKcD5h8zA
Frans de Waal http://pin.primate.wisc.edu/factsheets/image/98
http://www.animalpictures1.com/r-mouse-87-mouse-1515.htm http://www.animalpictures1.com/r-rat-106-baby-rat-1874.htm

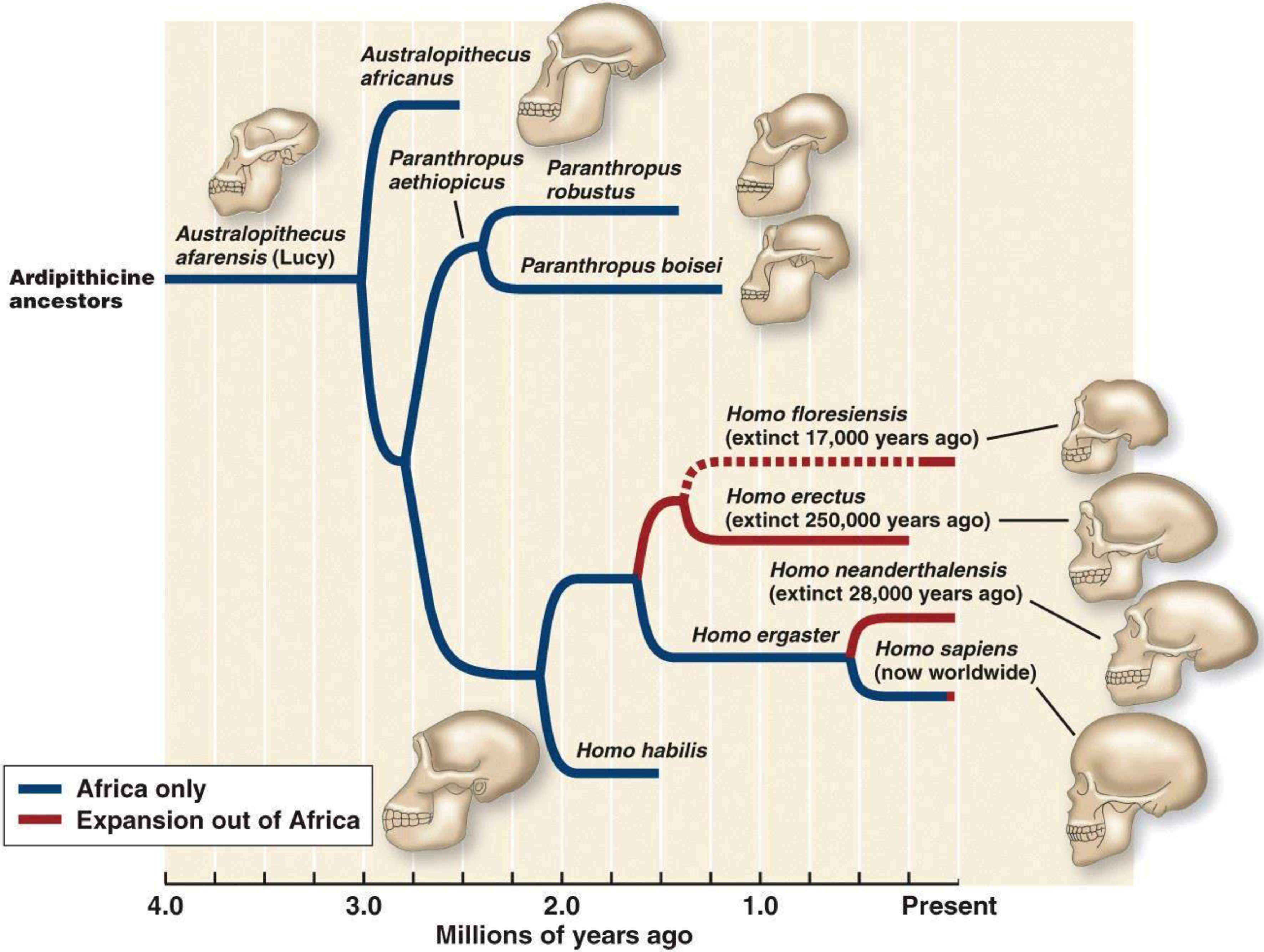
Primate evolutionary tree

65 mya	Mammals called archonta give rise to primates
36 mya	Some primates become diurnal - monkeys with opposable thumbs
25 mya	First apes
5-10 mya	Climate cools, African forests replaced by savanna & grasslands
4-5 mya	Ancestors become bipedal - bipedal primates can carry items in hands
2.5 mya	Tool use
2 mya	Brains get larger – presumably because of selection for intelligence due to potential to use tools

Bipedal gait



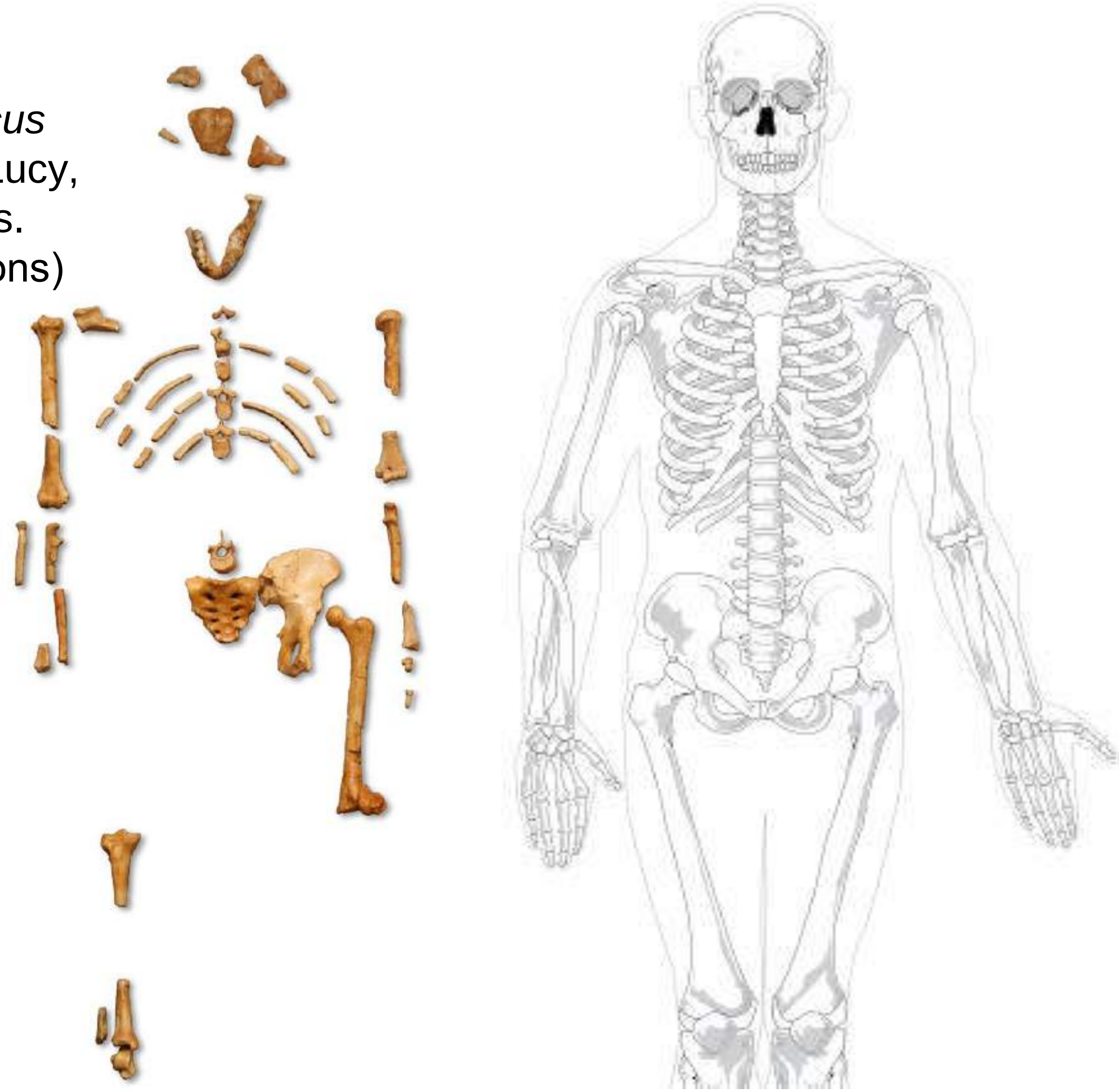
http://www.etap.org/demo/history_6/lesson1/pedal.jpg



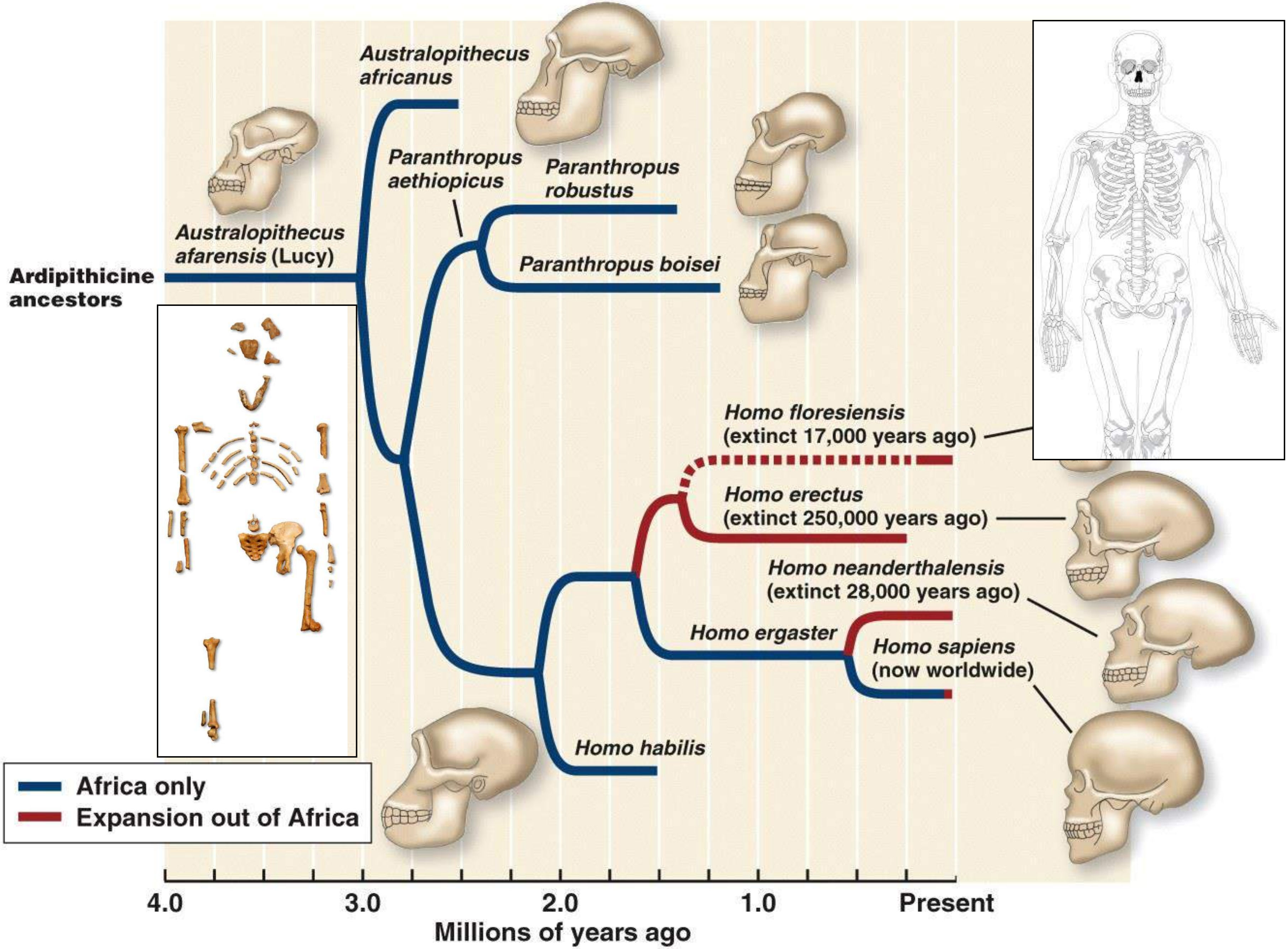
PRINCIPLES OF LIFE, Figure 23.52

Figure 29.43

This adult female *Australopithecus afarensis* skeleton, nicknamed Lucy, was discovered in the mid 1970s. (credit: “120”/Wikimedia Commons)



https://de.wikipedia.org/wiki/Datei:Human_skeleton_front_no-text_no-color.svg



***PRINCIPLES OF LIFE*, Figure 23.52**

https://www.nature.com/articles/d41586-019-00672-2, Researchers are continuing excavations in Denisova Cave in Siberia with the hope of finding more remains from Denisovans.Credit: IAET SB RAS

Neanderthal genes live on in modern humans

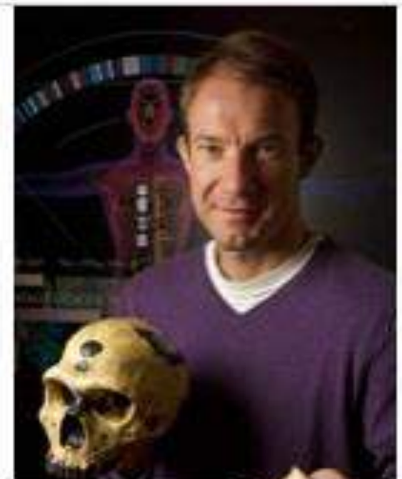
BY THE ASSOCIATED PRESS
DAILY NEWS STAFF WRITER

Thursday, May 06, 2010

WASHINGTON -- We have met Neanderthal and he is us - at least a little. The most detailed look yet at the Neanderthal genome helps answer one of the most debated questions in anthropology: Did Neanderthals and modern humans mate?

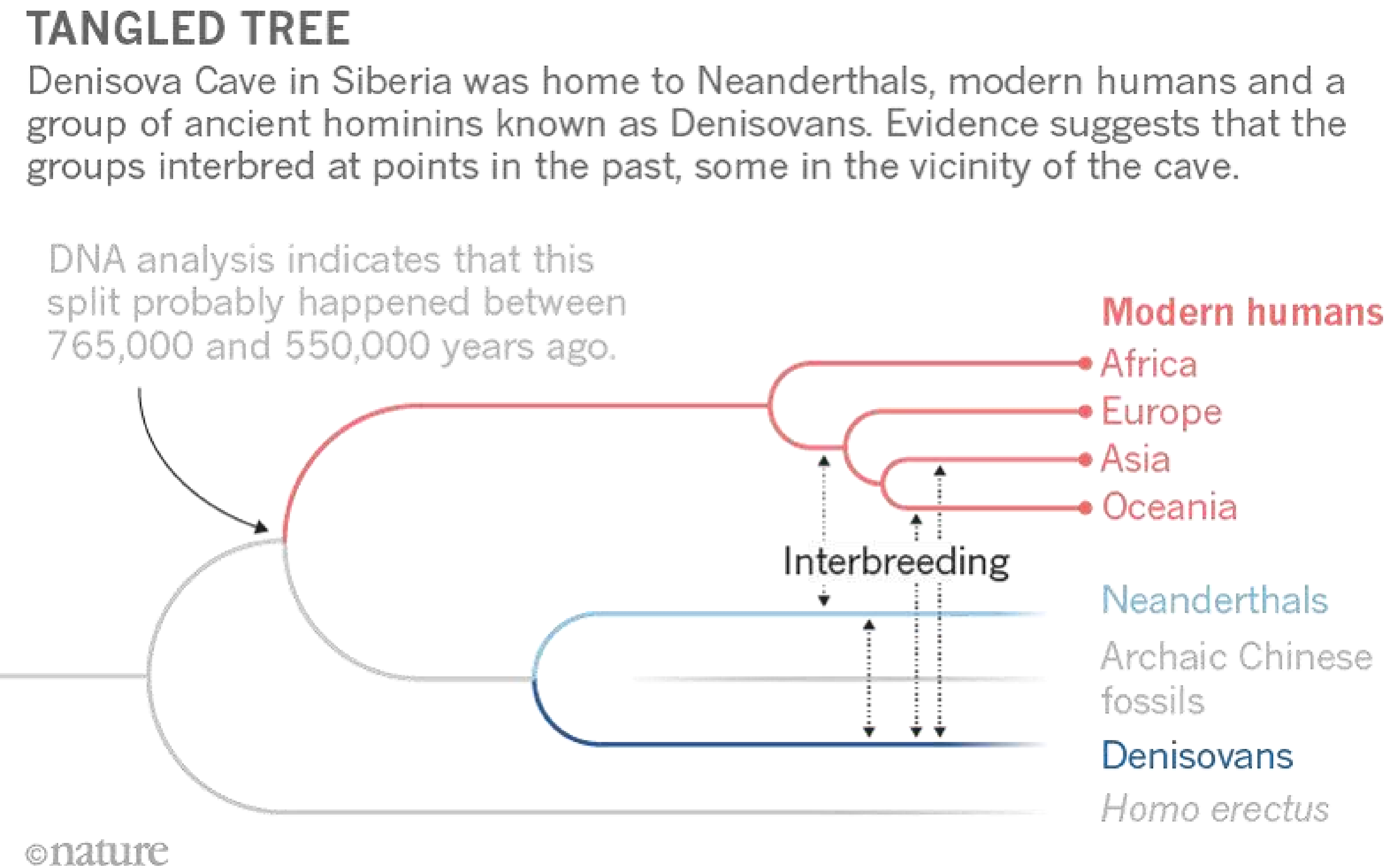
The answer is yes, there is at least some cave man biology in most of us. Between 1 percent and 4 percent of genes in people from Europe and Asia trace back to Neanderthals.

"They live on, a little bit," says Svante Paabo of the Max Planck Institute for Evolutionary Anthropology in Leipzig, Germany.



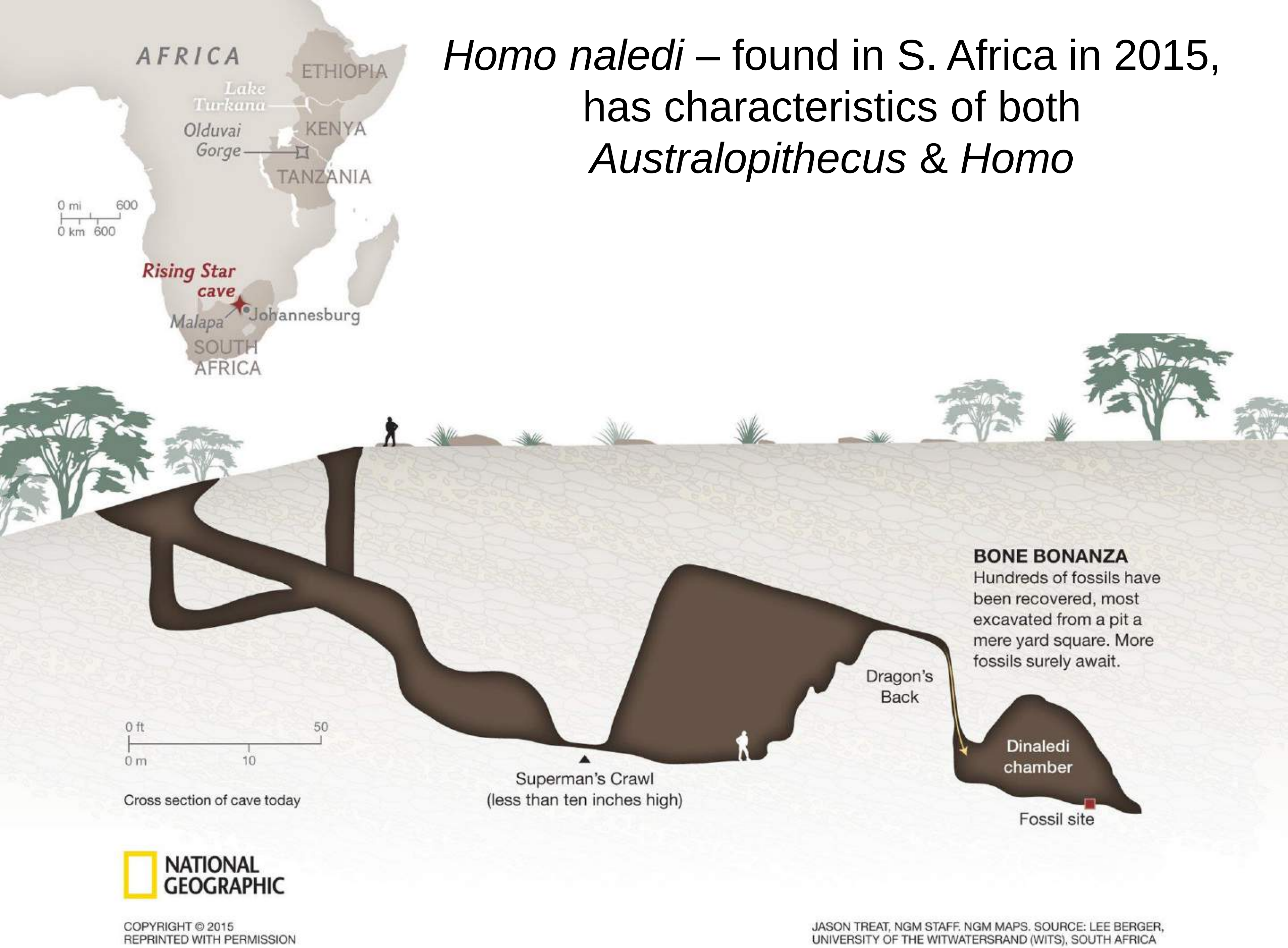
University of California Santa Cruz professor Ed Green holds replicas... (MacKenzie/AP)

http://articles.nydailynews.com/2010-05-06/entertainment/27063688_1_neanderthal-genes-modern-humans-svante-paabo



https://www.nature.com/articles/d41586-019-00672-2 Figure source: C. B. Stringer & I. Barnes *Proc. Natl Acad. Sci. USA* **112**, 15542–15543 (2015).

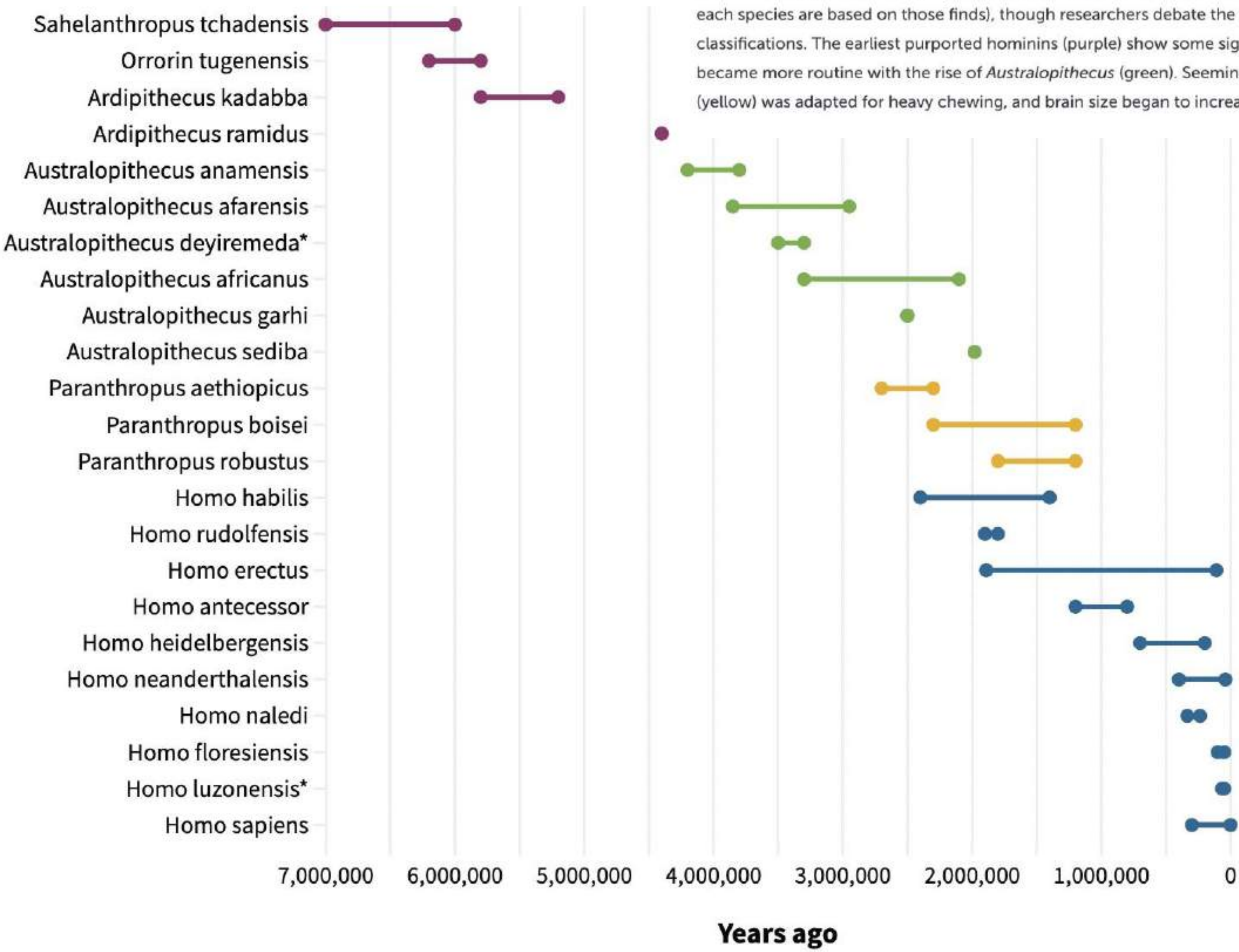
Homo naledi – found in S. Africa in 2015, has characteristics of both *Australopithecus* & *Homo*



Hominin species across time

All in the family

Fossil finds suggest that many hominin species have lived over the last 7 million years (dates for each species are based on those finds), though researchers debate the validity of some of these classifications. The earliest purported hominins (purple) show some signs of upright walking, which became more routine with the rise of *Australopithecus* (green). Seemingly short-lived *Paranthropus* (yellow) was adapted for heavy chewing, and brain size began to increase in *Homo* species (blue).



*Recently proposed species

Sources: Smithsonian Institution's Human Origins Program, Y. Haile-Selassie *et al/Nature* 2015, R. Pickering *et al/Science* 2011, Australian Museum, F. Détroit *et al/Nature* 2019

H. THOMPSON

https://www.sciencenews.org/article/human-evolution-species-origin-fossils-ancient-dna

Immediate ancestors of humans

5 mya	Hominids split from apes
4.5 mya	*Australopithecus* (“Lucy”) - truly bipedal, survived for 2 million years
~2.1 mya	*Homo erectus* in Africa, Europe & Asia
500,000 ya	*H. neanderthalis* in Africa
300,000 ya	*H. sapiens* in Africa & Middle east
100,000 ya	*H. neanderthalis* in Europe & Siberia
~~35,000~~ ya	*H. sapiens* in Europe
200,000 ya	(2019 *Nature* report*, Apidima 1)
28,000 ya	*H. neanderthalis* still in Europe

Maybe
170,000
year overlap

Harvati et al. (2019) Apidima cave fossils provide earliest evidence of *Homo sapiens* in Eurasia, *Nature*, 571:500-504.

Genetic Structure of Modern Human Populations

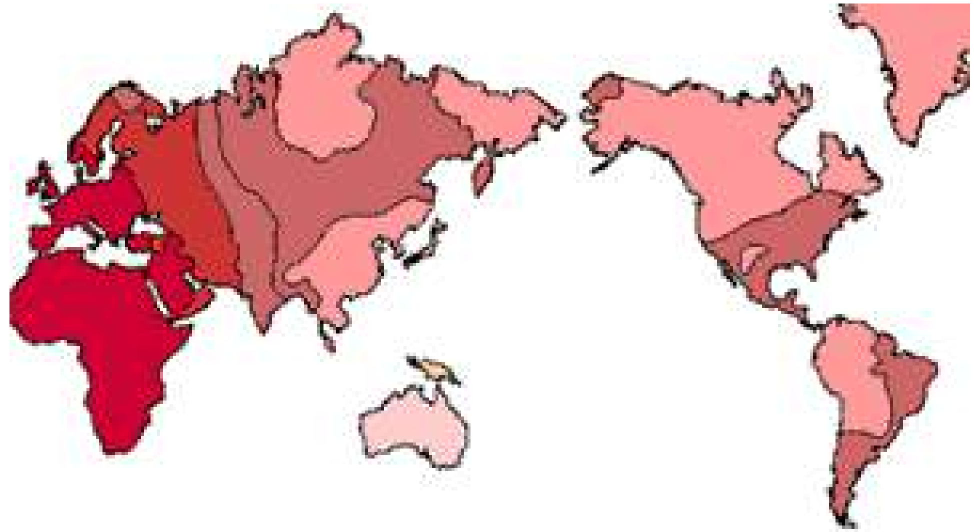
Noah A. Rosenberg, Jonathan K. Pritchard, James L. Weber, Howard M. Cann, Kenneth K. Kidd, Lev A. Zhivotovsky, Marcus W. Feldman

> "Within-population differences among individuals account for 93 to 95% of genetic variation; differences among major groups constitute only 3 to 5%."

www.sciencemag.org, SCIENCE, VOL 298, 20 DECEMBER 2002

Human “races”

Genetic similarities among people from different areas



No biological basis for conventionally identified races.

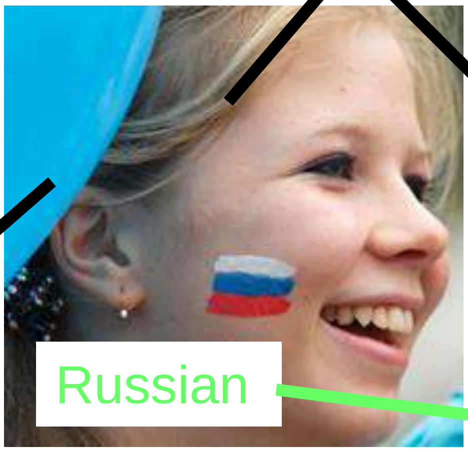
Criteria for race distinctions do not correlate with other genetic similarities & differences among humans.

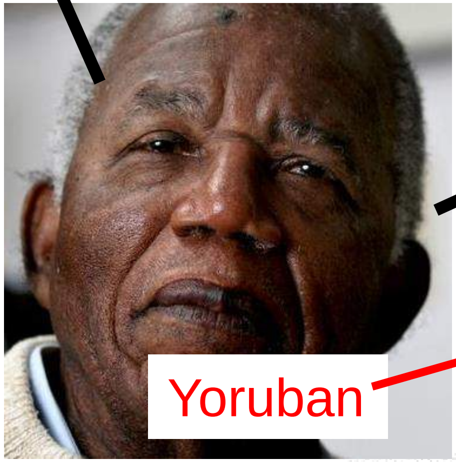
There are cultural differences among populations, but these are not correlated with genetic differences.

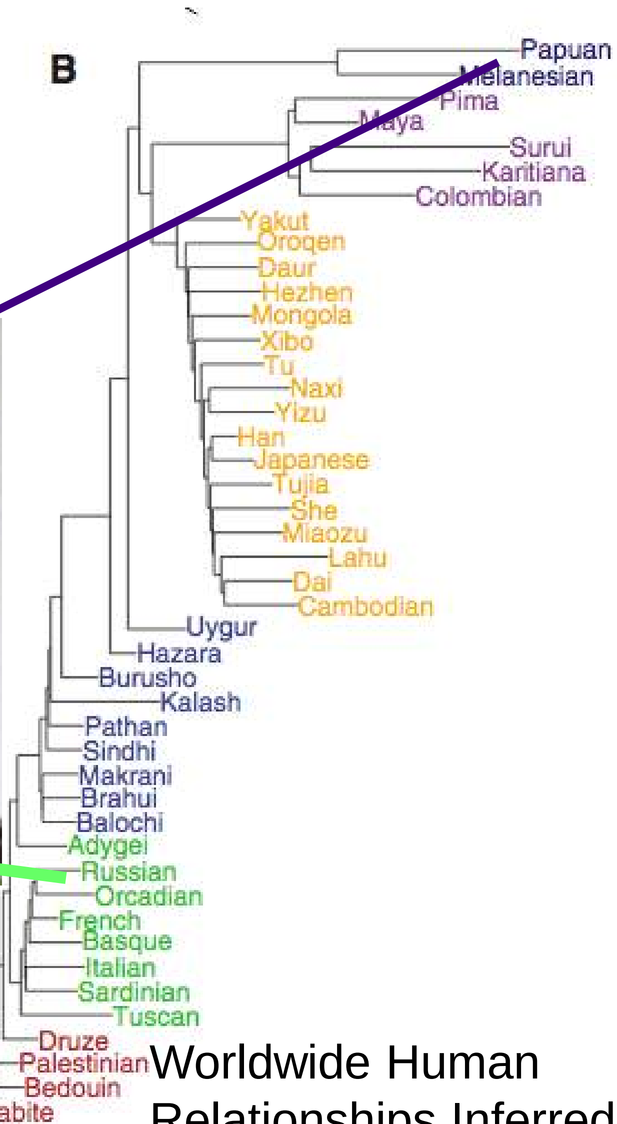
World map of human genetic similarity.
L. L. Cavalli-Sforza, P. Menozzi, and A. Piazza, The History and Geography of Human Genes, Princeton University Press.

http://www.wwnorton.com/college/anthro/evolve4/ch/15/welcome.shtml

Fig. 1. Individual ancestry and population dendrogram. (**A**) Regional ancestry inferred with the *frappe* program at $K = 7$ (*13*) and plotted with the Distruct program (*31*). Each individual is represented by a vertical line partitioned into colored segments whose lengths correspond to his/her ancestry coefficients in up to seven inferred ancestral groups. Population labels were added only after each individual's ancestry had been estimated; they were used to order the samples in plotting. (**B**) Maximum likelihood tree of 51 populations. Branches are colored according to continents/regions. * indicates the root of the tree, also where the chimpanzee branch is located.







Close relatives

Close relatives

Distant relatives

Worldwide Human Relationships Inferred from Genome-Wide Patterns of Variation

http://www.abc.net.au/7.30/content/2012/s3577104.htm#

Li, J.Z. et al.

www.sciencemag.org SCIENCE VOL 319 22 FEBRUARY 2008

http://247ureports.com/writers-defend-achebes-latest-book/

http://english.ruvr.ru/2012_03_19/68927054/

Evolution by natural selection

Natural selection –

Natural processes determine which individuals survive and reproduce and which ones do not.

Another term for natural processes is ecological processes.

To survive and reproduce requires tolerating the physical and chemical conditions of the environment while obtaining sufficient resources and avoiding getting eaten.

One reason to study ecology:

– to understand natural selection

What are the big problems?

Might understanding our evolutionary history (as hunters and gatherers) and how natural selection works illuminate consideration of any of those big problems?

Does our evolutionary history cause or exacerbate any problems today?

Does your life (and every other life) depend on the normal functioning of ecosystems?

How?

Which processes?

Where does food come from?

Where does the air you breathe come from?

Where does water come from?

Where do clothing and shelter come from?

First reason to study ecology –

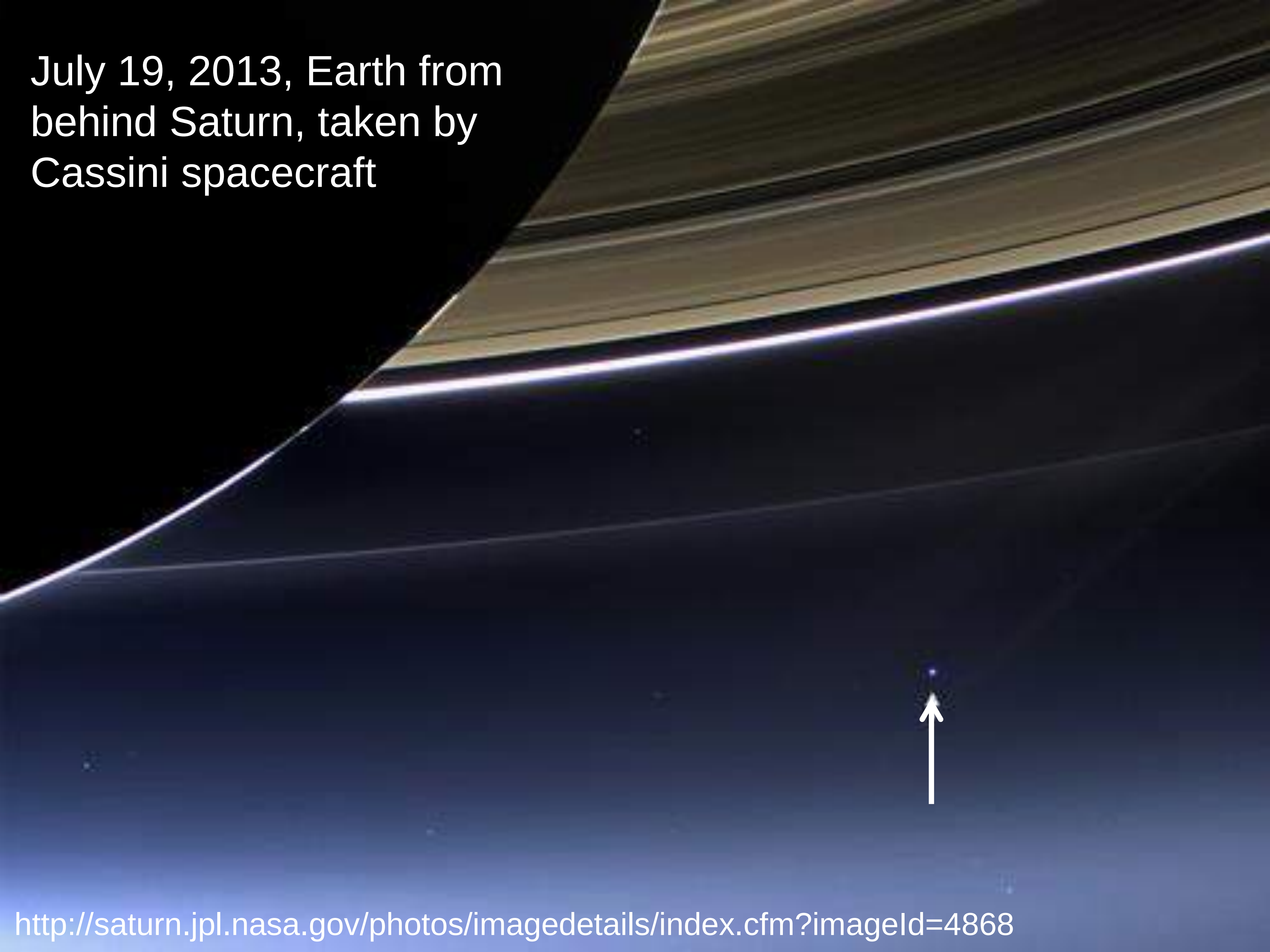
Understand natural selection & evolution

A second reason to study ecology –

We cannot survive without the functioning of healthy ecosystems, but we are damaging ecosystems more and more every day.

“Then what happens?”

July 19, 2013, Earth from behind Saturn, taken by Cassini spacecraft



http://saturn.jpl.nasa.gov/photos/imagedetails/index.cfm?imageId=4868

http://gosmellthecoffee.com/files/2008/10/trafficjam.jpg

Boreal forest before tar sands extraction

http://www.bluegranola.com/tag/boreal-forest/

Boreal forest after tar sands extraction

http://www.borealbirds.org/tarsands.shtml

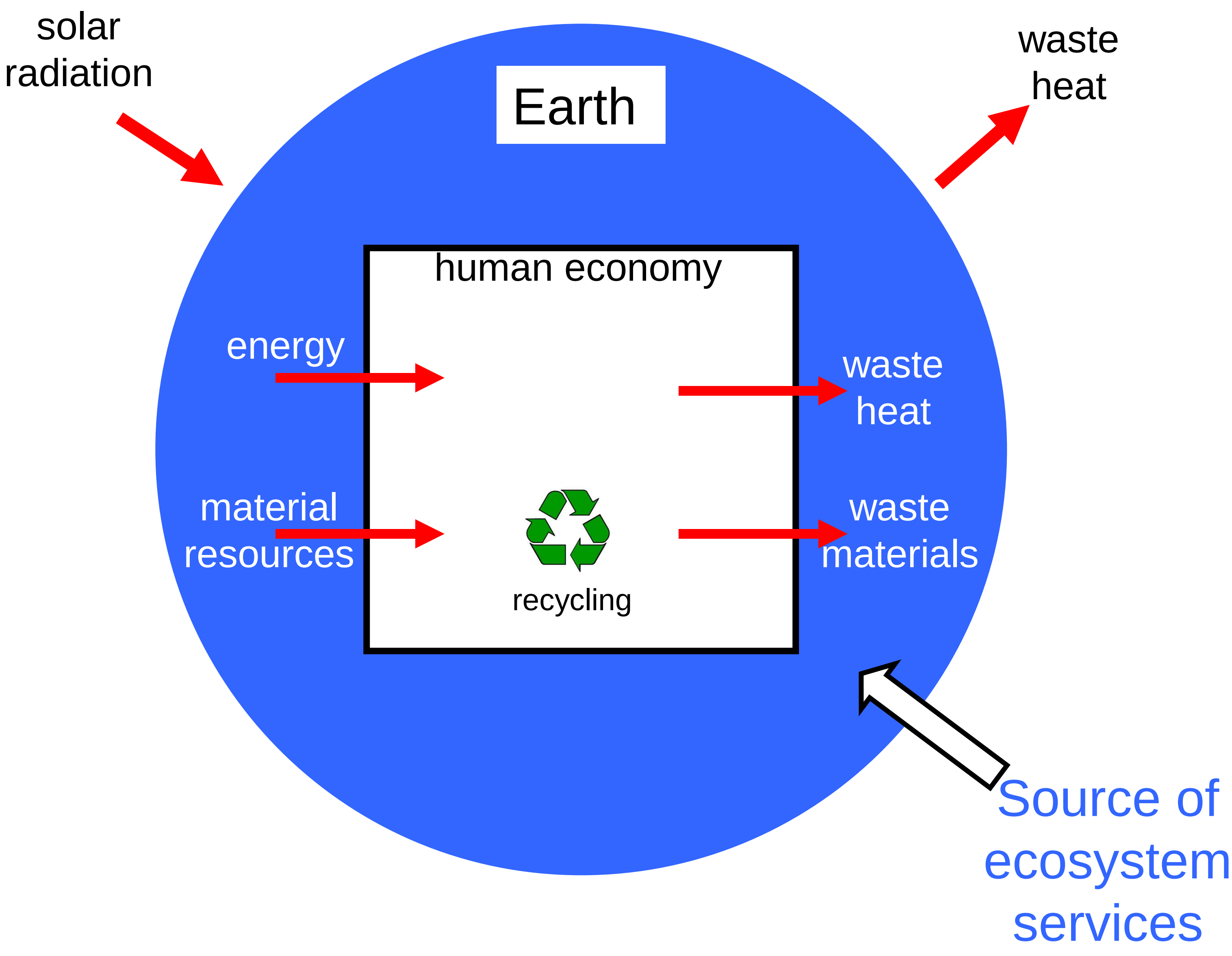
Ecosystem services

(things we get for free from ecosystems)

- oxygen
- water supply
- soil
- wood & fibers
- water purification
- element cycling
- UV shield
- wild genetic material
- climate moderation
- flood prevention
- air purification
- pollination
- recreation
- inspiration

https://www.mining.com/wp-content/uploads/2016/10/six-months-after-wildfires-canadas-oil-sands-now-hit-by-di-caprios-new-movie.jpg, http://diplomatonline.com/mag/wp-content/uploads/2012/03/Diplomat_Dec100091.jpg

An ecological view of how the world works



Grizzly bears are like golden retrievers now. – Bill McKibben

http://www.chicagotribune.com/features/lifestyle/green/chi-endangered-threatened-species-080515-pg,0,2716741.photogallery

How many rivets can pop before the plane crashes?

Stephen Hawking, May 2017, Starmus Festival, Norway:

“Our physical resources are being degraded at an alarming rate. We have given our planet the disastrous gift of climate change. Rising temperatures, a reduction in the polar ice caps, deforestation, and decimation of animal species. … We are running out of space and the only places to go to are other worlds. .... Spreading out may be the only thing that saves us from ourselves. I am convinced that humans need to leave earth.”

https://www.youtube.com/watch?v=lpG5P6ugeeI, https://commons.wikimedia.org/wiki/File:Physicist_Stephen_Hawking_in_Zero_Gravity_NASA.jpg

Mannequin in Elon Musk’s Tesla headed for Mars

https://en.wikipedia.org/wiki/Elon_Musk%27s_Tesla_Roadster#/
media/File:Elon_Musk%27s_Tesla_Roadster_(40143096241).jpg

7.6 billion people

Stephen Hawking

2,000 colonists

1/4,000,000

7,599,998,000 left behind

Elon Musk

2,000,000 colonists

1/4,000

7,598,000,000 left behind

Only option for most people: protect this planet.

We aren’t going to Mars

Ecology

The study of the distribution and abundance of organisms.

The study of [everything that affects] the distribution and abundance of organisms [and the consequences of those distributions and abundances].

Problems whose solutions require ecological understanding

These are not separate issues

Climate change

Renewable resource availability & sustainability
- water
- soils
- forests
- fish
- hunted species

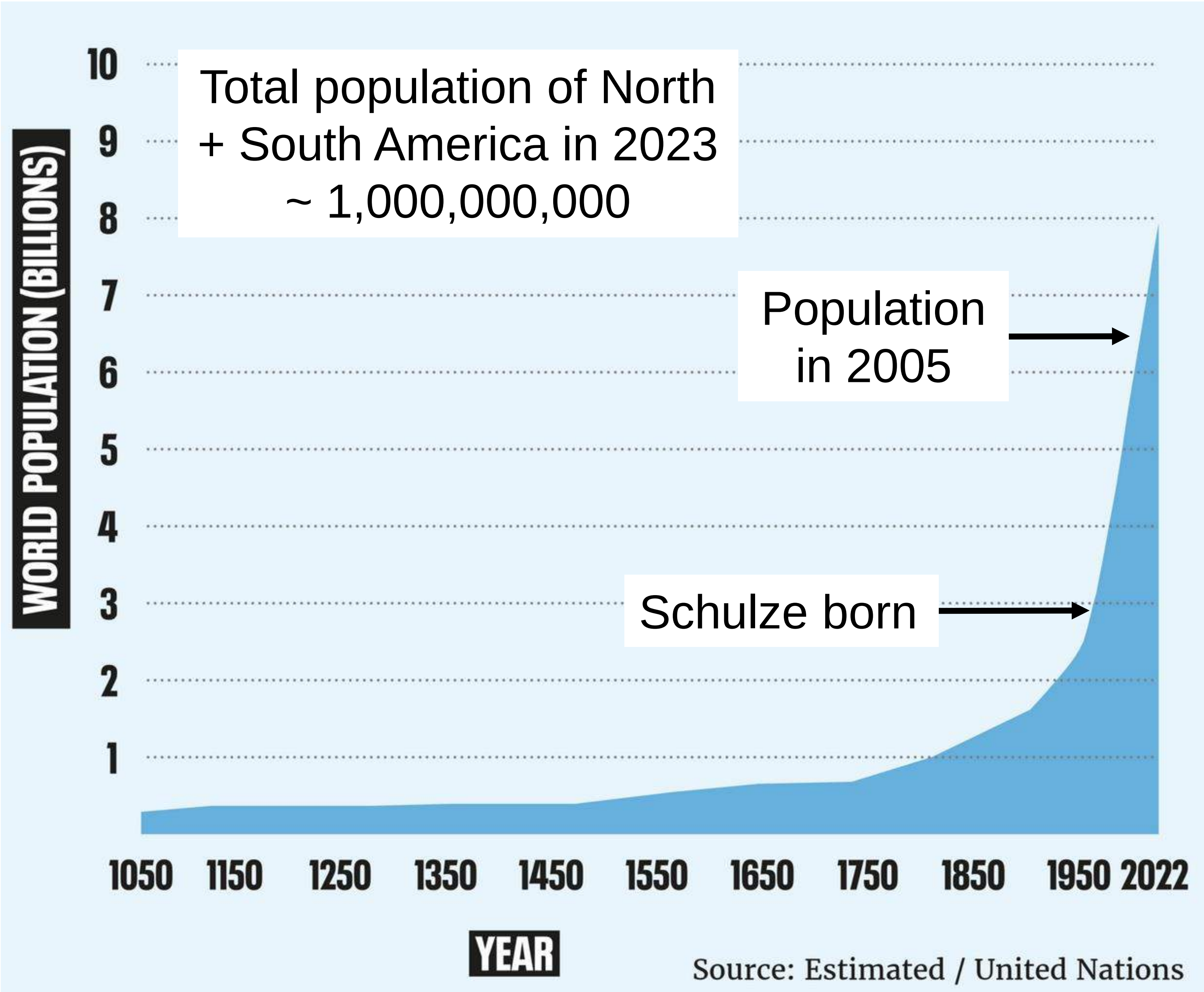
Ecosystem effects of pollutants & genetically modified organisms

Non-native species such as
- West Nile virus, dengue fever, zebra mussels, fire ants

Disease outbreaks
- Why do disease outbreaks happen at some times in some places and not other times in other places?

Species conservation

Sustainability / carrying capacity for people



Total population of North + South America in 2023 ~ 1,000,000,000
Population in 2005
Schulze born
WORLD POPULATION (BILLIONS)
10
9
8
7
6
5
4
3
2
1
1050
1150
1250
1350
1450
1550
1650
1750
1850
1950
2022
YEAR
Source: Estimated / United Nations

Graham Coreil-Allen, Flickr

Herman Daly's Guidelines for Sustainability

Renewable resources should not be depleted faster than they are regenerated.

Wastes should not be produced faster than they are assimilated (made harmless).

Non-renewable resources should not be depleted faster than substitutes are developed.

Herman Daly's Guidelines for Sustainability

Renewable resources should not be depleted faster than they are regenerated.

violations – aquifers, soils, forests, fish, natural habitats

Wastes should not be produced faster than they are assimilated (made harmless).

violations – greenhouse gases, persistent organic pollutants, heavy metals, nutrient pollution of water, estrogen mimics & other toxins, landfills,
300 pounds of waste per person per day in the U.S.

Non-renewable resources should not be depleted faster than substitutes are developed.

violations – fossil fuels, various metals, phosphorus

Conclusion: situation not sustainable

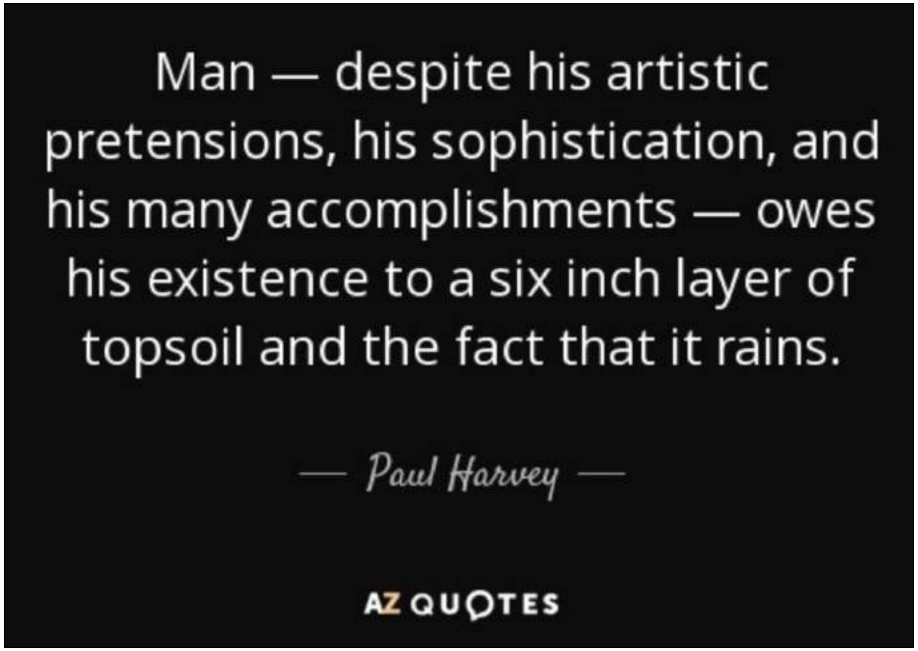
The Problem:

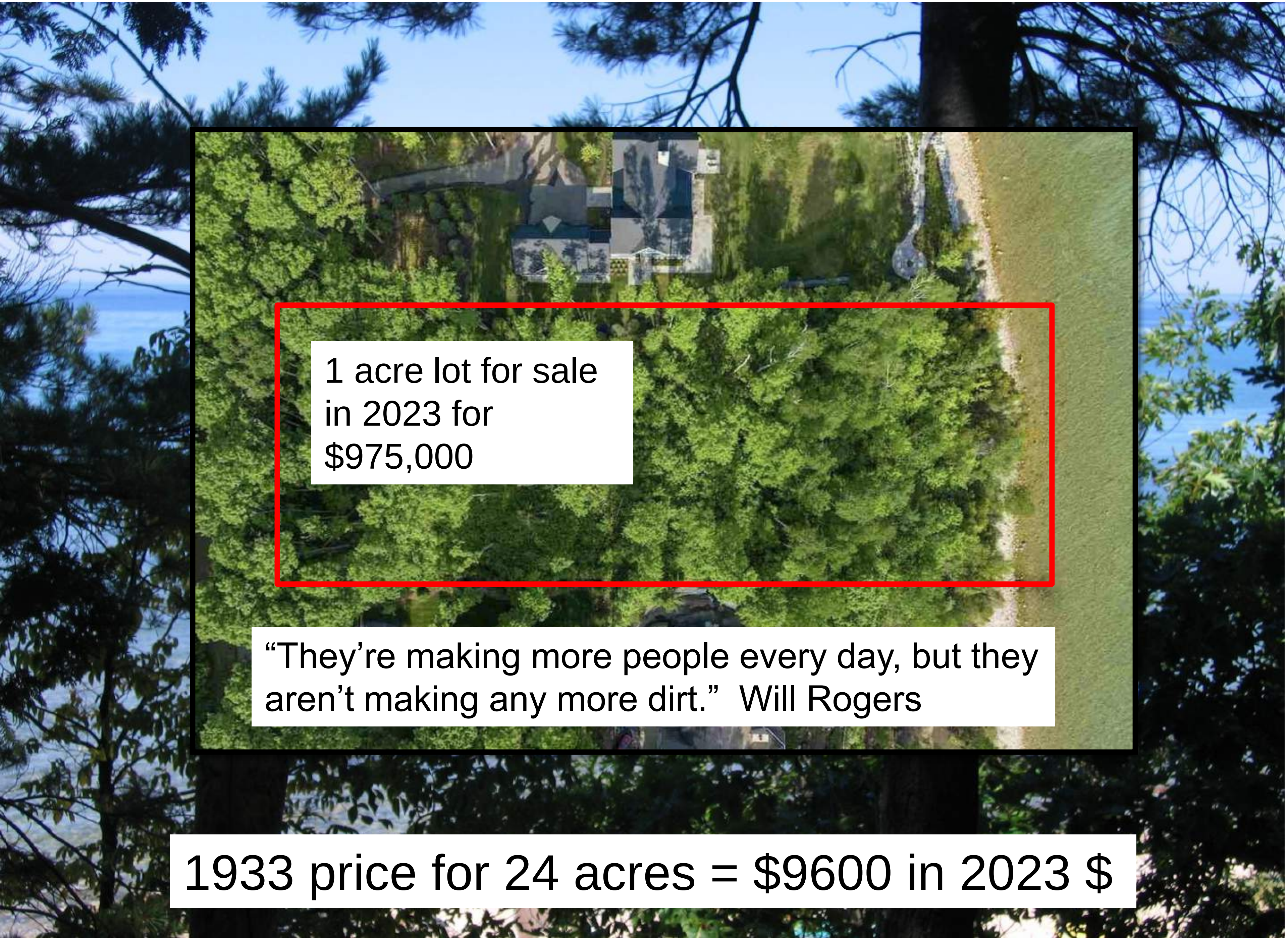
Present activities are not sustainable because -

Present activities are degrading ecosystem services.

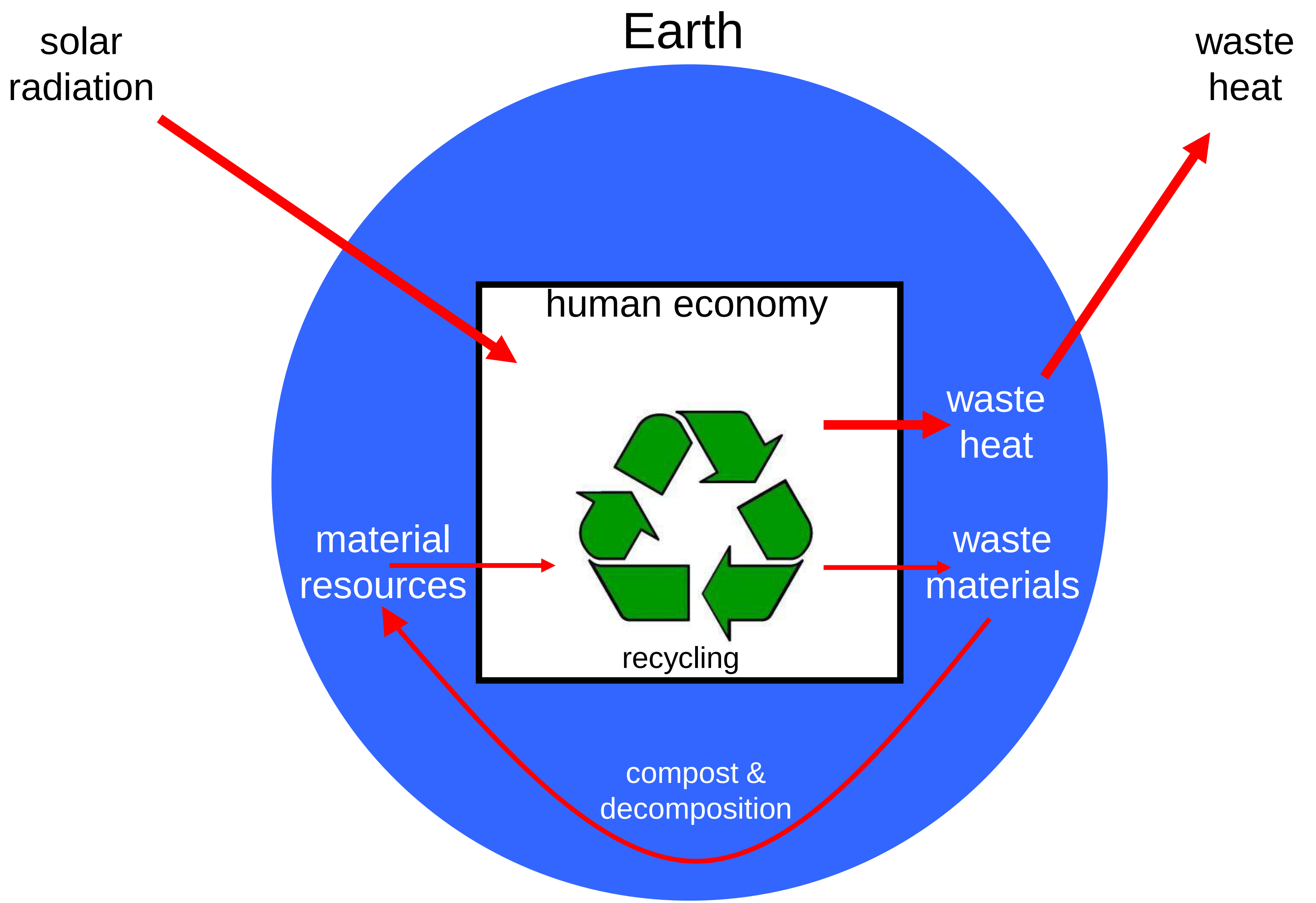
Either we will change our behavior or chaos will result.

For the sake of future generations & other species society needs to shift onto a sustainable path. How?




1 acre lot for sale in 2023 for $975,000
“They’re making more people every day, but they aren’t making any more dirt.” Will Rogers
1933 price for 24 acres = $9600 in 2023 $

An ecological view of how the economy needs to work



RECYCLING DOS AND DON'TS

YES

NO

Please don't put trash in the recycling. When in doubt, throw it out!

Email rkarcher@austincollege.edu with questions

Destruction of ecosystem services cannot be prevented without understanding how ecosystems work.

Ecology: Introduction

Outline

- Evolution, ecology, & behavior
- Ecosystem services
- Guidelines for sustainability
- Biomes
  - Types
  - Distribution
  - Determinants of distributions
  - Human impacts on distributions

Biome

A characteristic assemblage of plants associated with a particular climate.

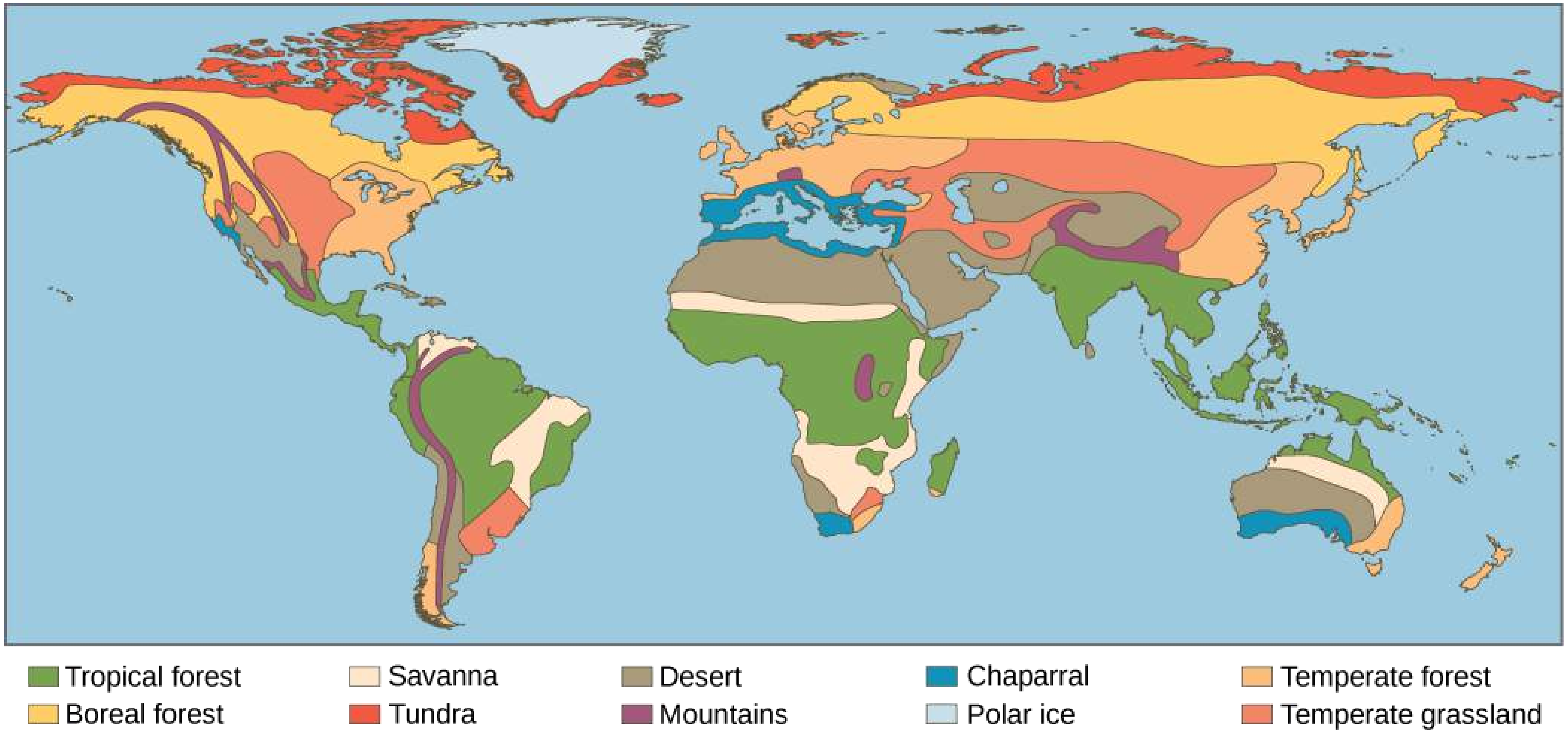
A type of ecosystem

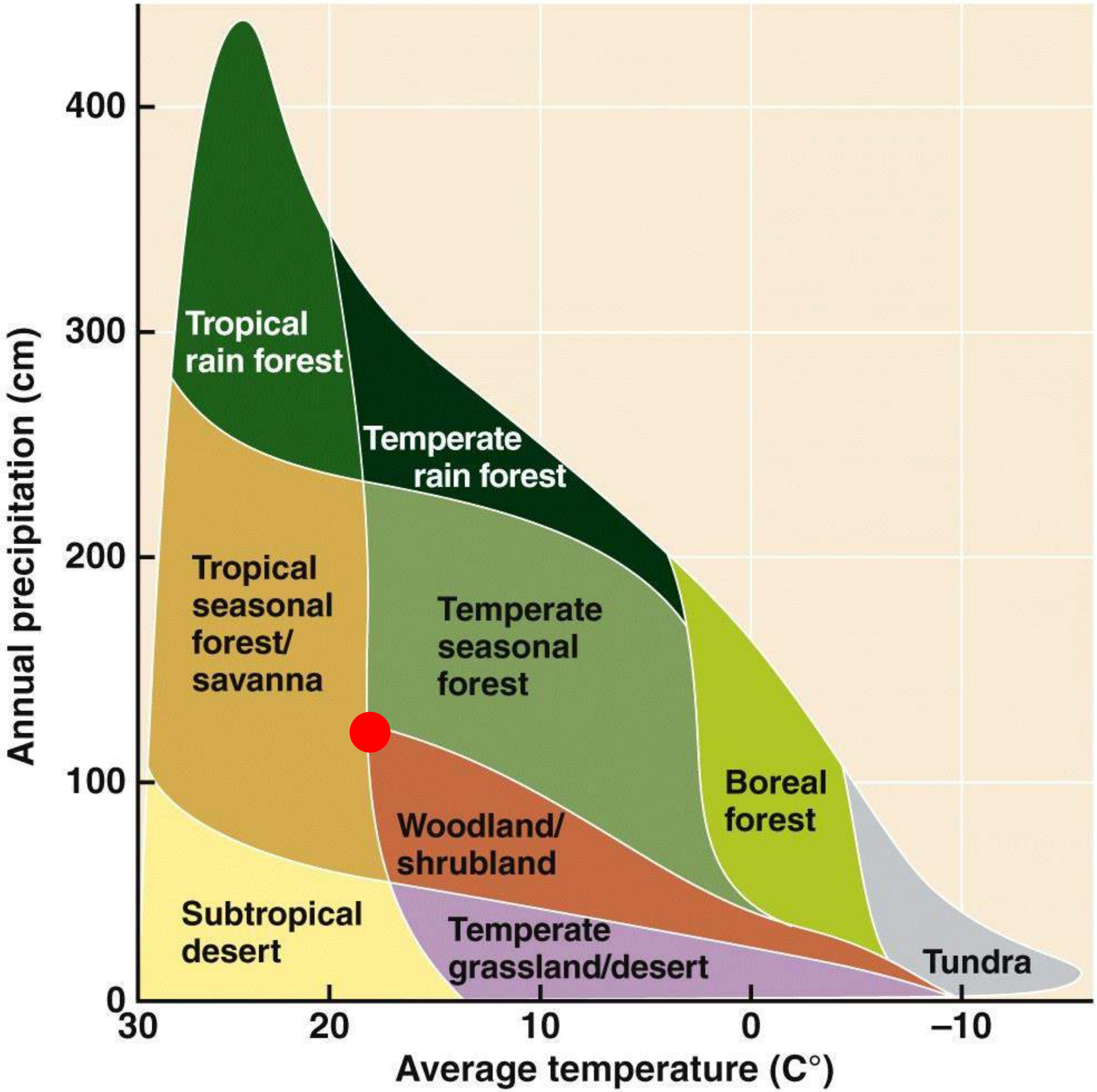
Biome ~ Ecosystem ~ Ecological Community


http://www2.ku.edu/~geography/CurrentResearch/wcj/BillJohnsonWeb%20004.jpg

http://images.en.tralea.com/search.aspx?q=taiga&offset=250

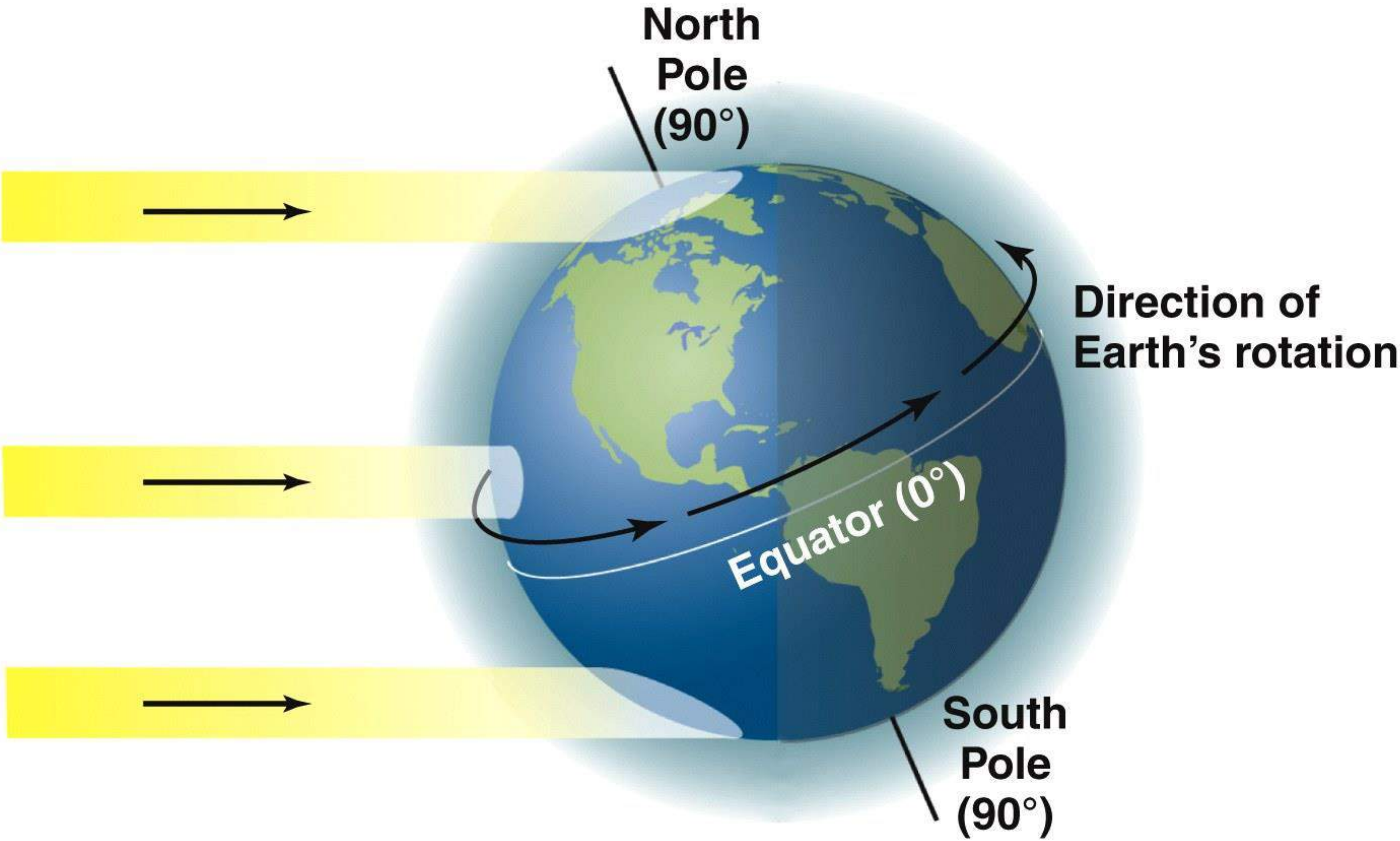
Figure 44.12


Tropical forest
Boreal forest
Savanna
Tundra
Desert
Mountains
Chaparral
Polar ice
Temperate forest
Temperate grassland



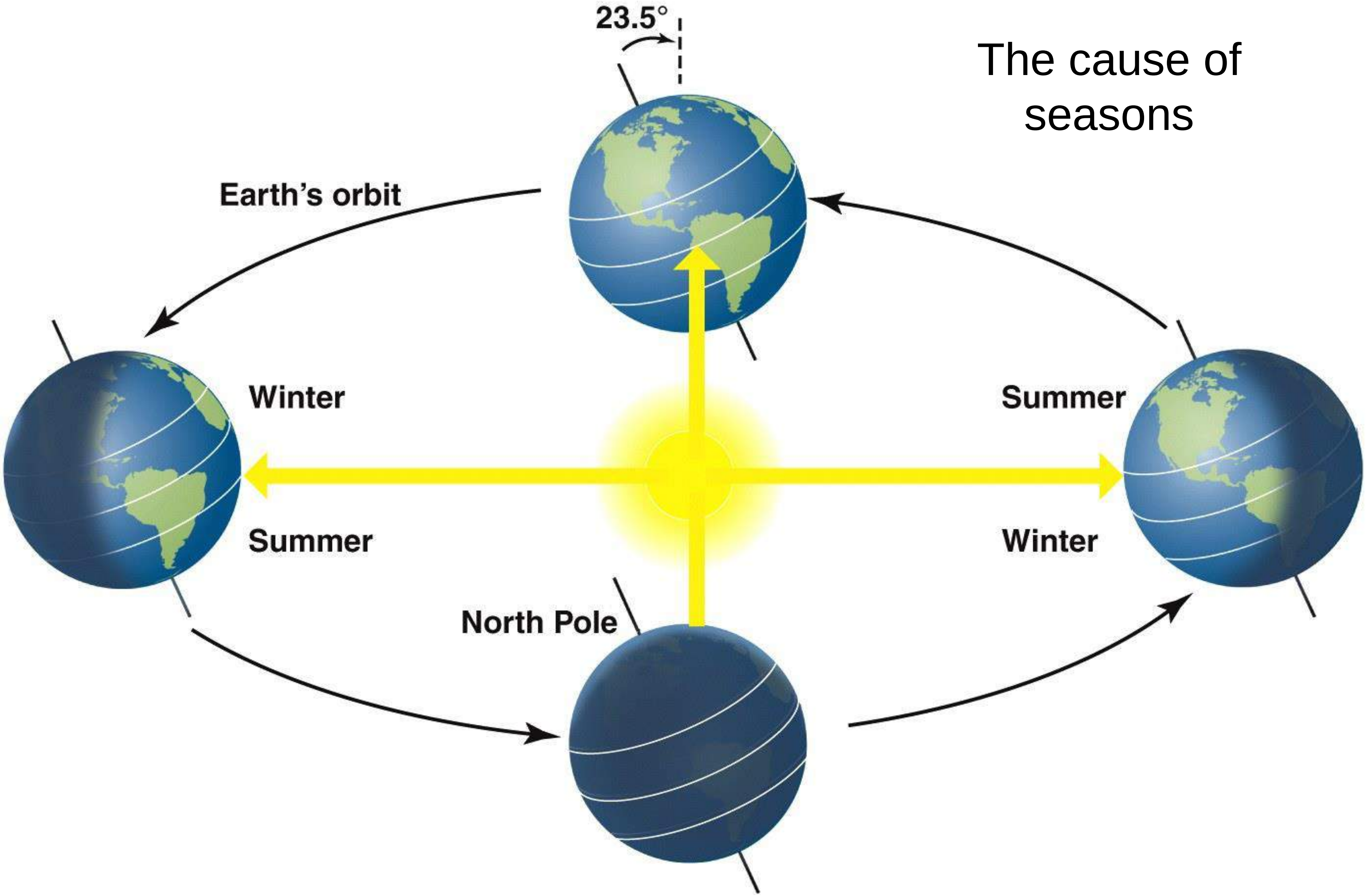
***PRINCIPLES OF LIFE*, Figure 42.10**

Why does temperature and water availability vary around the planet?



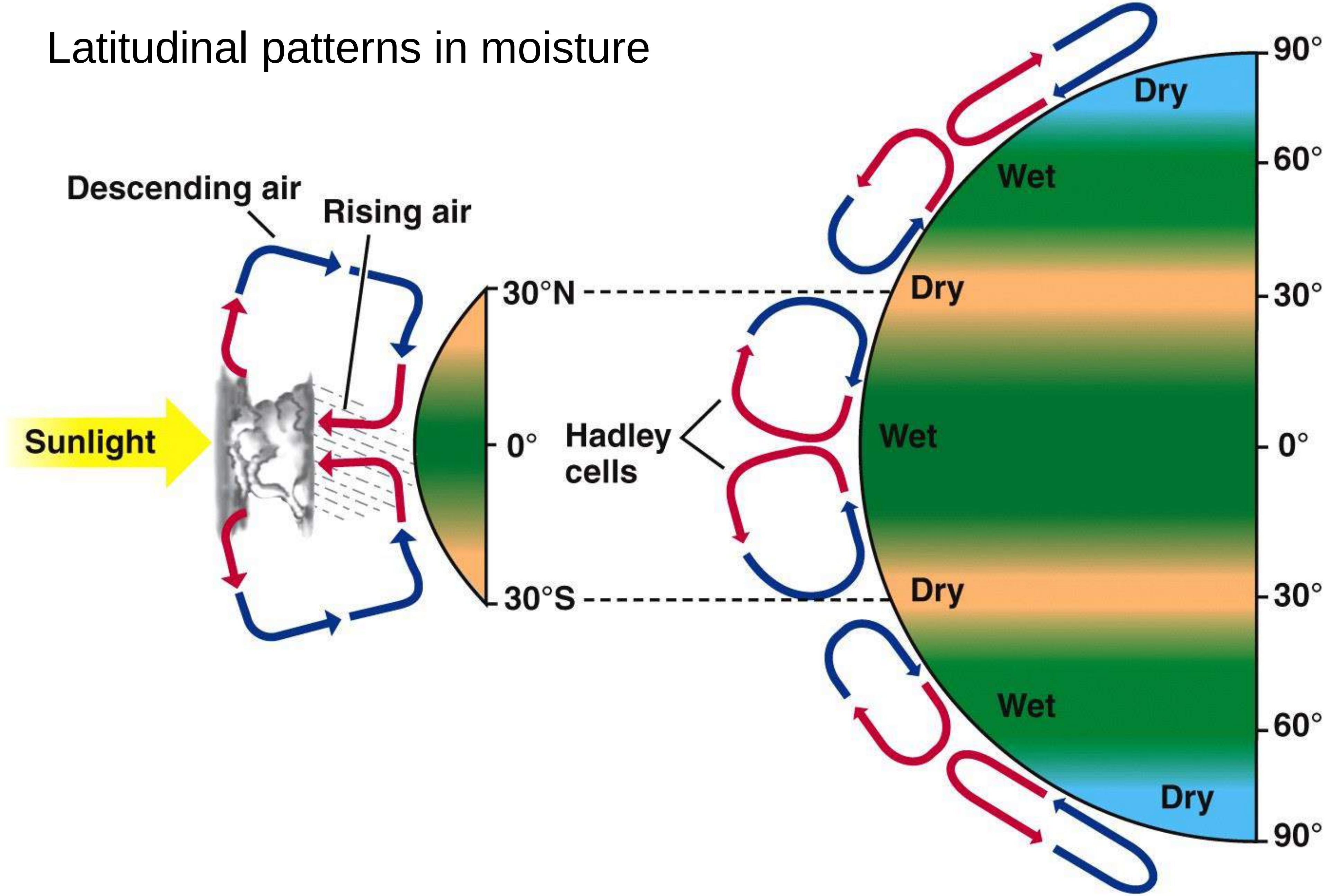
PRINCIPLES OF LIFE, **Figure 42.3**

The cause of seasons

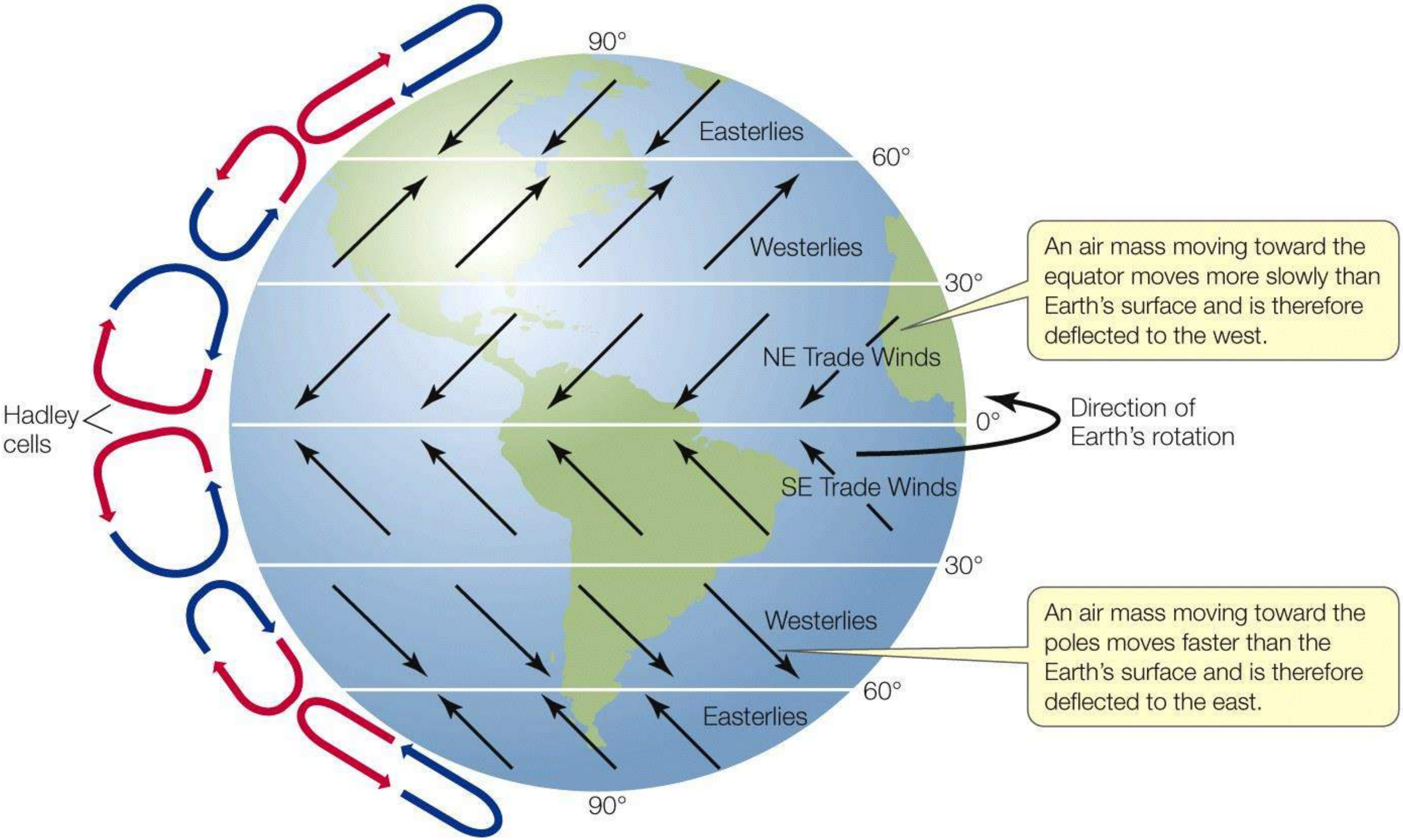


PRINCIPLES OF LIFE, Figure 42.4

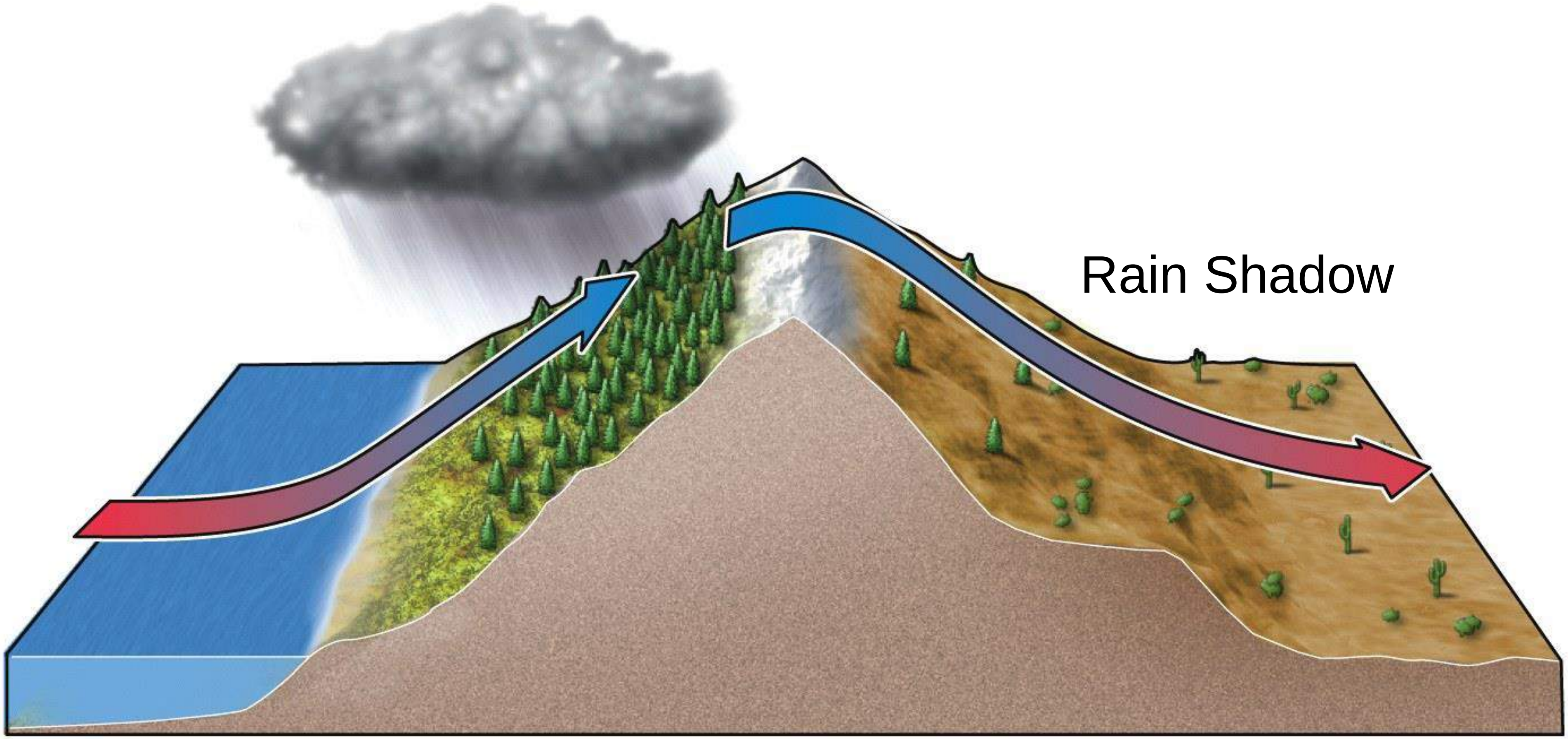
Latitudinal patterns in moisture



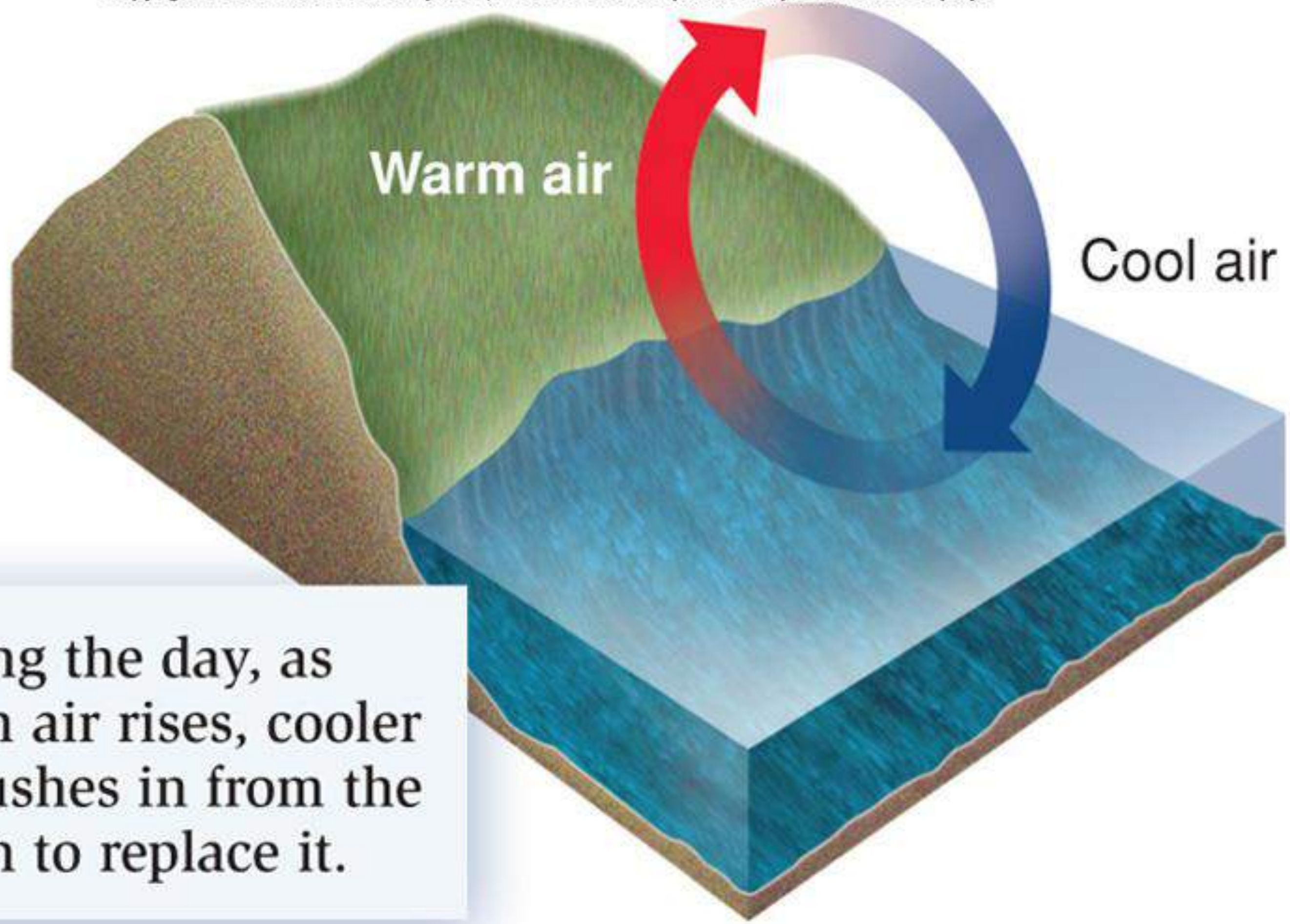
PRINCIPLES OF LIFE, Figure 42.5



***PRINCIPLES OF LIFE,* Figure 42.6**



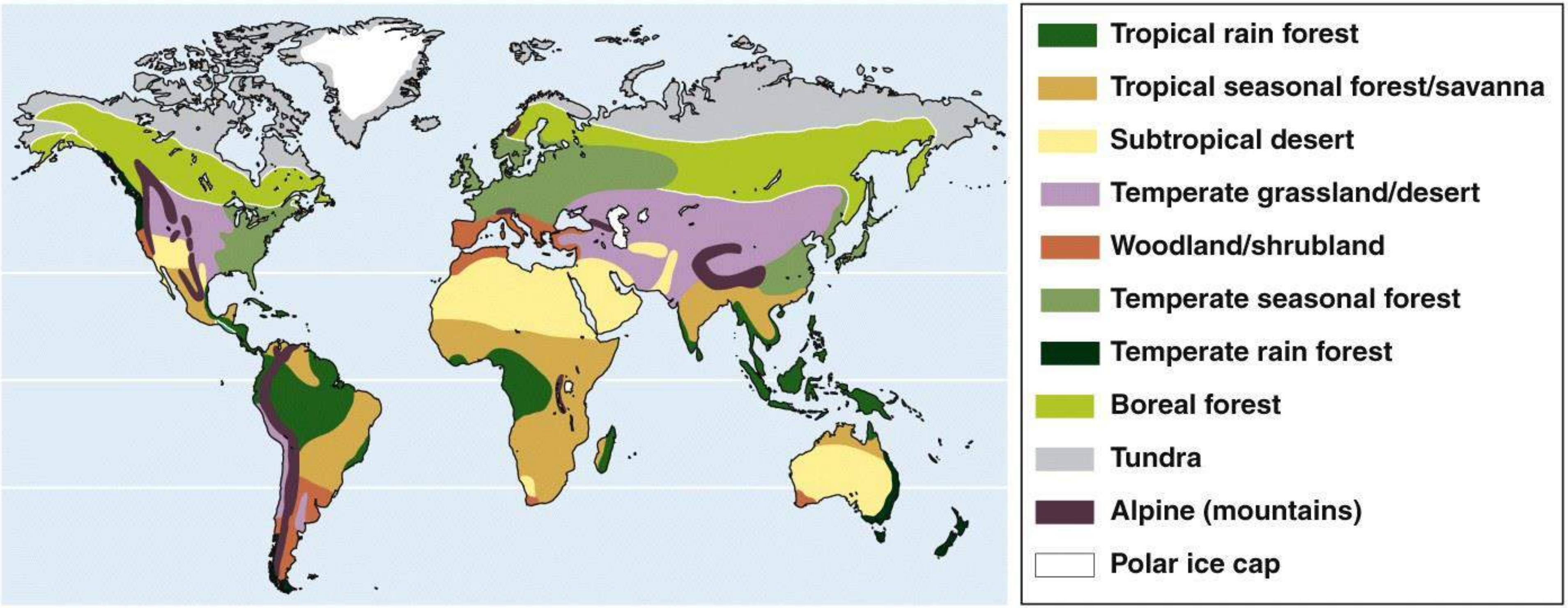
PRINCIPLES OF LIFE, Figure 42.9



During the day, as warm air rises, cooler air rushes in from the ocean to replace it.

(b) Sea breezes

http://www.seagrant.umn.edu/superior/facts



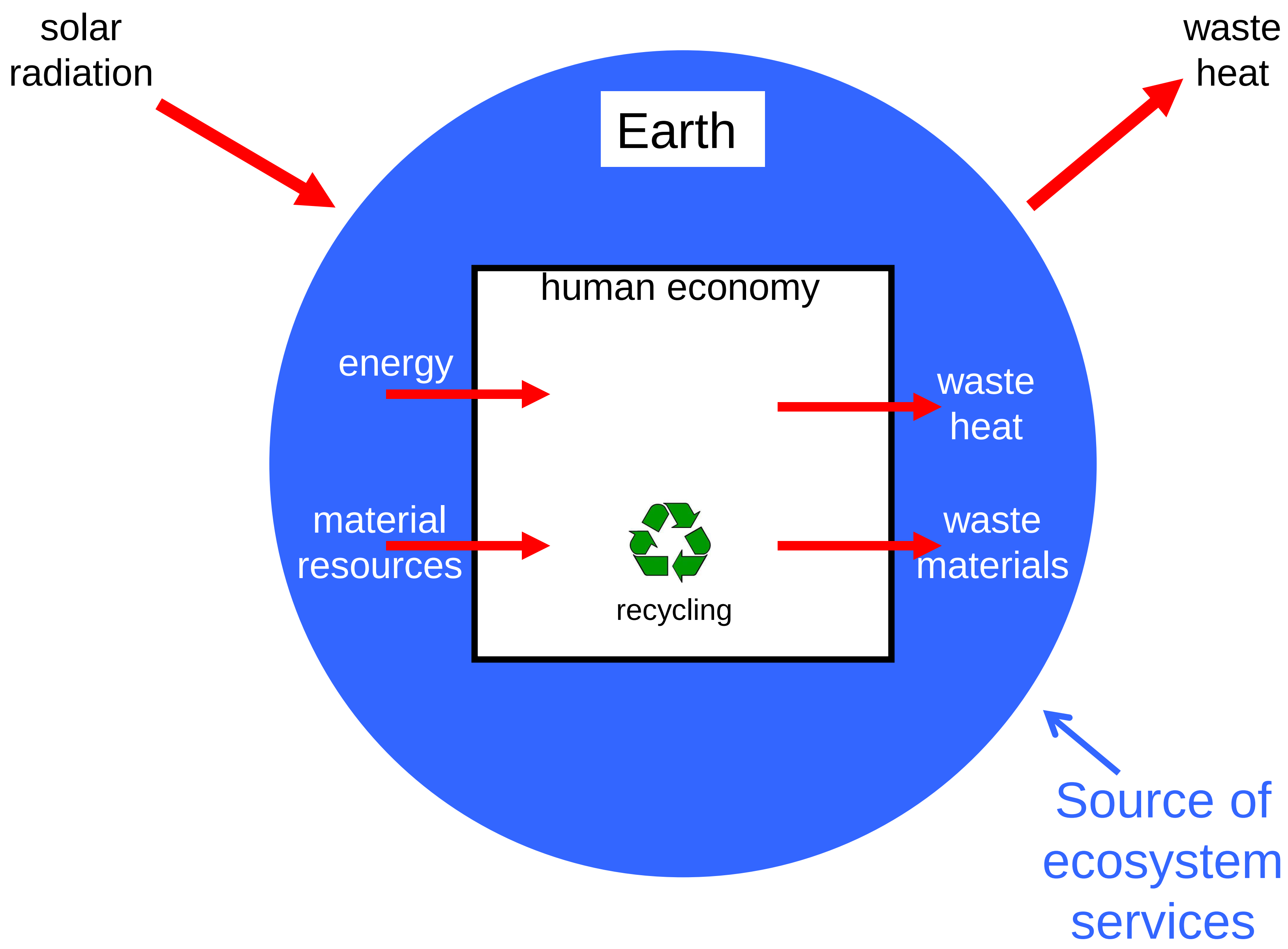
PRINCIPLES OF LIFE, **Figure 42.11**

By the way: what is wrong with this map?

Land Use Animation

http://www.youtube.com/watch?v=gBTlIaf12-4&feature=related

***PRINCIPLES OF LIFE,* Figure 43.12**



solar radiation
waste heat
Earth
human economy
energy
waste heat
material resources
waste materials
recycling
Source of ecosystem services

Ecosystems are going to have to be restored

Ecology as a Practical Matter

Present human activities are not sustainable

We deplete resources and accumulate wastes.

We damage ecosystem services.

As the population has grown, the extent of relatively intact biomes has shrunk.

Reversal of these trends requires ecological understanding (how to <u>restore</u>, fisheries, soils, aquifers, biodiversity, ecosystem services, etc.)

Physiological & population ecology

Outline

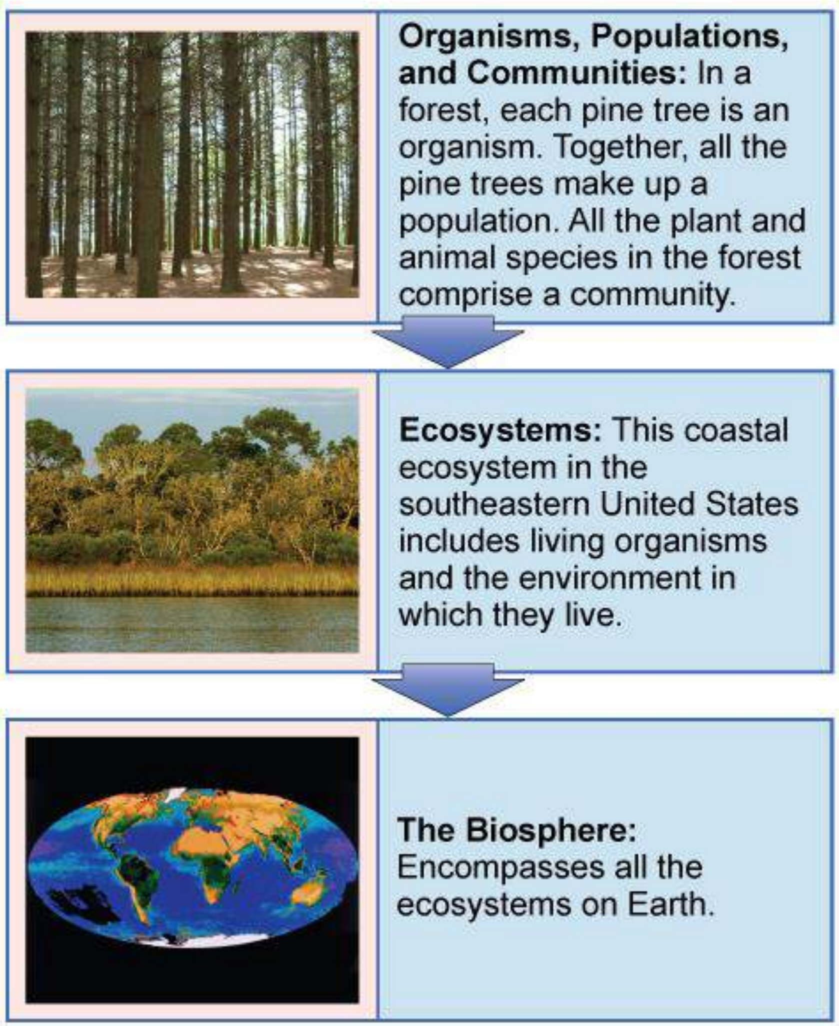
The niche:
  Where individuals can survive & thus species can live

Dispersal:
  How individuals (& thus species) move

Population growth & regulation:
  Why are some small & others huge?

Human population size & growth
  How has one species population kept on growing?
  Can that go on?

Figure 44.2



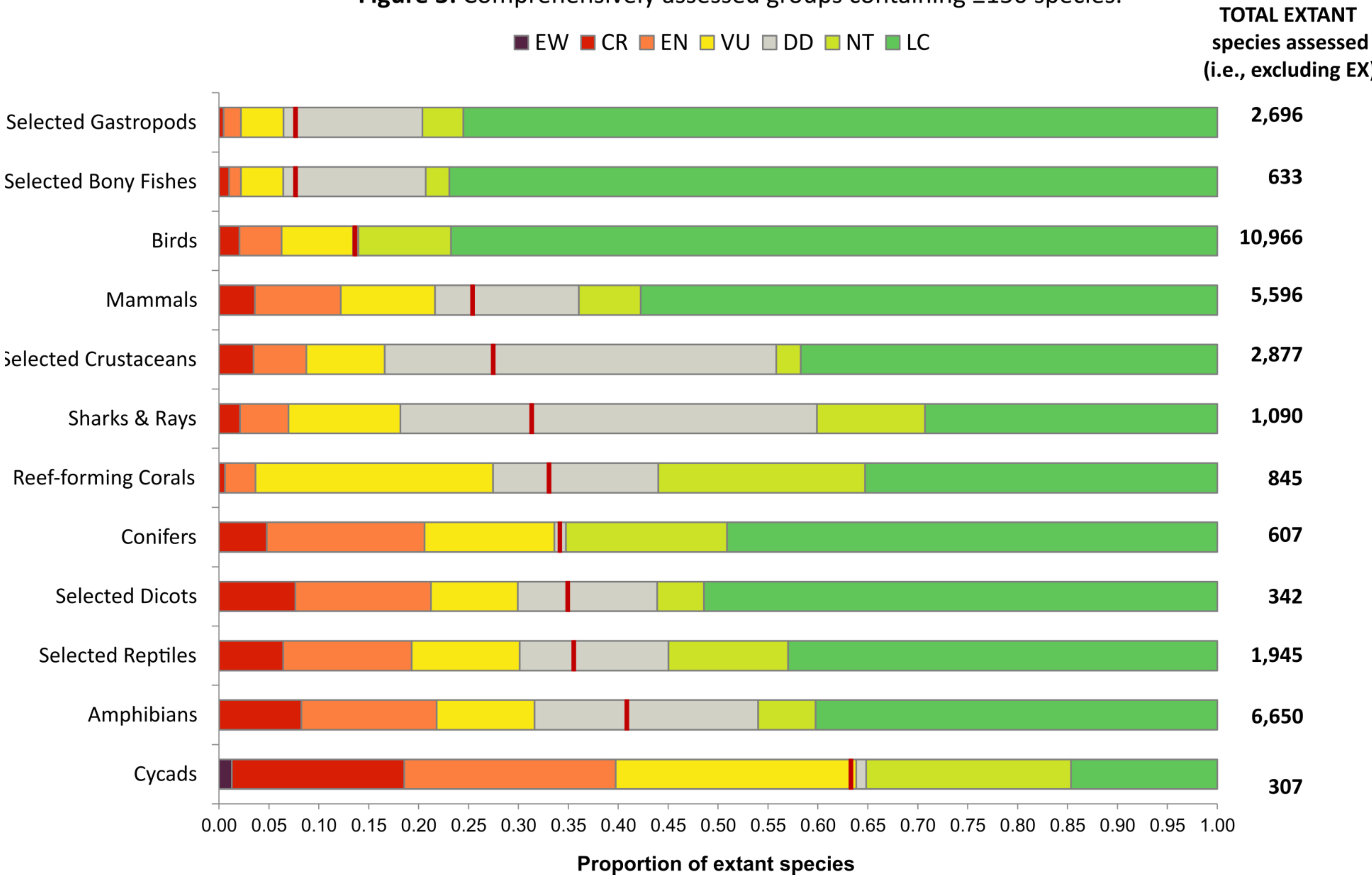
Biomes: types of ecosystems (e.g. grassland)

- Ecologists study within several biological levels of organization. (credit “organisms”: modification of work by “Crystl”/Flickr; credit “ecosystems”: modification of work by Tom Carlisle, US Fish and Wildlife Service Headquarters; credit “biosphere”: NASA)

Does the abundance of non-human species matter?

What determines if those abundances increase or decrease?

Figure 3: Comprehensively assessed groups containing ≥150 species.



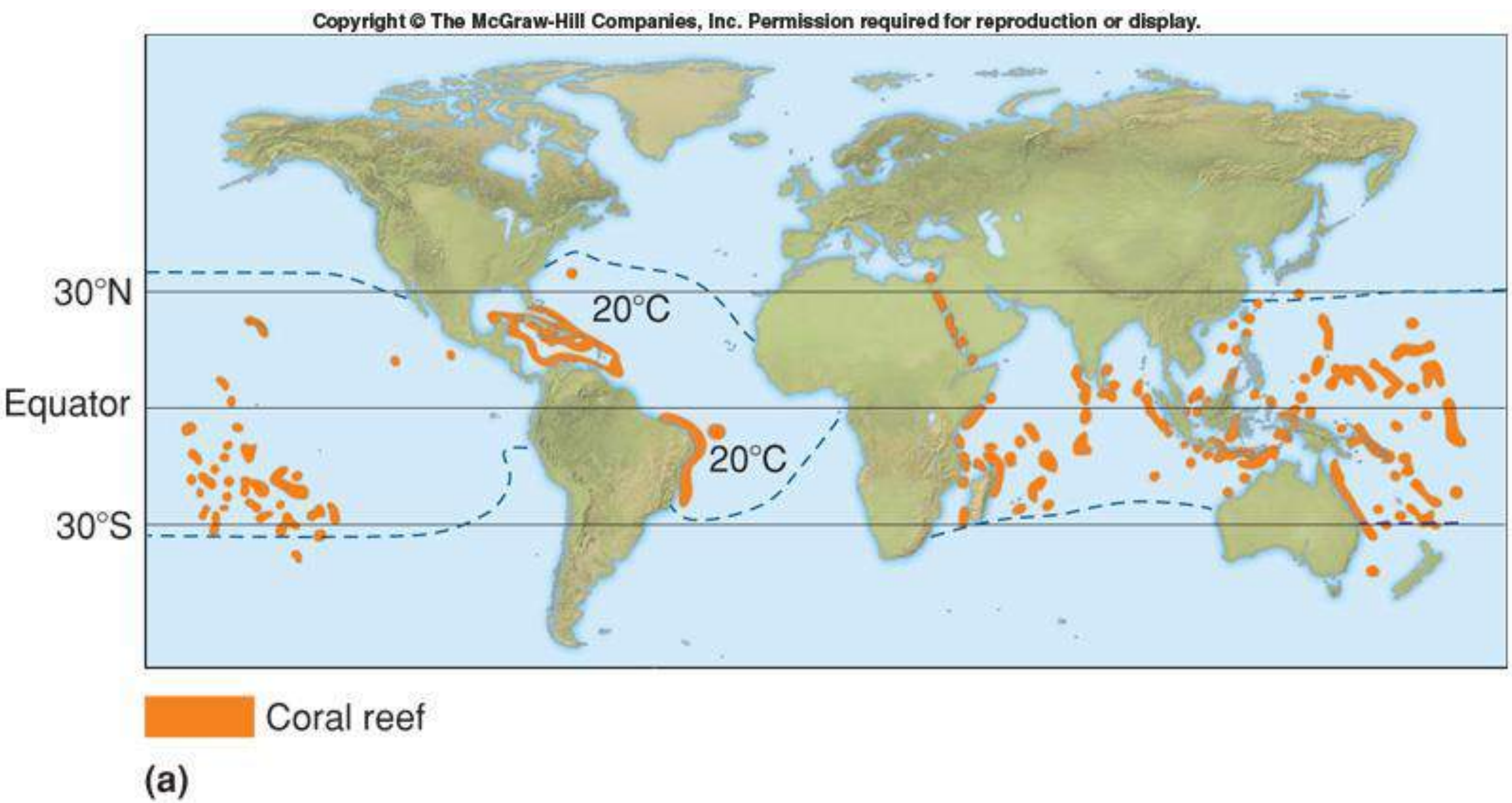
http://www.iucnredlist.org/about/summary-statistics#Table_7

Figure 3. The proportion of extant (i.e., excluding Extinct) species in *The IUCN Red List of Threatened Species. Version 2018-1* assessed in each category for the more comprehensively assessed groups. Species are grouped into classes (with the exception of reef-forming corals, which includes species from classes Hydrozoa and Anthozoa), and are ordered according to the vertical red lines, which indicate the best estimate for proportion of extant species considered threatened (CR, EN, or VU). Best estimates of percentage threatened species (with lower and upper estimates) for each group are: **cycads** 63% (63-64%); **amphibians** 41% (32-54%); **selected reptiles** (marine turtles, seasnakes, chameleons, crocodiles and alligators) 35% (30-45%); **selected dicots** (magnolias, birches and cacti) 35% (30-44%); **conifers** 34%(34-35%); **reef-forming corals** 33% (27-44%); **sharks & rays** 31% (18-60%); **selected crustaceans** (lobsters, freshwater crabs, freshwater crayfishes and freshwater shrimps) 27% (17-56%); **mammals** 25% (22-36%); **birds** 13% (13-14%); **selected bony fishes** (sturgeons, tunas, billfishes, blennies, pufferfishes, angelfishes, butterflyfishes, surgeonfishes, tarpons, ladyfishes, gropuers, wrasses, seabreams, picarels, porgies, seahorses, pipefishes, trumpetfishes, shrimpfishes, cornetfishes, seamoths, and ghost pipefishes) 7.5% (6-21%); **selected gastropods** (cone snails) 7.5% (6-20%). The numbers to the right of each bar represent the total number of extant species assessed for each group. **EW** - Extinct in the Wild, **CR** - Critically Endangered, **EN** - Endangered, **VU** - Vulnerable, **NT** - Near Threatened, **DD** - Data Deficient, **LC** - Least Concern.

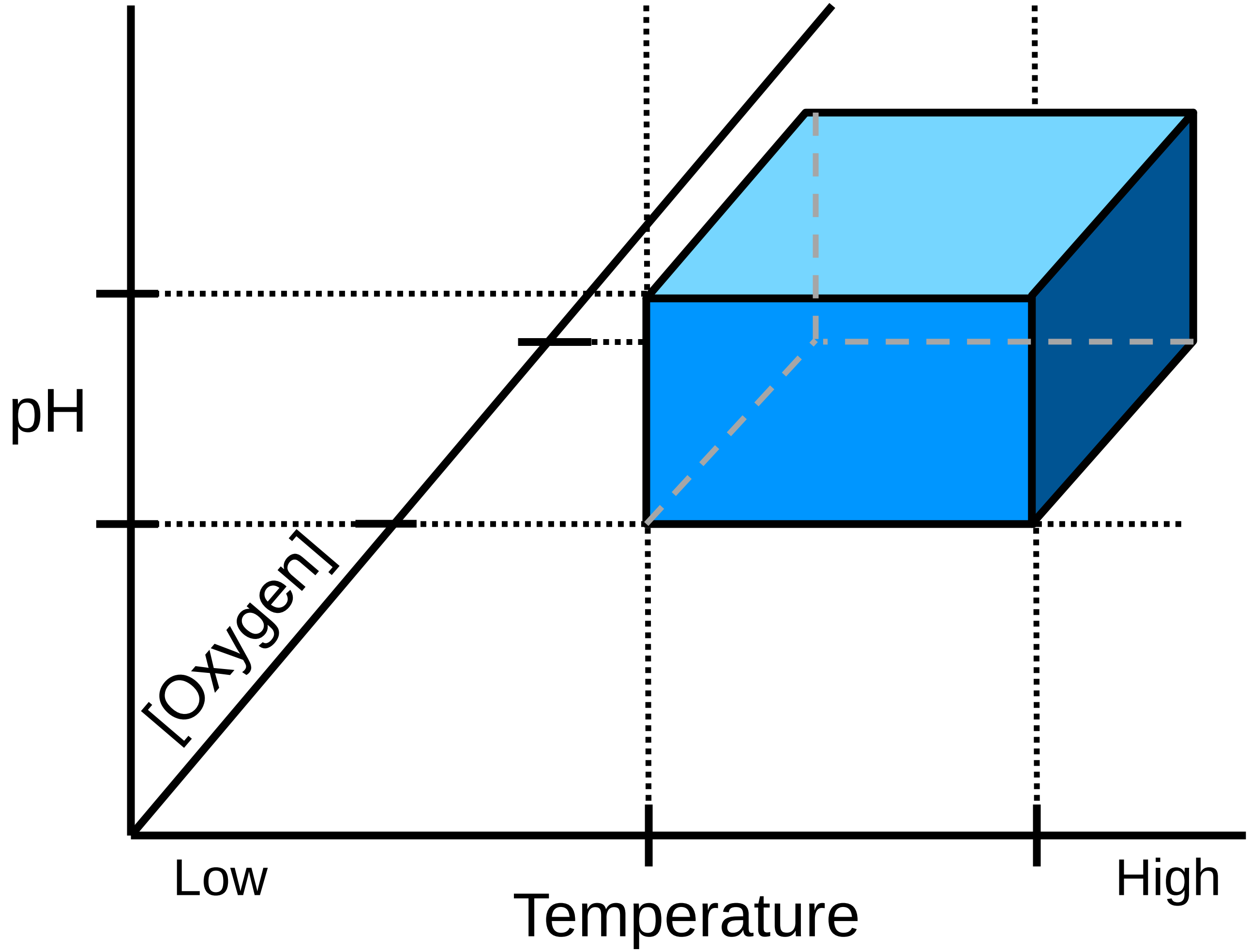
The niche:

the set of physical and chemical conditions required by an organism.

Species live in some places, not others.



Where can a fish live?



Do any other variables matter? Yes.

N-dimensional niche?

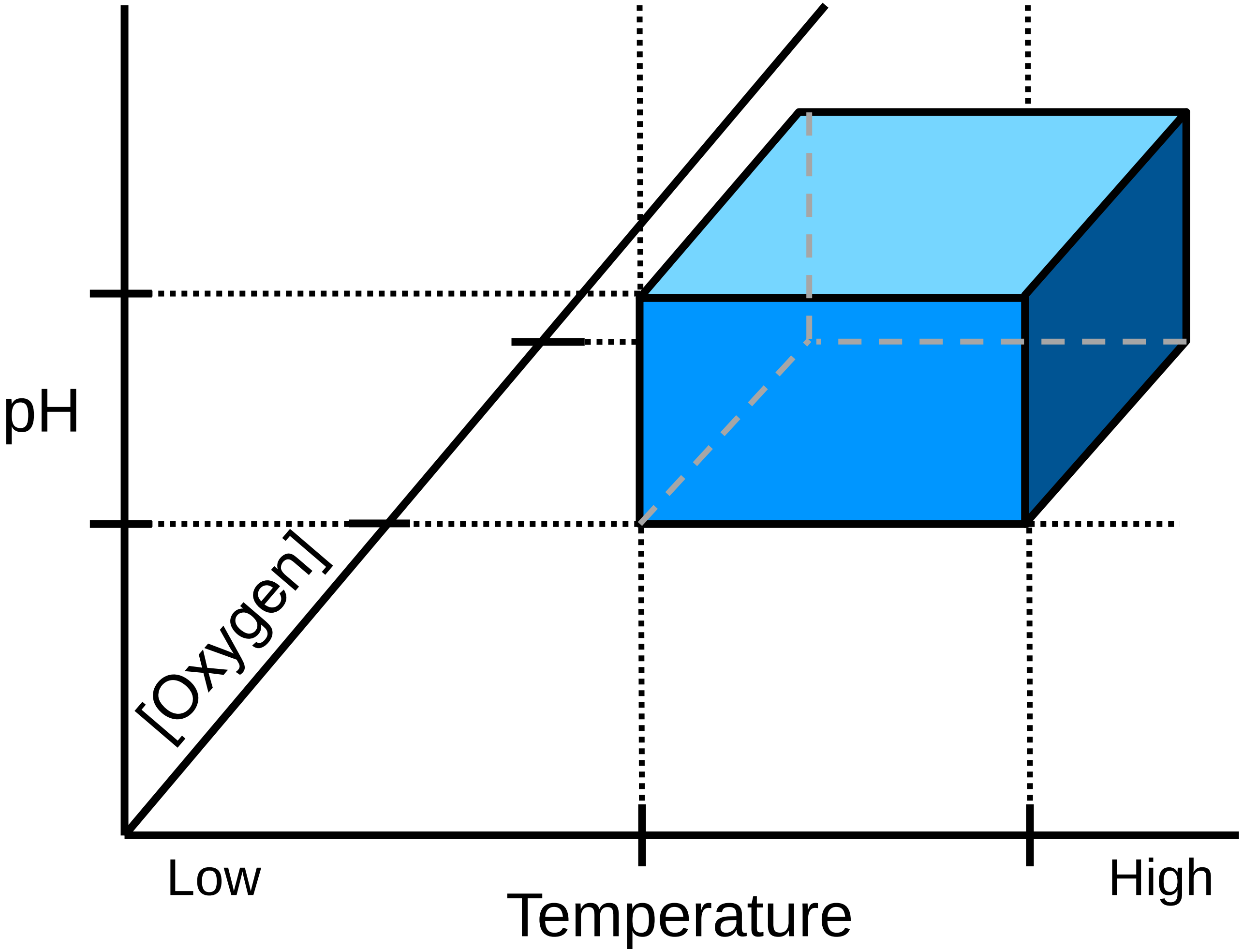
Evolutionary adaptations expand niche boundaries.

(Evolution → Ecology)

Types of adaptations:

- behavioral
- physiological
- morphological
- life history

If a species is absent from an area, is that because the area does not meet the species niche requirements, <u>or because the species never dispersed to that area</u>?

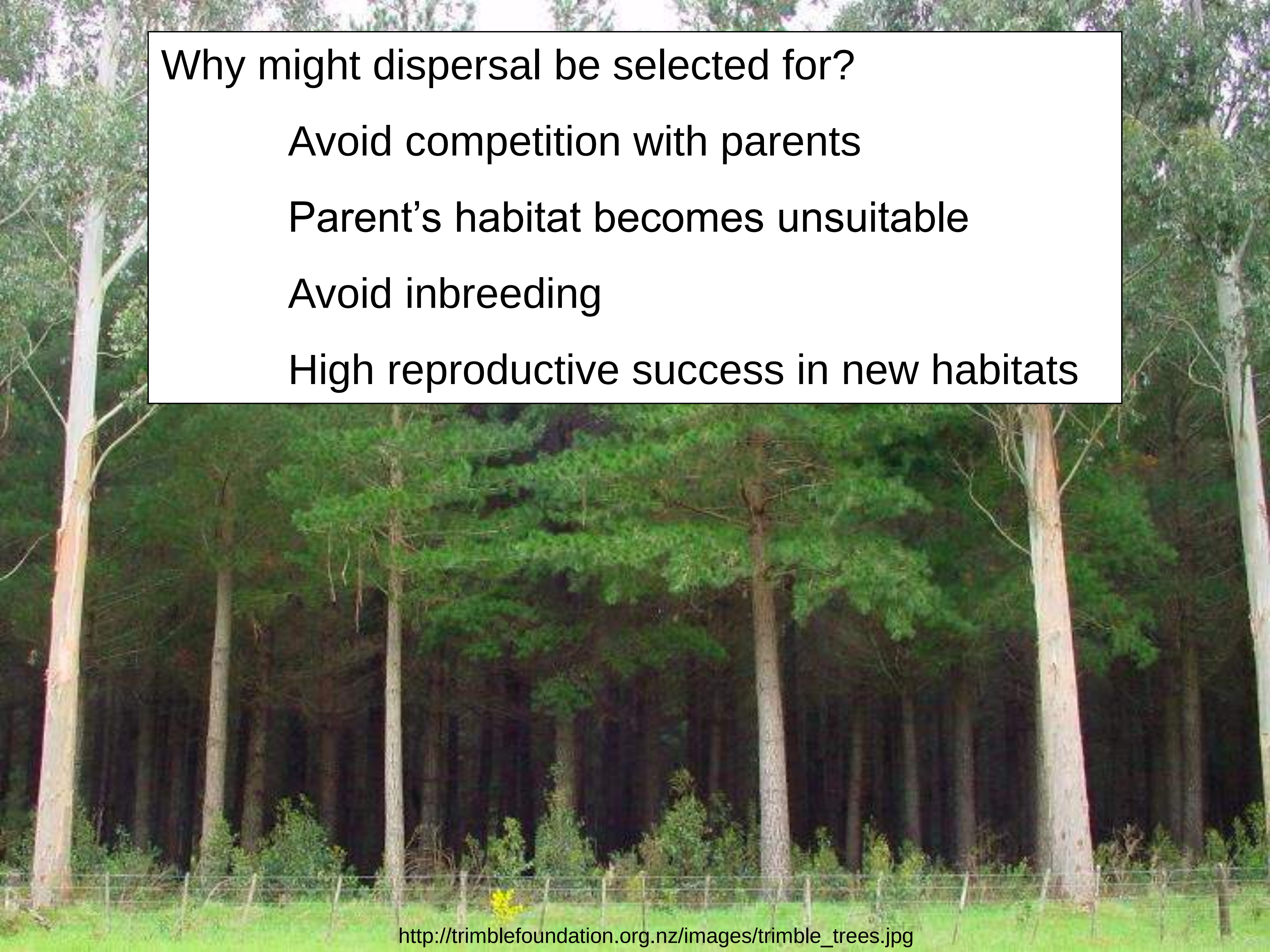


Species only live only in places where they first evolve
or where they eventually reach.
All species have adaptations that enable dispersal

http://blueridgeblog.blogs.com/blue_ridge_blog/valle_crucis_park/

Why might dispersal be selected for?

- Avoid competition with parents
- Parent’s habitat becomes unsuitable
- Avoid inbreeding
- High reproductive success in new habitats



http://trimblefoundation.org.nz/images/trimble_trees.jpg

Dormant eggs (ephippia) of the crustacean zooplankton *Daphnia*

http://ezramagazine.cornell.edu/FALL09/ResearchSpotlight.html

Physiological & population ecology

Outline

- Ecological questions
- Some species of interest
- The niche
- Dispersal
- Population growth & regulation
- Human population size & growth

If a species disperses to a new location, how large will its population grow?

Fire ants dispersed to N. America on a ship that docked in Mobile Alabama

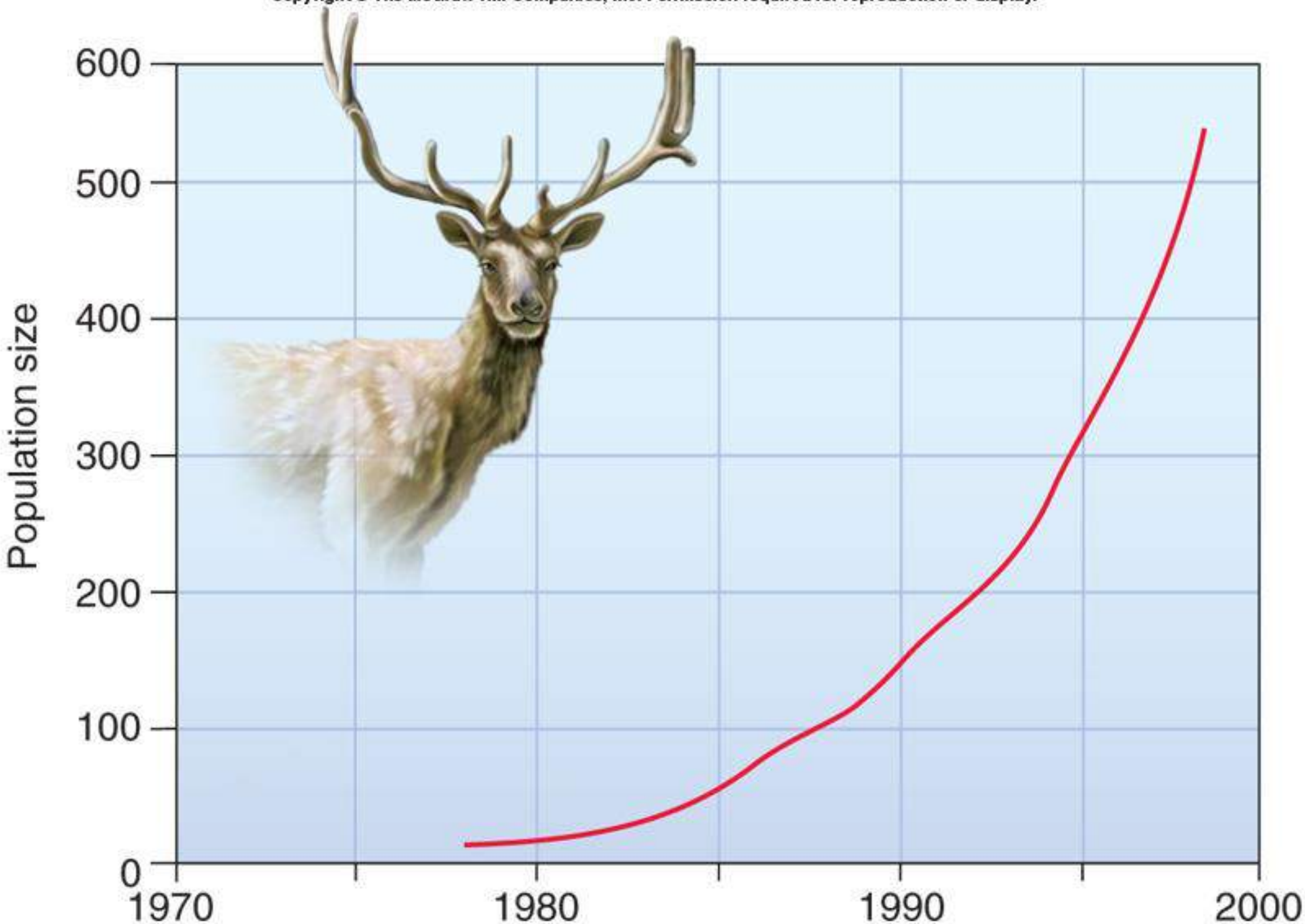
Various tropical diseases are dispersing north and south as the climate warms

The most abundant grasses in North Texas pastures are not native to North America.

Imagine a few deer reach an island in a frozen lake

How will their population grow?

Imagine a few deer reach an island in a frozen lake
How will their population grow?



Do populations usually grow like the deer?

Is there a balance of nature?

[E]very organic being naturally increases at so high a rate, that, if not destroyed, the earth would soon be covered by the progeny of a single pair. … [A]s more individuals are produced than can possibly survive, there must in every case be a struggle for existence.

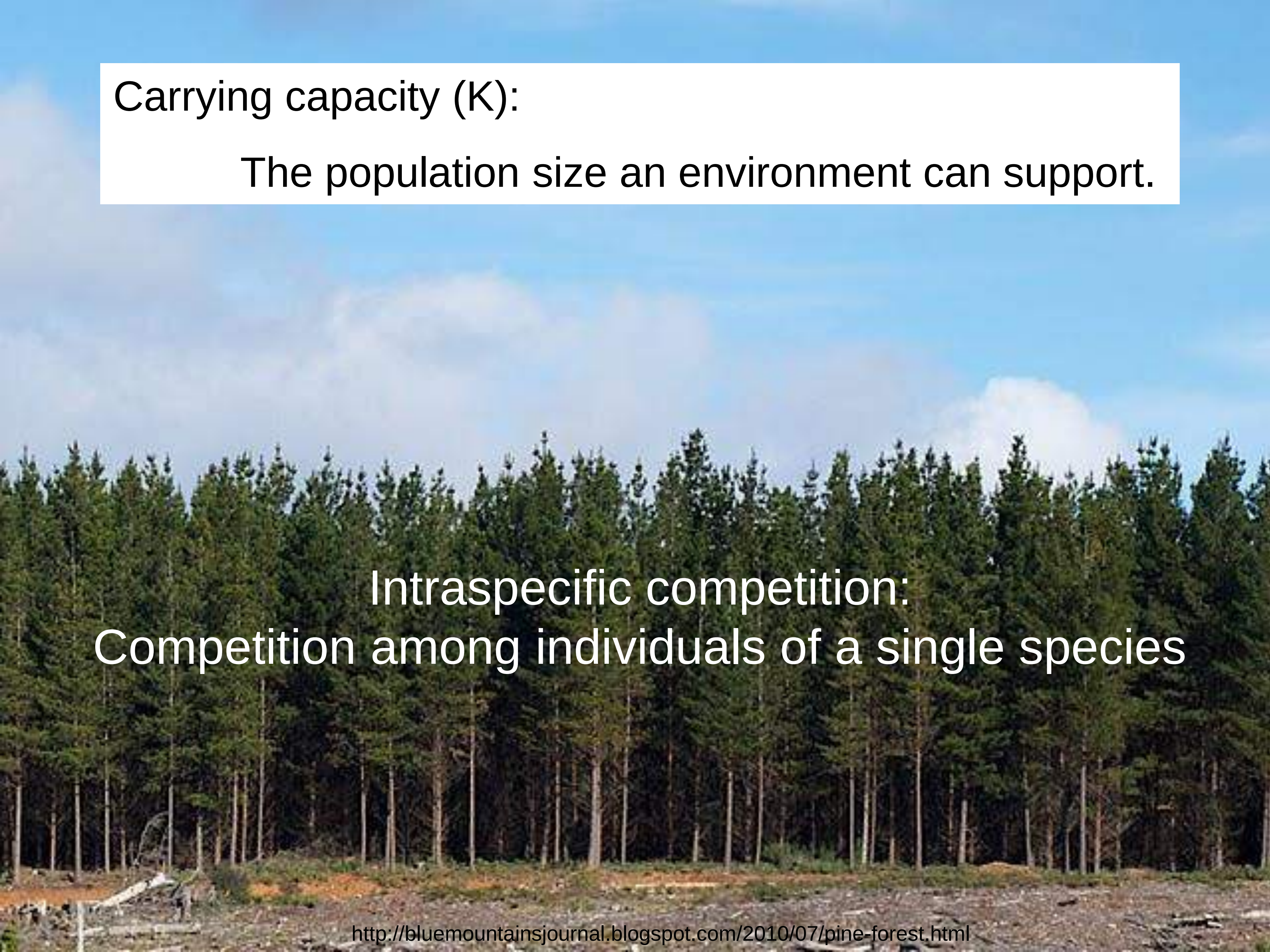
Charles Darwin, Origin of Species

Competition:

Two or more individuals share a limiting resource.

Carrying capacity (K):

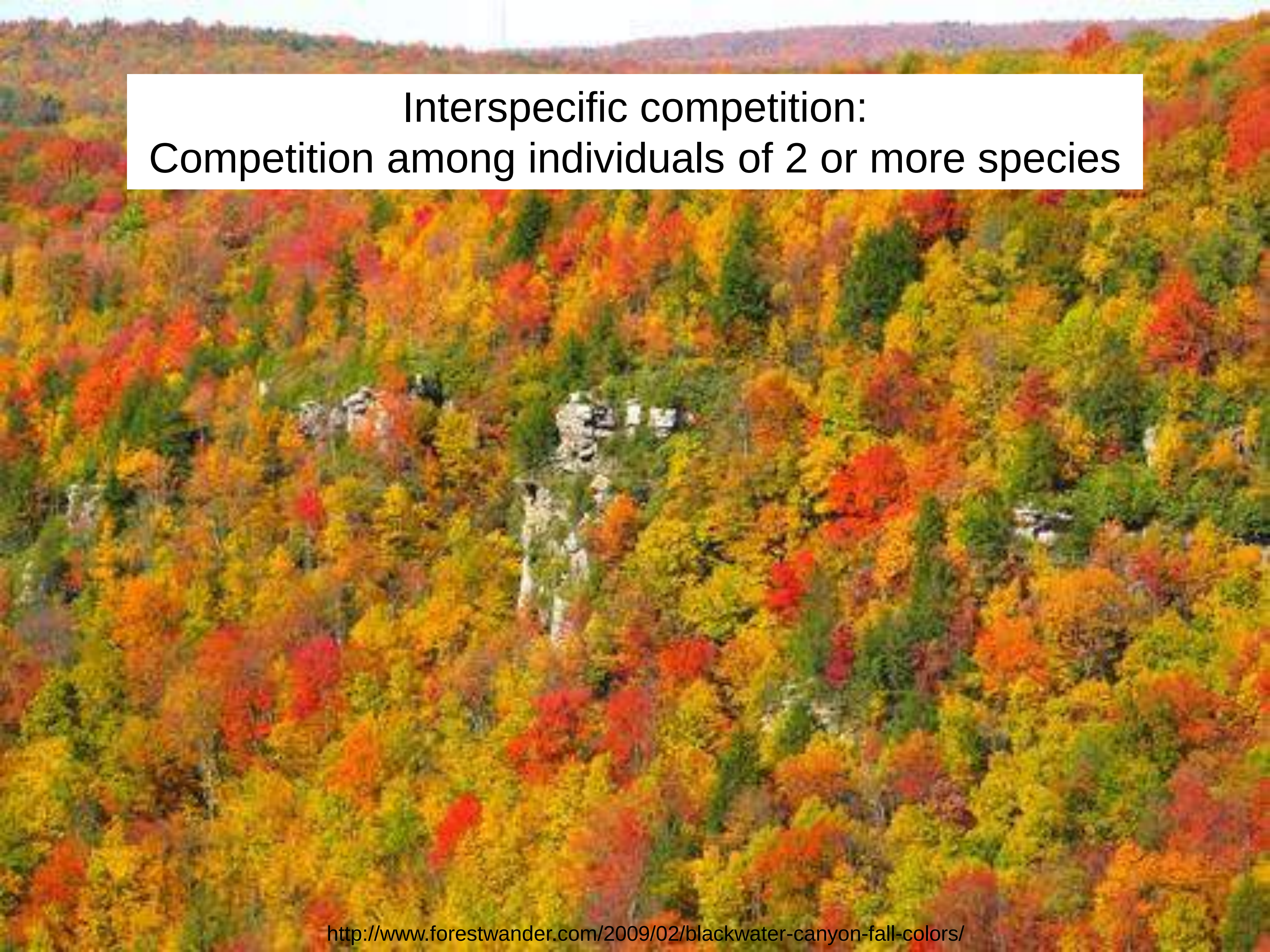
The population size an environment can support.



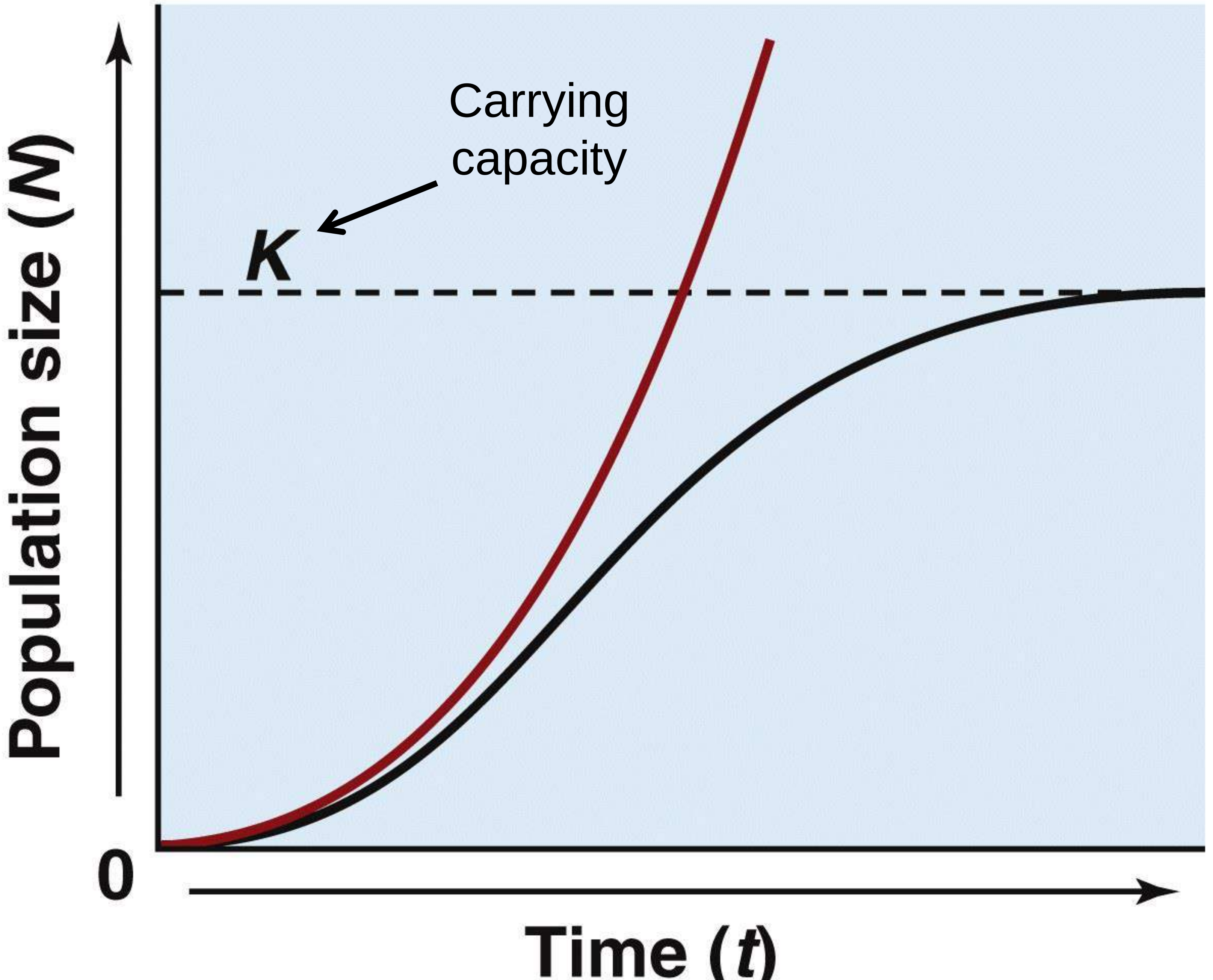
Intraspecific competition:
Competition among individuals of a single species

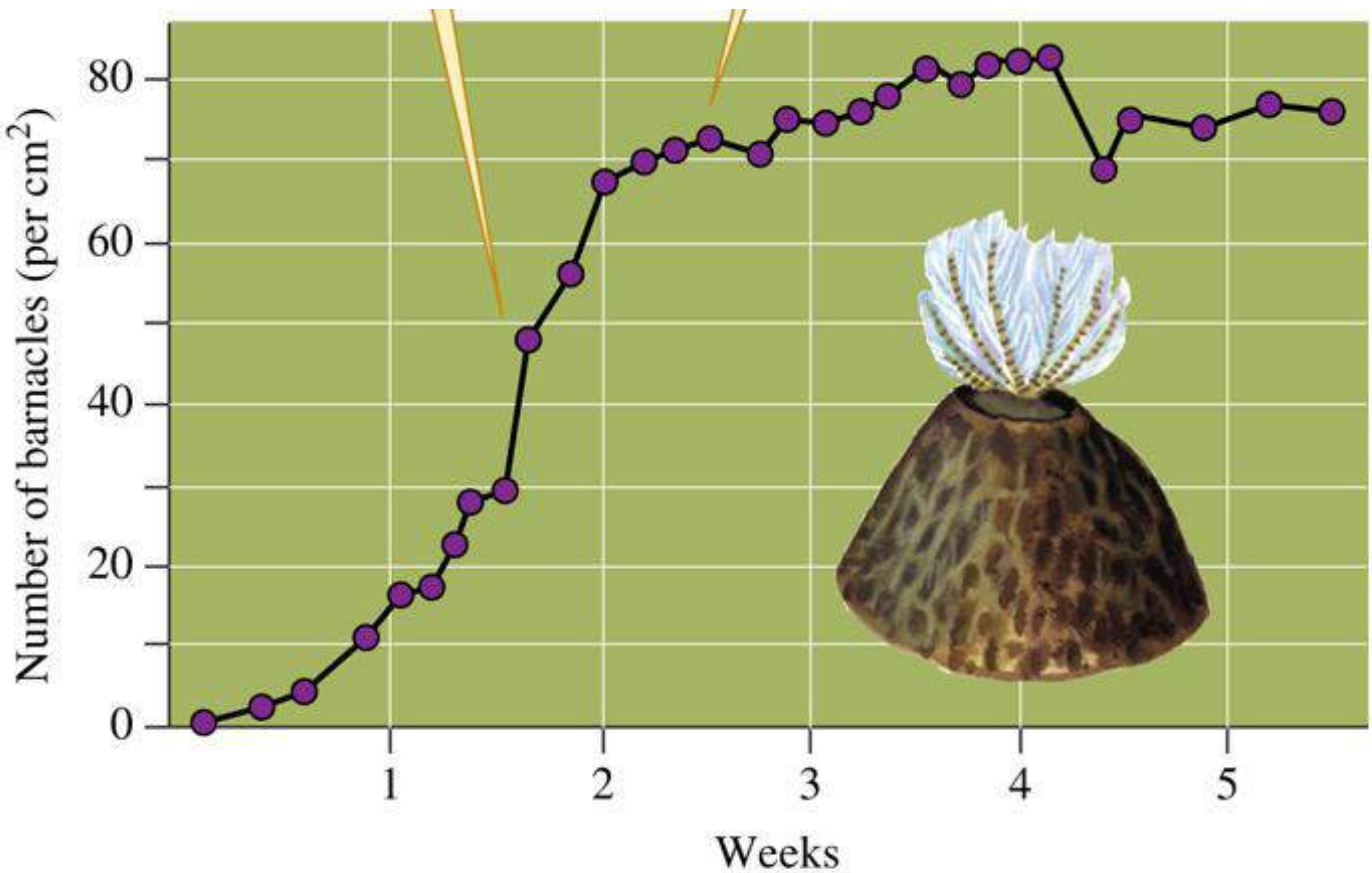
http://bluemountainsjournal.blogspot.com/2010/07/pine-forest.html

Interspecific competition:
Competition among individuals of 2 or more species



http://www.forestwander.com/2009/02/blackwater-canyon-fall-colors/


Carrying
capacity
K
Population size (N)
0
Time (t)



Number of barnacles (per cm²)
0
20
40
60
80
1
2
3
4
5
Weeks

Regulate:

To increase when low and decrease when high.

To push a system back toward equilibrium.

http://crabtreeheating.com/job_photos/heat_pumps.htm

http://www.pexsupply.com/Honeywell-TH8110U1003-VisionPro-Thermostat-1-Heat-1-Cool-3909000-p

Density dependent:

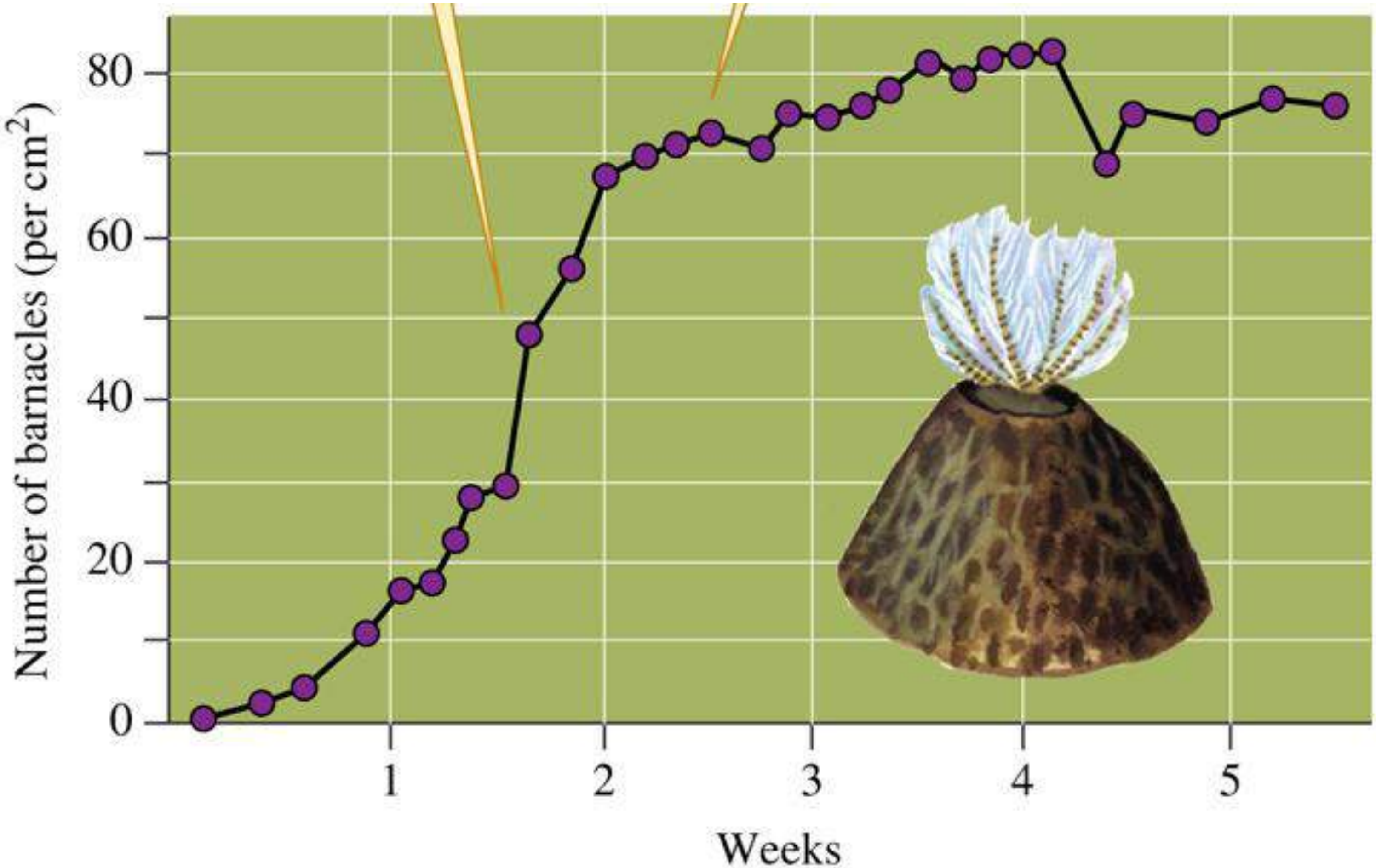
Per capita population growth rate depends on population density (in most cases declines as population density increases).

Only density dependent processes can regulate population sizes.

Regulation occurs only per capita birth rate, death rates, or both vary with population density.

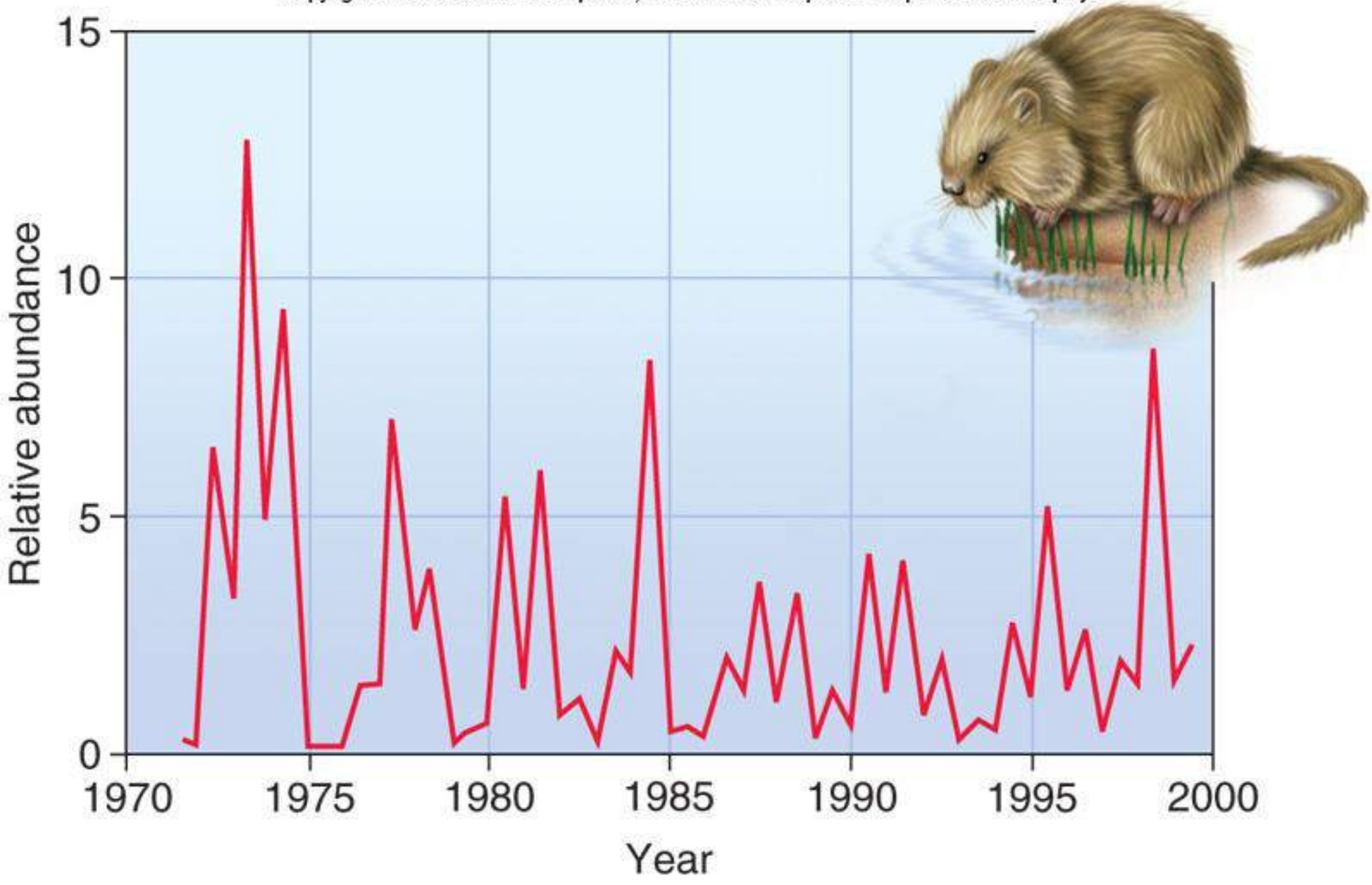
Biological interactions are often density dependent
- e.g. competition, predation, parasitism
- These happen because of the population density

Abiotic factors are not generally density dependent
- e.g. extreme weather
- These happen regardless of population density



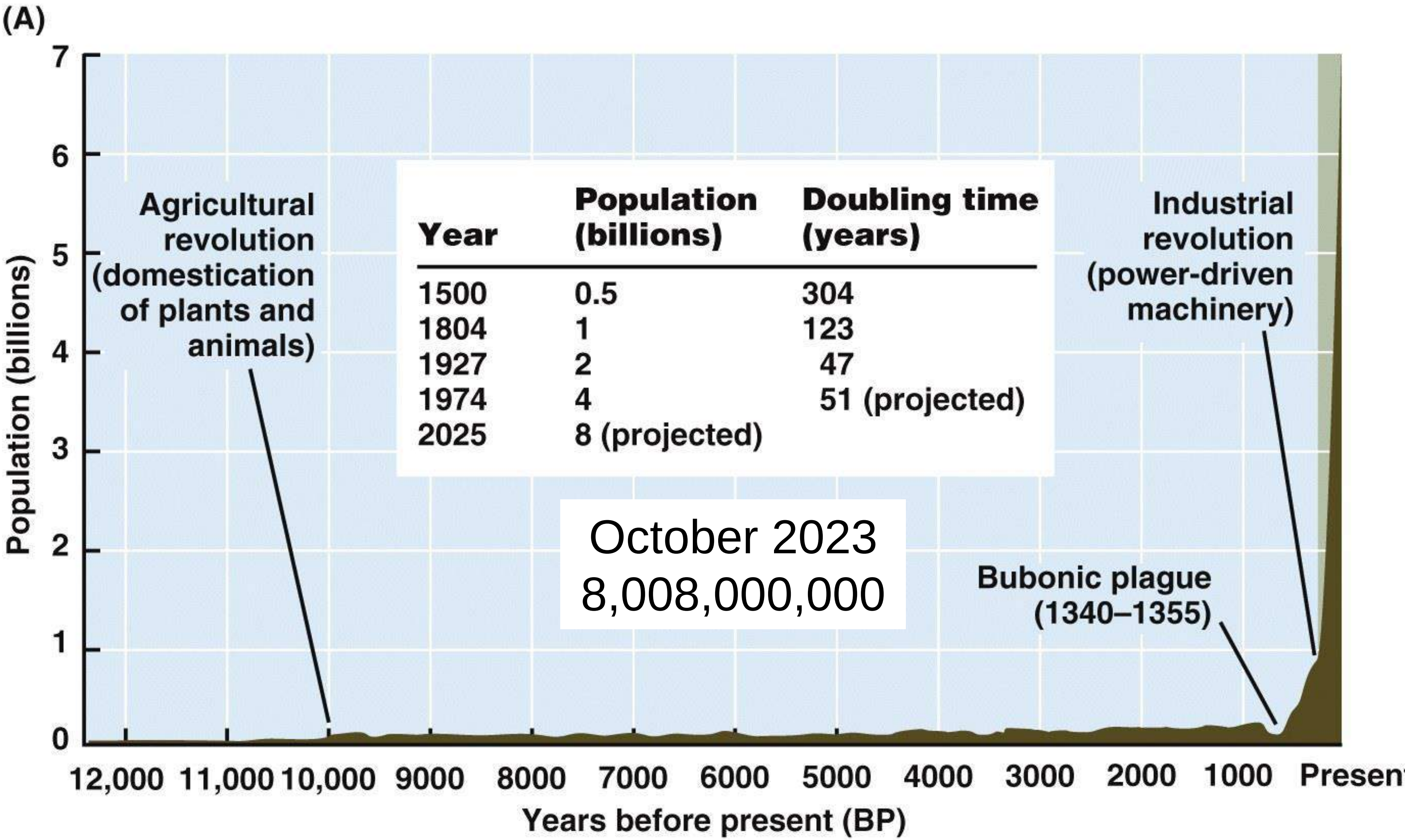
Population growth is not always this smooth

Some populations cycle



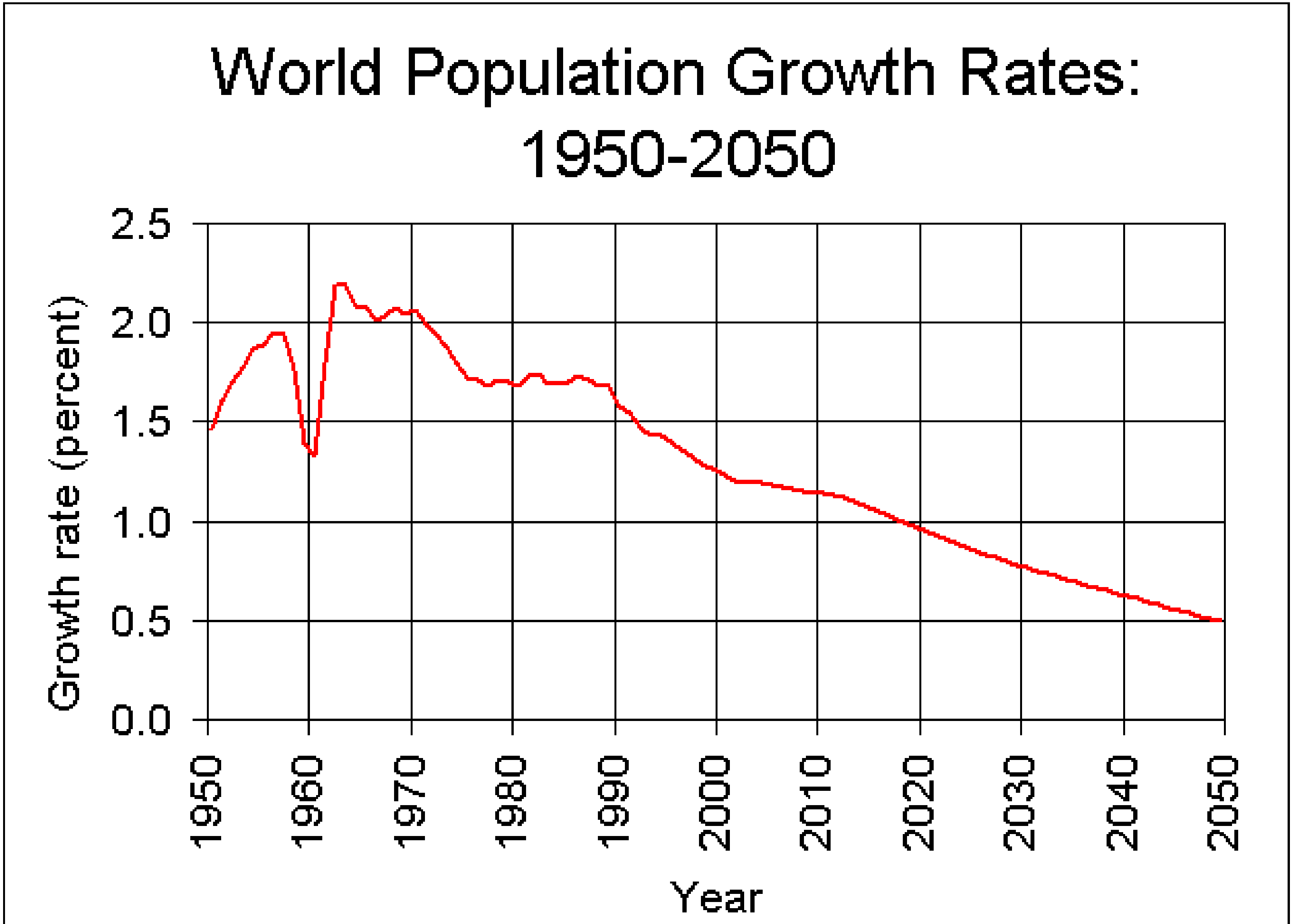
(b) Voles in Sweden

The history of human population growth



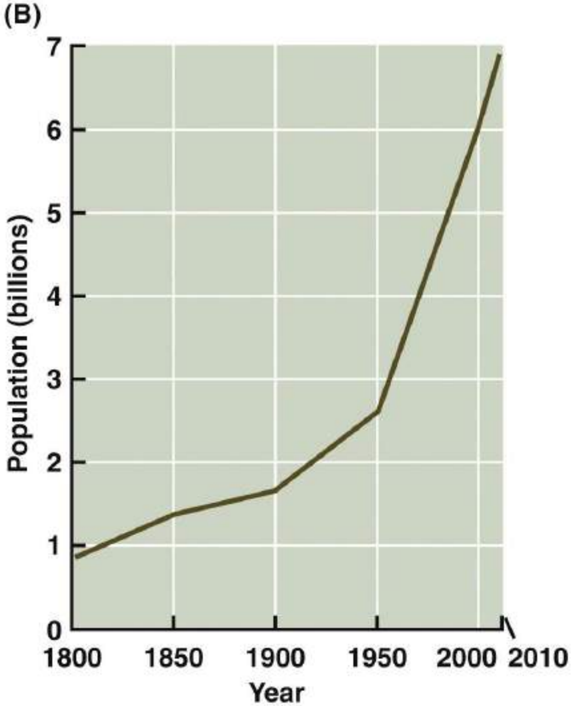
Year	Population (billions)	Doubling time (years)
1500	0.5	304
1804	1	123
1927	2	47
1974	4	51 (projected)
2025	8 (projected)	

PRINCIPLES OF LIFE, **Figure 43.9 (Part 1)**



Source: U.S. Census Bureau, International Data Base, July 2007 version.

Has our population not yet reached its carrying capacity, or has it exceeded carrying capacity but managed to continue to increase anyway?



PRINCIPLES OF LIFE, Figure 43.9 (Part 2)

Exceeded: depleting a “one-time inheritance of natural capital.”

Current human population is maintained at expense of costs to future.

Physiological & Population Ecology Summary

Species maintain populations only where niche requirements met.

Adaptations broaden niche boundaries.

Some potential habitats are uninhabited due to failure to disperse to those sites.

Once a population reaches a new site it may grow, but will not grow indefinitely.

Population sizes tend to be regulated, but sometimes only loosely.

The human population has grown dramatically, as if not regulated.
- by depleting a one-time inheritance of natural capital.

Community Ecology

Outline

- Types of interactions among species
  - Competition
  - Predation
  - Mutualism
  - Coevolution
- Species diversity
  - How does species diversity affect ecosystem functioning?
  - Factors that reduce species diversity
- Succession

Community

An assemblage of organisms living close enough together to have potential to interact.

Types of interspecific interactions

Interspecific competition: ≥2 species use same limiting resource, one or both suffer.

Predation (including parasitism): one individual benefits, other suffers.

Mutualism: both species benefit.

Commensalism: one species benefits, other is unaffected.

Coevolution: reciprocal evolution of ≥2 species in response to each other

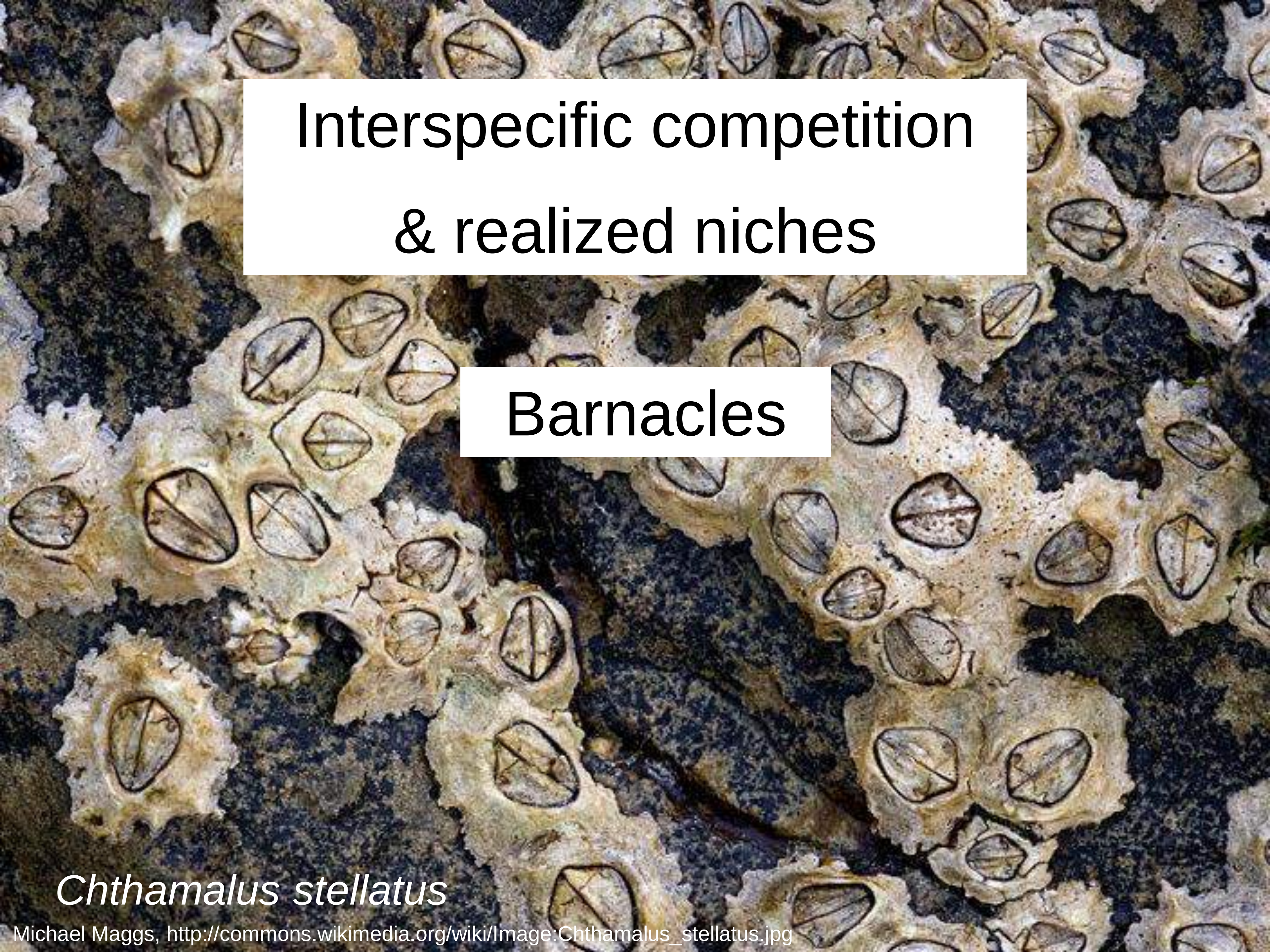
Fundamental vs. realized niche

Fundamental niche: the set of conditions where a species could live in the absence of competitors & predators. (What we have called the niche so far.)

Realized niche: the sets of conditions where a species actually does live in the presence of predators and competitors (a subset of the fundamental niche).

Interspecific competition & realized niches

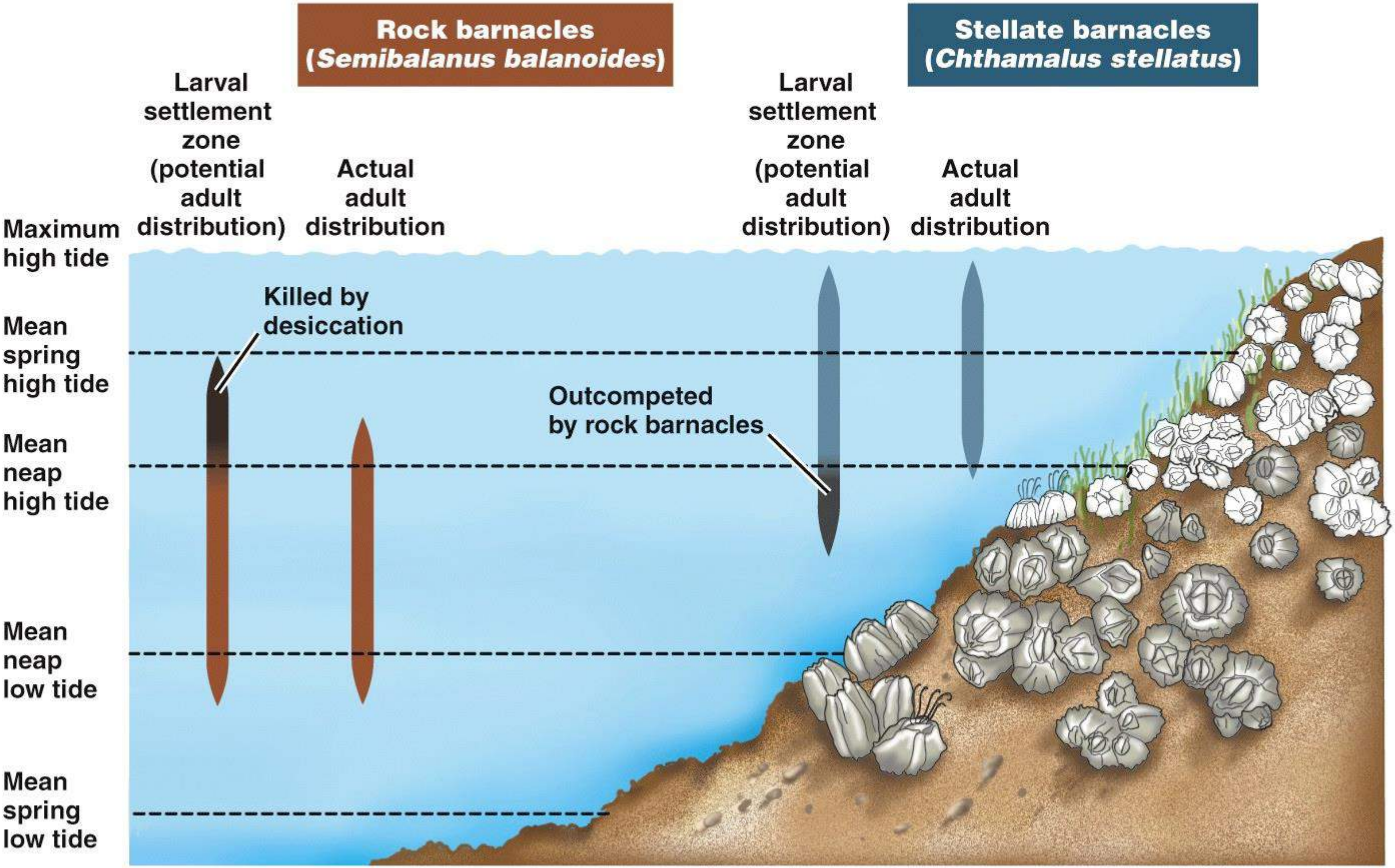
Barnacles



Chthamalus stellatus

Michael Maggs, http://commons.wikimedia.org/wiki/Image:Chthamalus_stellatus.jpg

http://www.microscopy-uk.org.uk/mag/indexmag.html?http://www.microscopy-uk.org.uk/mag/artjan99/barnac.html Wim van Egmond



PRINCIPLES OF LIFE, Figure 44.4

Predation

Selection favors individuals that survive and reproduce.

Selection also favors individuals that obtain sufficient resources.

Thus

Almost all creatures are routinely at risk of predation or have effective defenses against predation.


http://www.hiltonpond.org/images/HoneylocustThorns01.jpg

http://www.alaska-in-pictures.com/

http://alaska.usgs.gov/science/biology/shorebirds/gallery/DUNL_flock-Egegik_06_drr.jpg

http://www.duke.edu/web/nicholas/bio217/jrc25/fish-school.jpg

http://animals.nationalgeographic.com/staticfiles/NGS/Shared/StaticFiles/animals/images/800/walking-stick-insect.jpg

http://www.columbia.edu/itc/cerc/danoff-burg/invasion_bio/inv_spp_summ/blue_auratus.jpg

http://www.duke.edu/~jspippen/butterflies/monarch.htm

http://www.cwss-scm.ca/Weeds/images/Ascl1-common-milkweed.JPGhttp://www.tpwd.state.tx.us/learning/texas_nature_trackers/monarch/images/02b_lrg_monarch_thistle.jpg

Example of predatory interaction with different outcomes depending on evolutionary history

Brood Parasites
- birds that lay eggs in other birds' nests
- get other birds to raise their young`

Parasite lays egg in host nest

Parasite egg hatches first.

Parasite nestling pushes out host eggs & nestlings, or gets fed first.

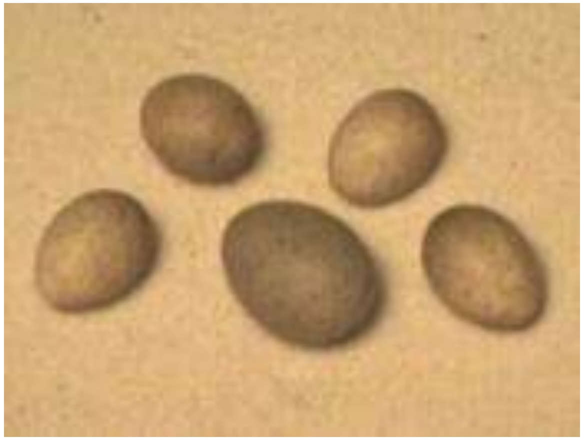
Parasite parent produces more eggs rather than feeding young.

Very effective when brood parasites first reach an area. Less effective over time. Why?

Reed Warbler raising Common Cuckoo

http://en.wikipedia.org/wiki/Cuckoo

Parasitic species new to continent (invasive species). Host has no evolutionary experience with parasite. Parasite egg does not match host eggs. Parasitism effective even though eggs look different. Why?



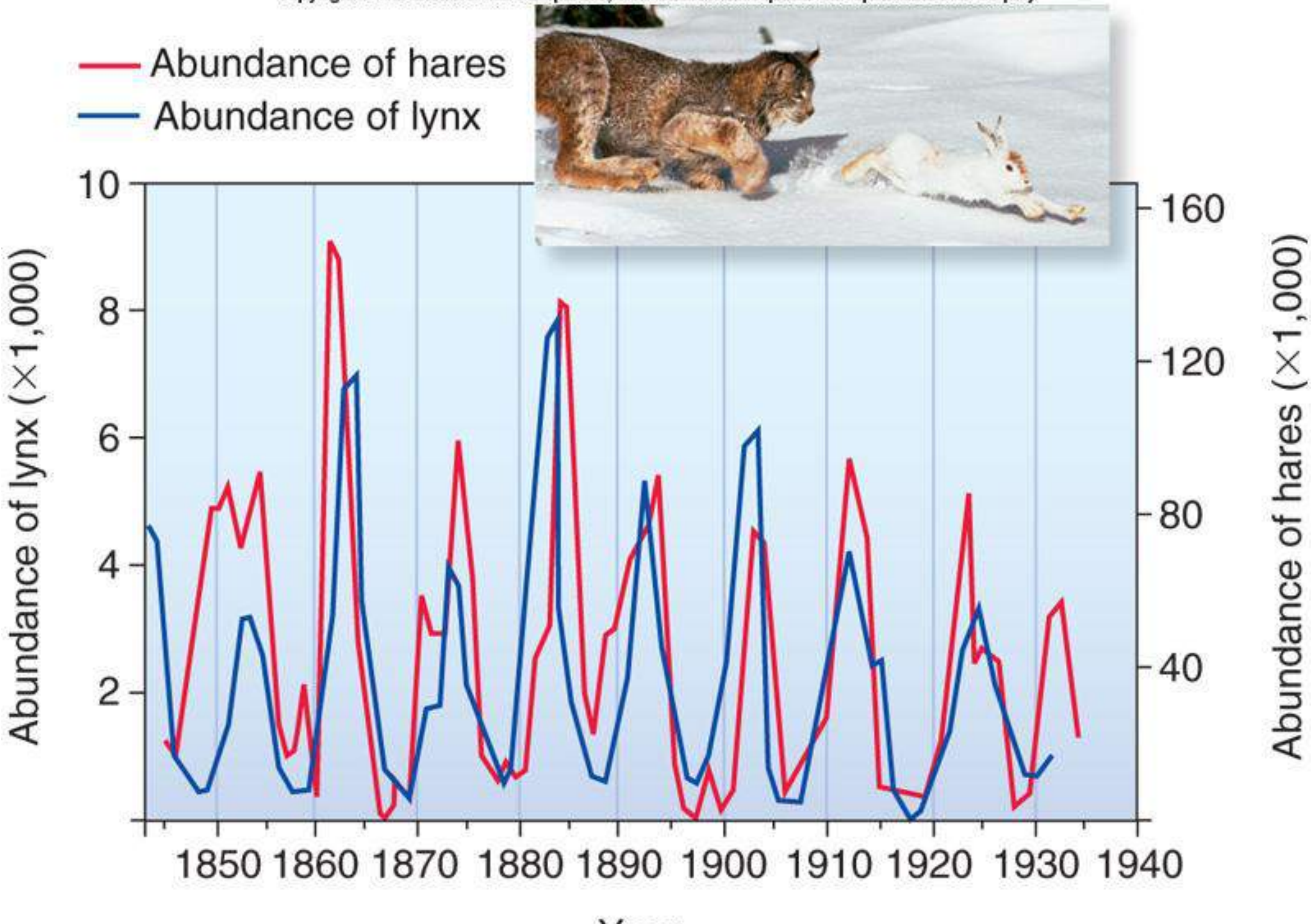
Native range of both species. Host has evolved ability to distinguish eggs. In turn, selection for parasite egg that matches host egg.

http://farm4.static.flickr.com/3293/2486989785_feb8382df3_m.jpg

http://www.royalalbertamuseum.ca/vexhibit/eggs/vexhome/broodpar.htm

How would you expect predators & prey to affect each others' abundance?

Cyclic abundance of a predator & its prey



Tom & Pat Leeson/Photo Researchers, Inc.

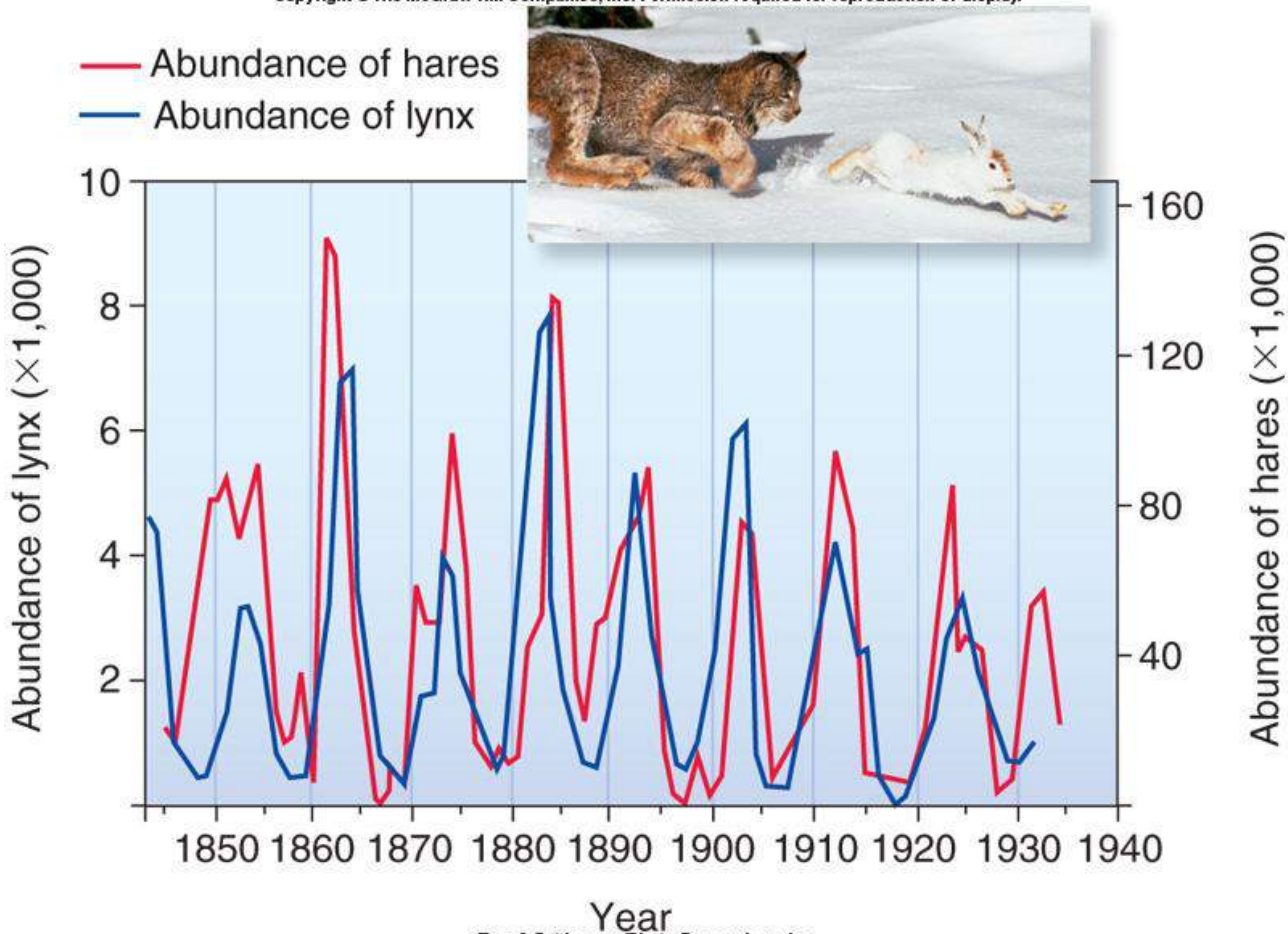
Explanation of cycles of abundance of hare & lynx

Original hypothesis –

Both rare, hare increases, lynx follows, lynx suppresses hare, lynx dies back due to lack of prey, cycle repeats

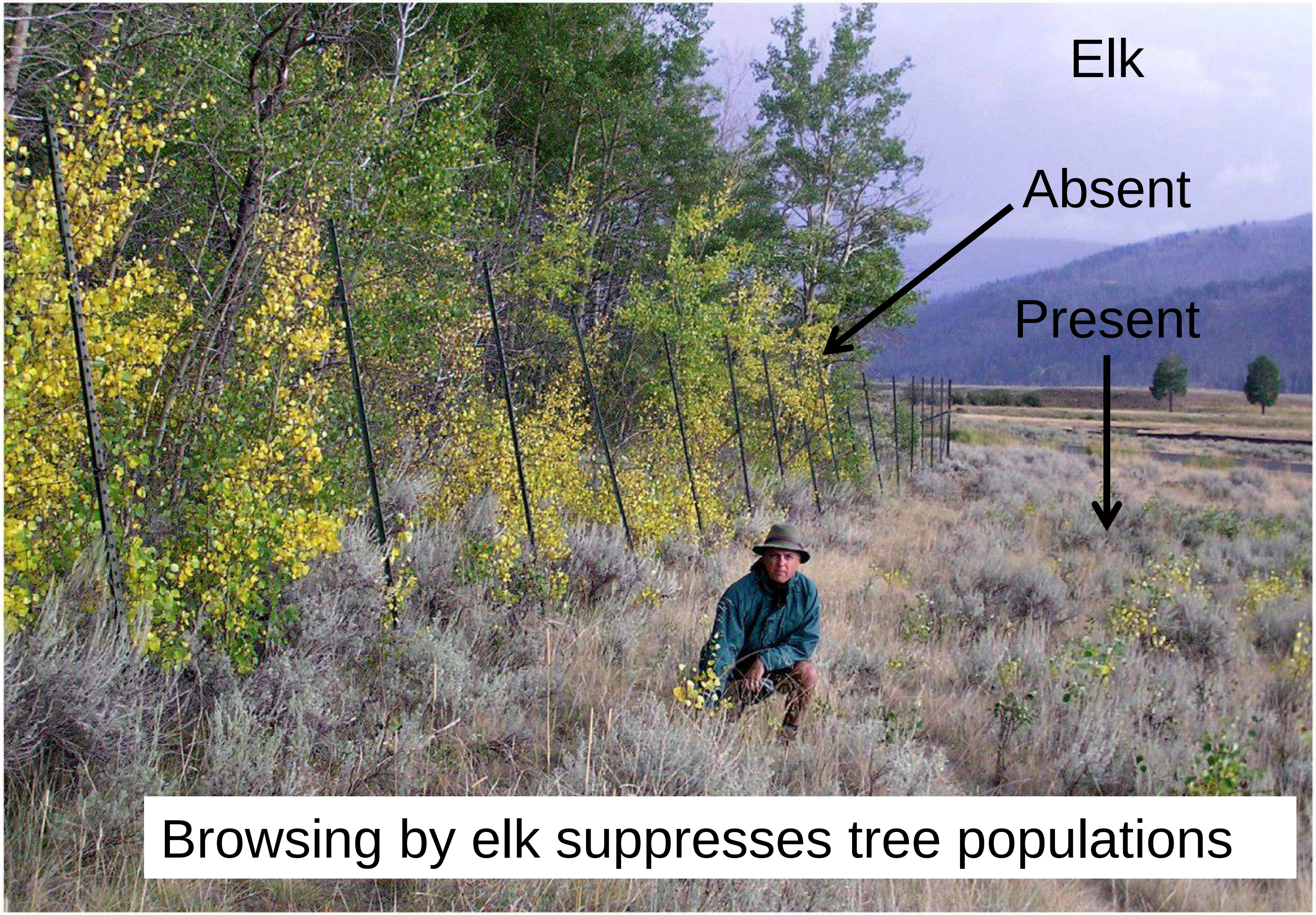
After further study –

Additional process involved – Plants browsed by hare responds to hare abundance. Plants produce defensive chemical in response to grazing. Maintains defenses for a while after hare population declines. Generates delay before hare rebound.



Tom & Pat Leeson/Photo Researchers, Inc.

Predator & prey populations do not always cycle. Many predators continually suppress prey populations.



PRINCIPLES OF LIFE, Figure 45.8 (Part 3)

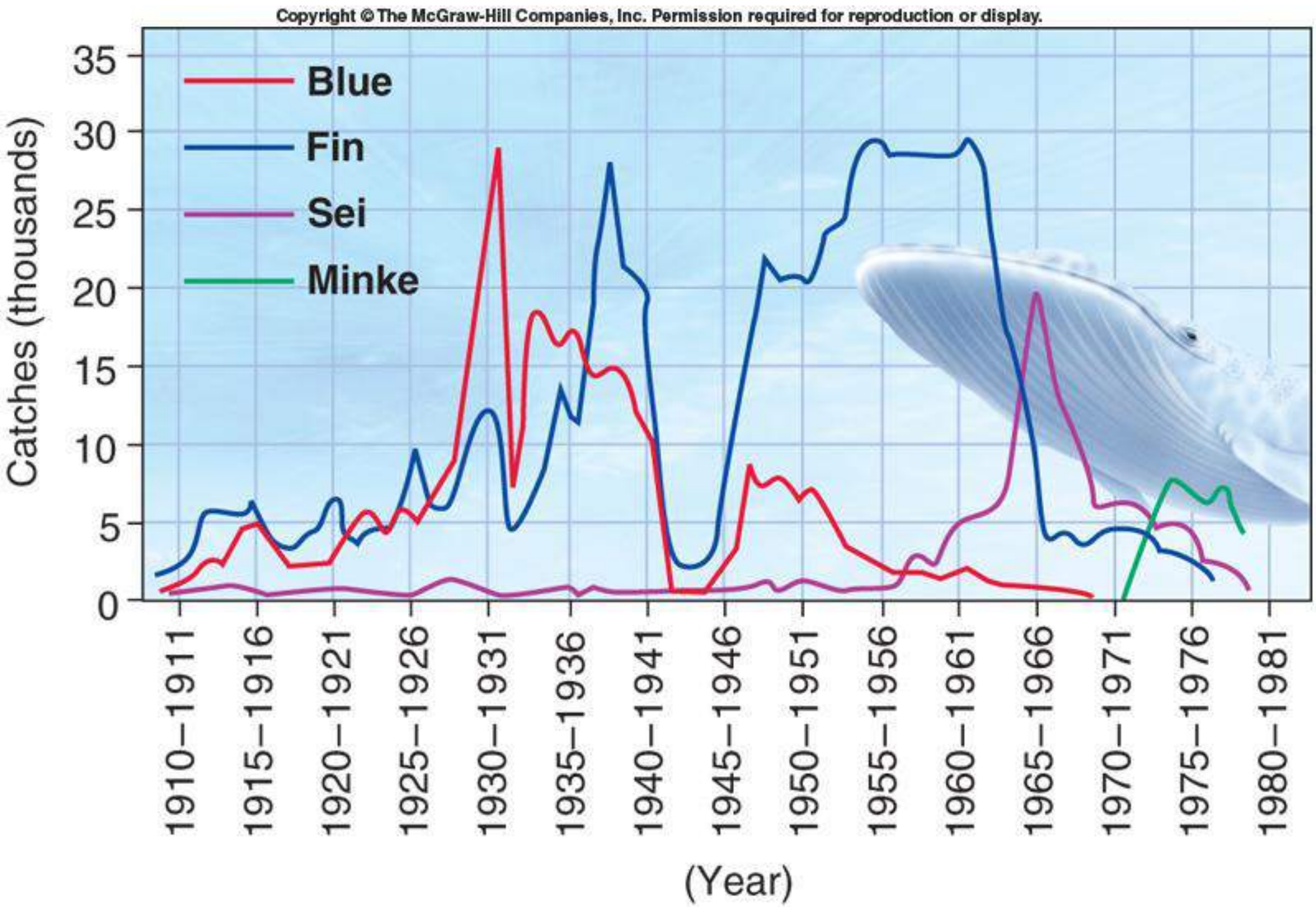
History of wolves and elk at Yellowstone

1. Wolves wiped out by people.
2. Elk population increases &
3. Elk behavior released from threat of wolf predation.
4. Elk linger near streams.
5. Elk browse leaves of small trees – killing trees, preventing tree reproduction near streams.
6. Streams lose shade & beavers lose source of wood.
8. Unshaded streams get hot and lose beaver dams.
9. “Riparian” species (e.g. song birds) lost &
10. Cool-water fish species lost.

A “trophic cascade”

Trophic: related to feeding relationships.

Humans as predators



Declines in marine fisheries due to overfishing

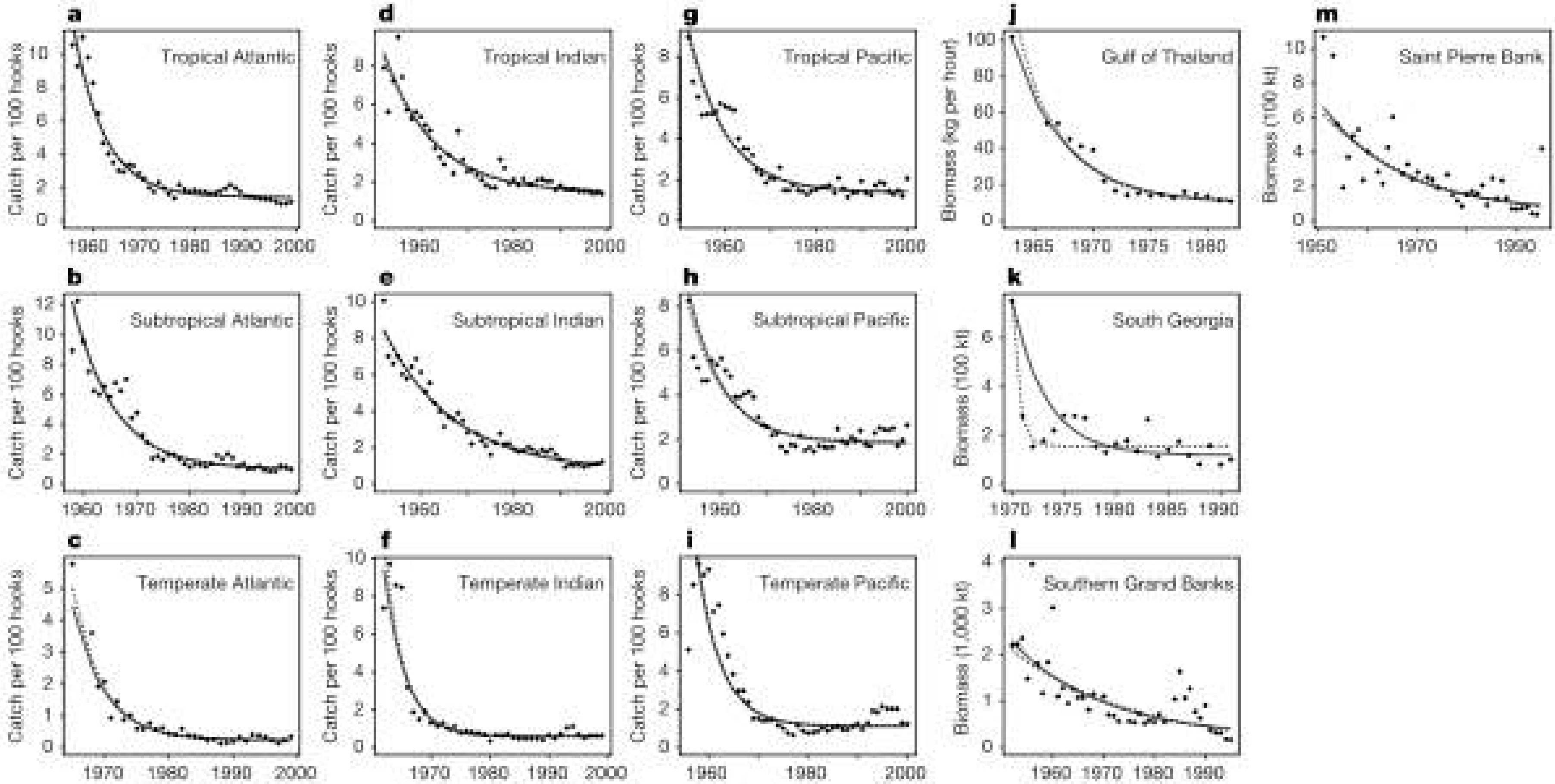
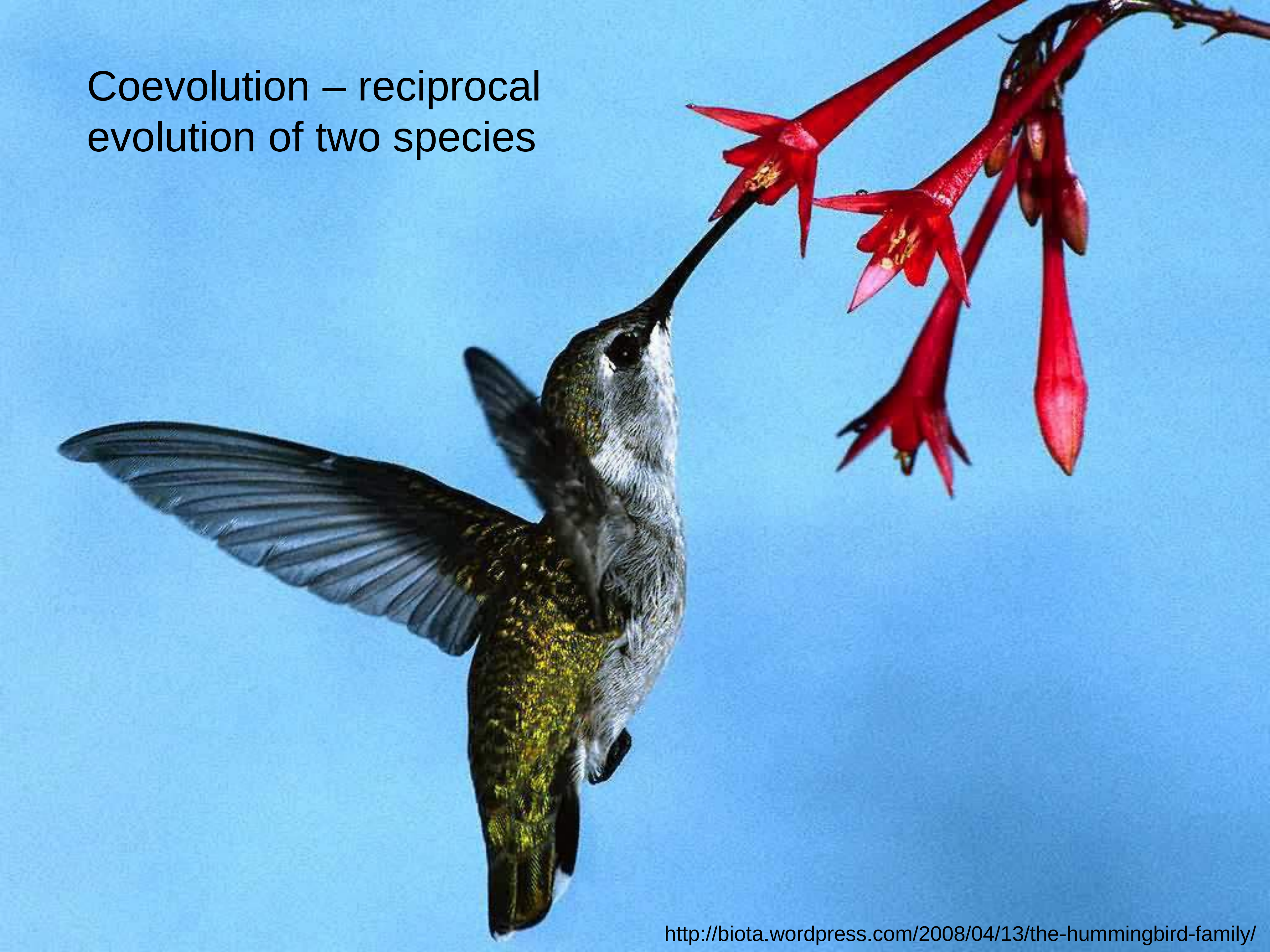


Figure 1 Time trends of community biomass in oceanic (**a**–**i**) and shelf (**j**–**m**) ecosystems. Relative biomass estimates from the beginning of industrialized fishing (solid points) are shown with superimposed fitted curves from individual maximum-likelihood fits (solid lines) and empirical Bayes predictions from a mixed-model fit (dashed lines).

280 © 2003 Nature Publishing Group NATURE | VOL 423 | 15 MAY 2003 | www.nature.com/nature

Myers & Worm, *Nature*, May 2003

Coevolution – reciprocal evolution of two species



http://biota.wordpress.com/2008/04/13/the-hummingbird-family/

Ants protect trees from competition & herbivores. Trees provide ants with sugary food, protein rich food, and shelter

Tropical *Acacia* shrub with mutualistic ants

http://pick4.pick.uga.edu/mp/20p?see=EL_DP162

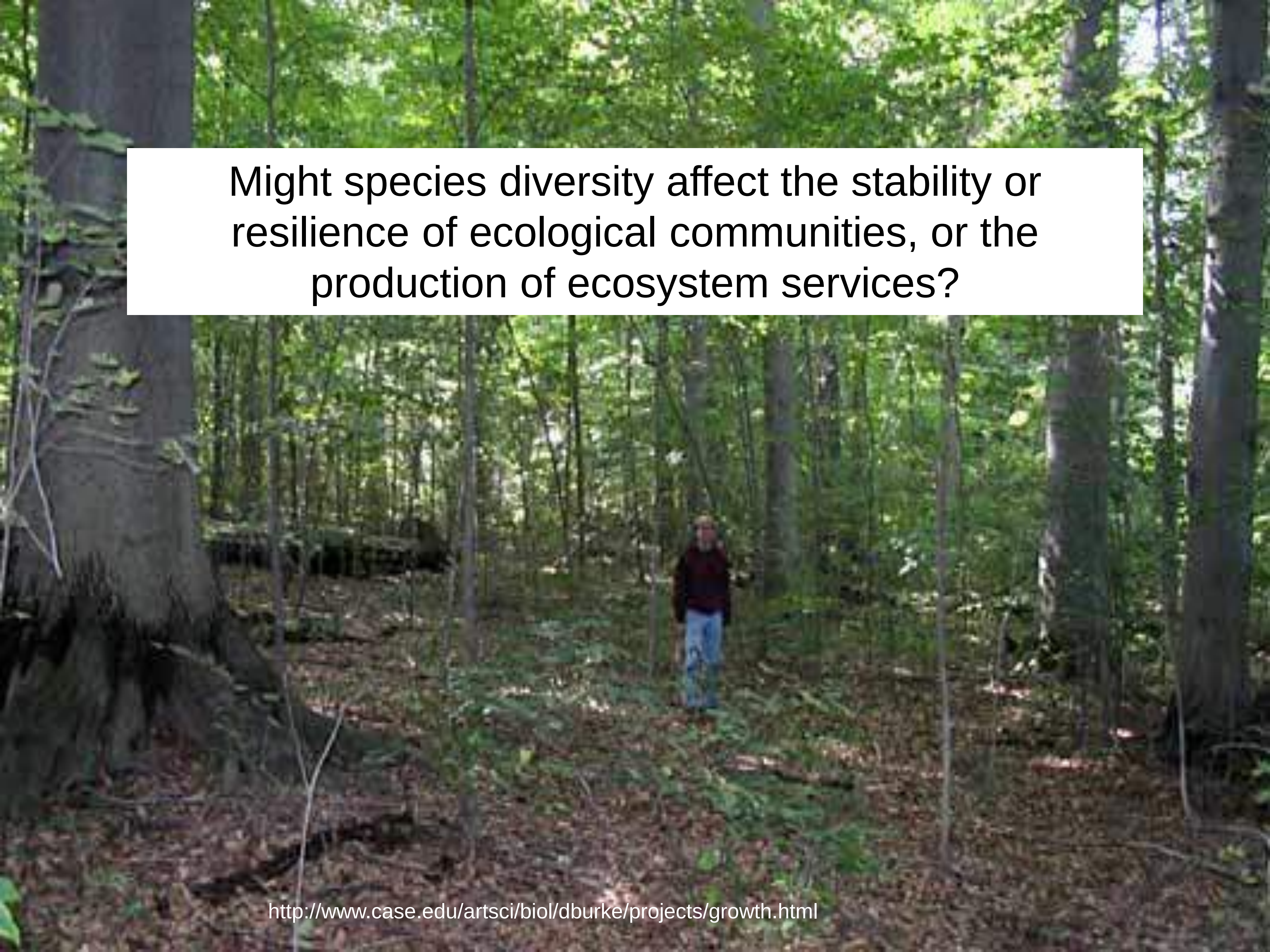
Note lack of plants around base of acacia trees.
Ants have bitten off competing vegetation.

Species Diversity

Why do some communities have so many more species than other communities?

Why care?

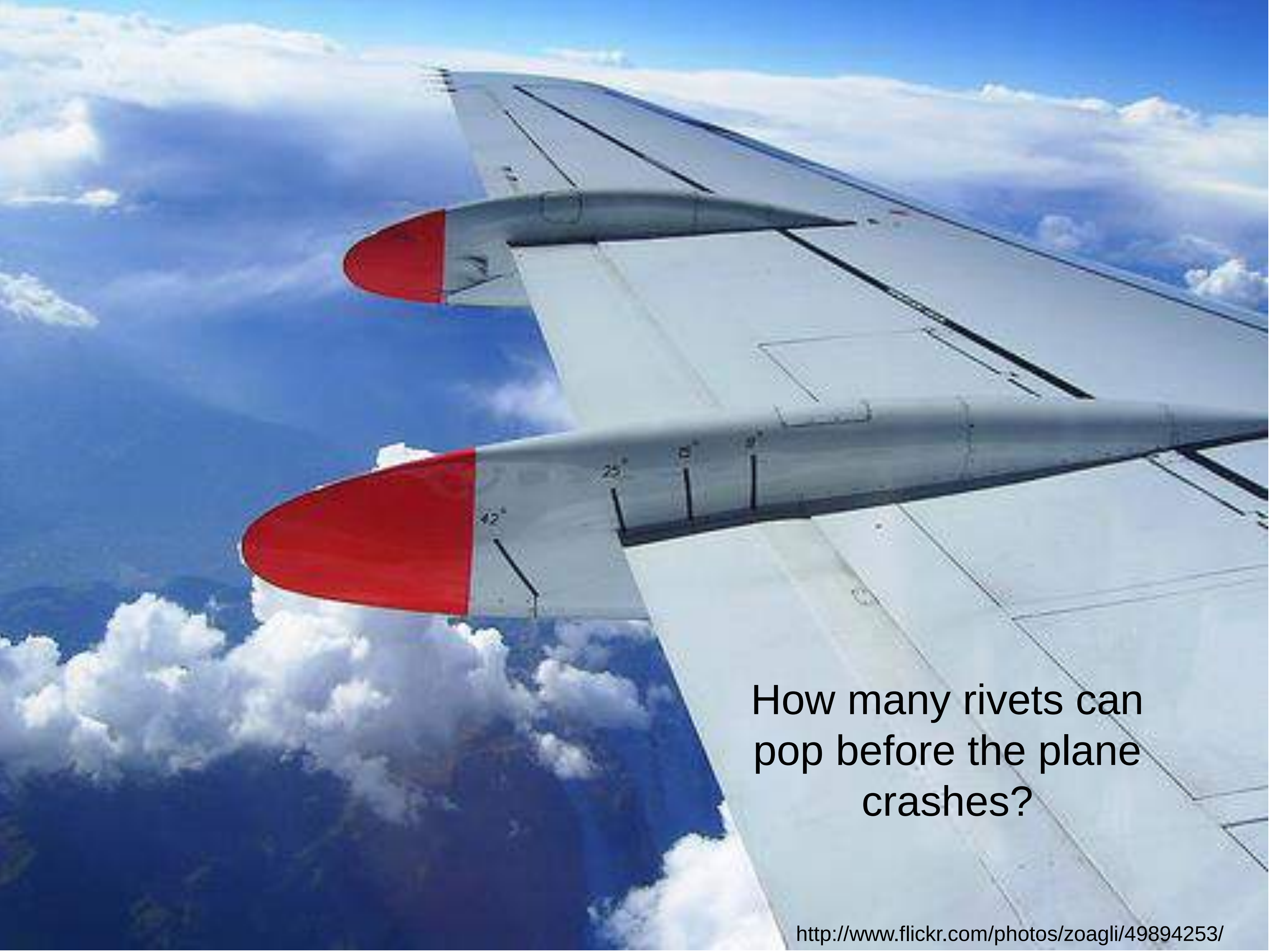
http://www.centraliahs.org/personnel/teachers_faculty/science/becker/biome%20web%20page/taiga.htm


Might species diversity affect the stability or resilience of ecological communities, or the production of ecosystem services?
http://www.case.edu/artsci/biol/dburke/projects/growth.html

How will the loss of beech trees affect the ecosystem?

http://www.michigan.gov/dnr/0,4570,7-153-10366_46403_46404-210259--,00.html

http://uptreeid.com/Health/_23-stemhdwd.html


How many rivets can pop before the plane crashes?
http://www.flickr.com/photos/zoagli/49894253/

Which forest would be altered the most if a disease wiped out the most common tree species?

http://www.centraliahs.org/personnel/teachers_faculty/science/becker/biome%20web%20page/taiga.htm

Higher species richness improves ecosystem function

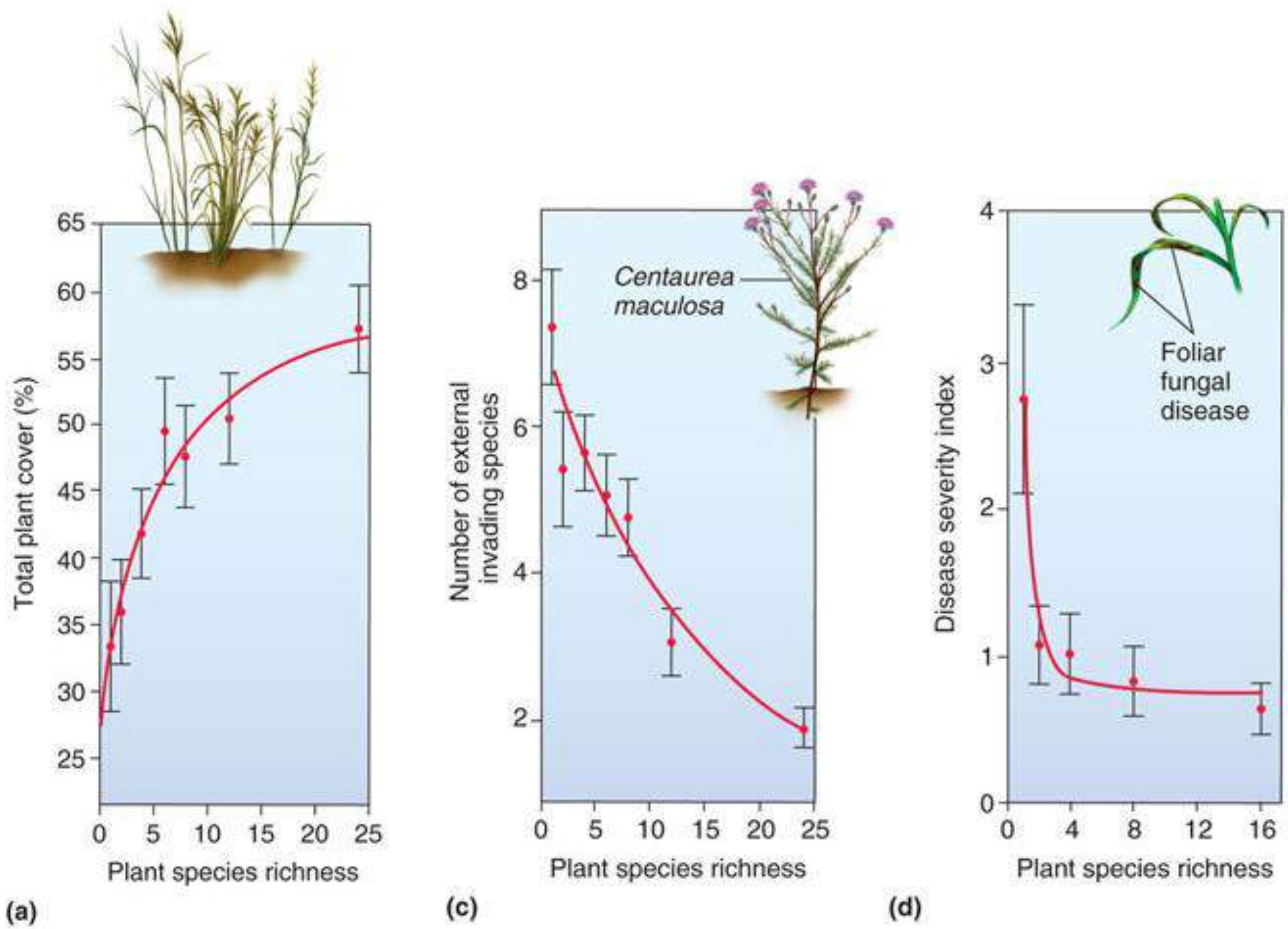


Figure from Brooker intro bio text, based on Cedar Creek study

Some factors that typically lead to low species diversity
(the opposites lead to high species diversity)

Competition

Non-native predators

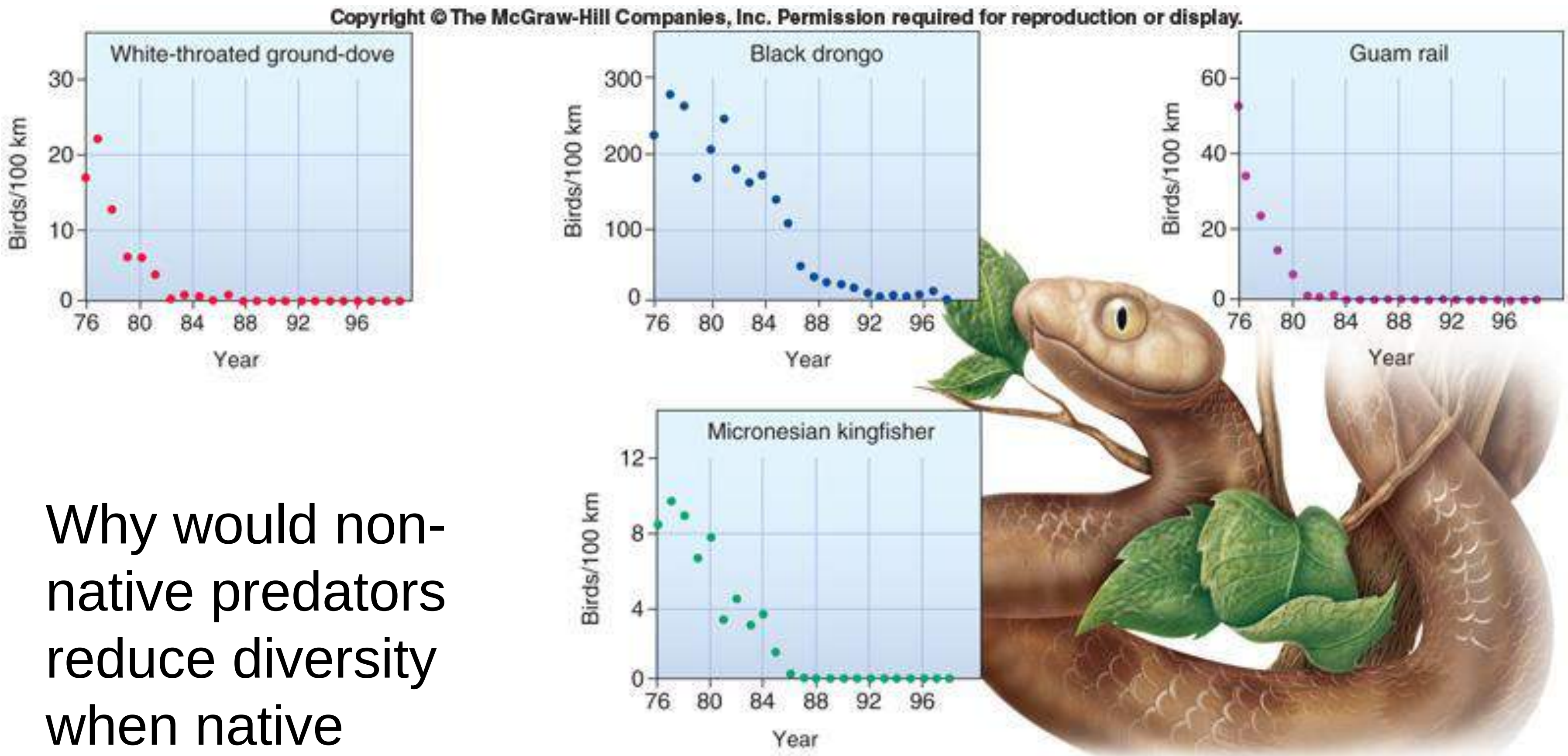
Isolation from sources of colonists

Small habitat size

Habitat destruction

Humans exacerbate all of these

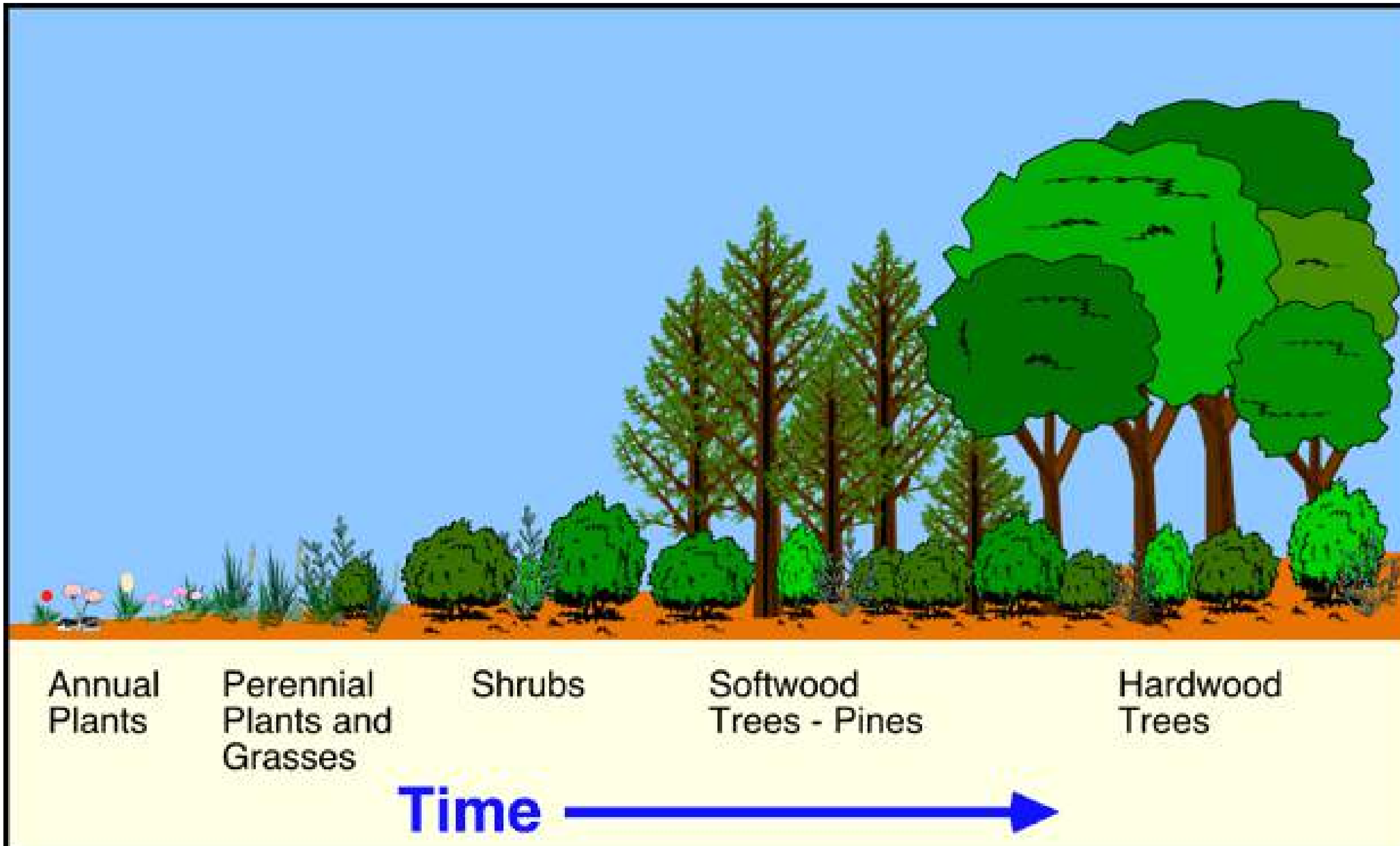
Non-native predator wipes out island birds



Why would non-native predators reduce diversity when native predators increase diversity?

https://rebellion.earth/

Succession
Predictable temporal change in community structure



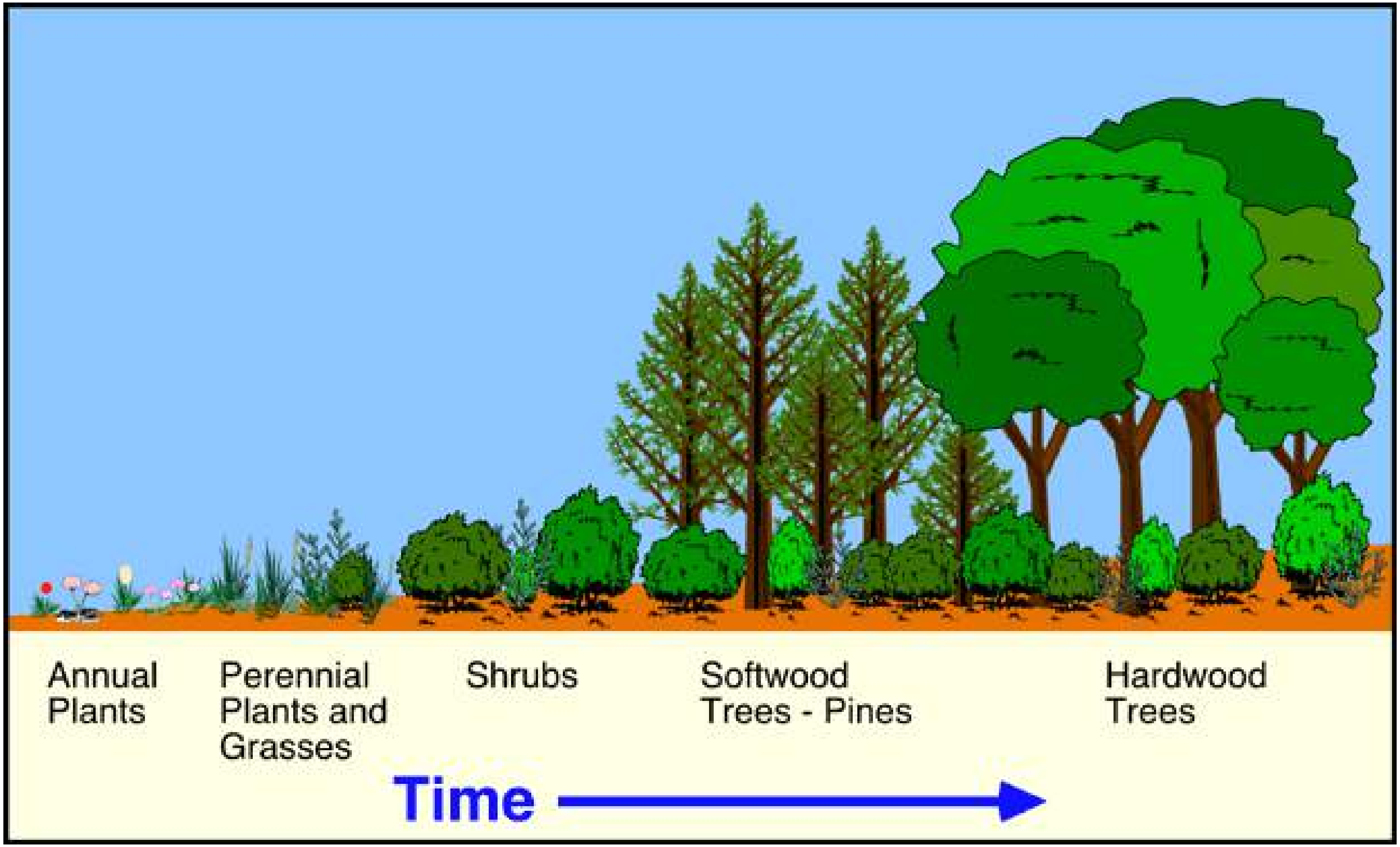
Michael Pidwirny, UBC, Okanagan, http://www.physicalgeography.net/fundamentals/images/succession.gif

Why succession occurs

Some species are fast colonizers.

Others are good competitors.

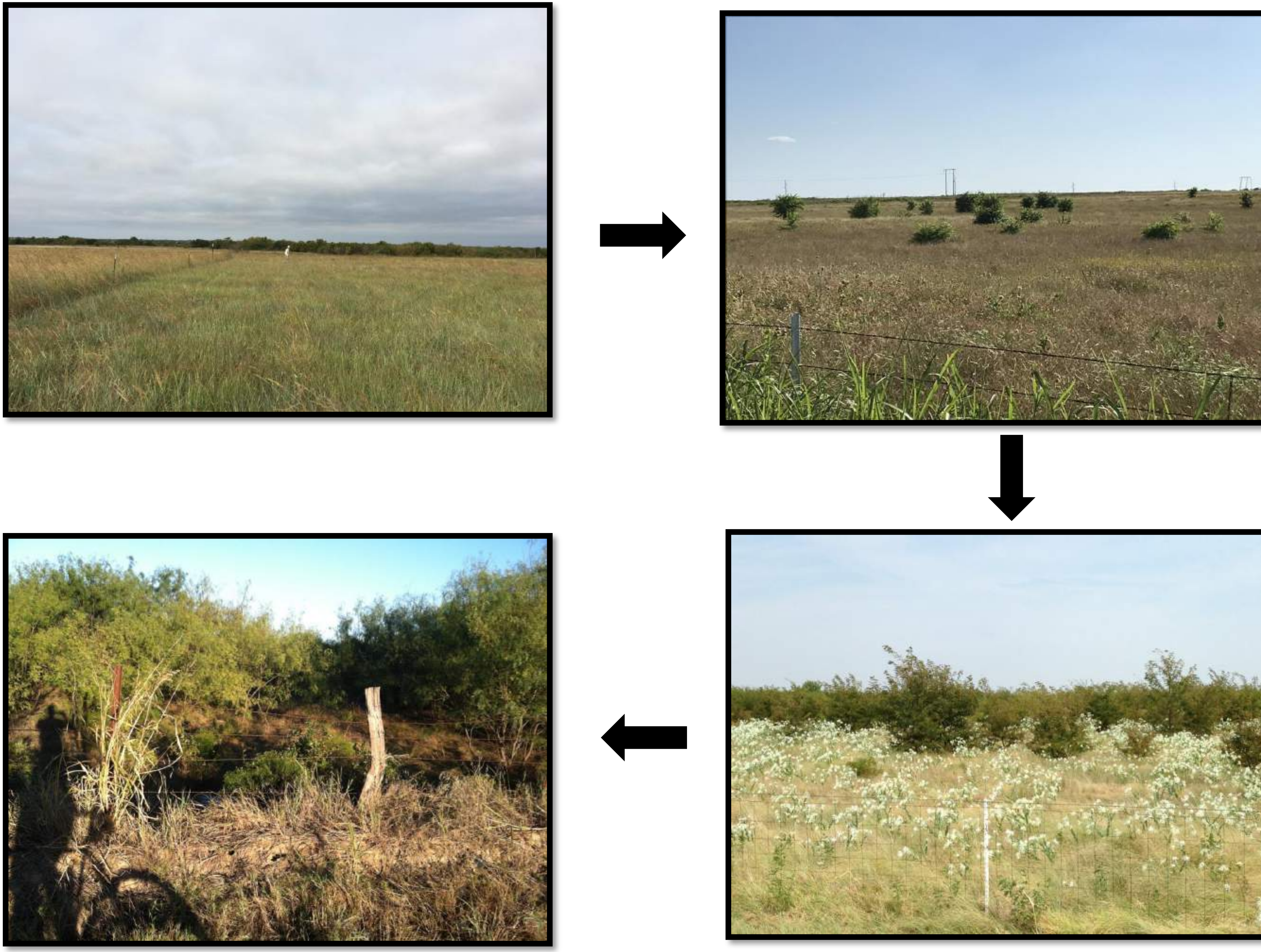
Early species change site conditions.
- sometimes facilitate colonization by later species.
- sometimes inhibit colonization by later species.



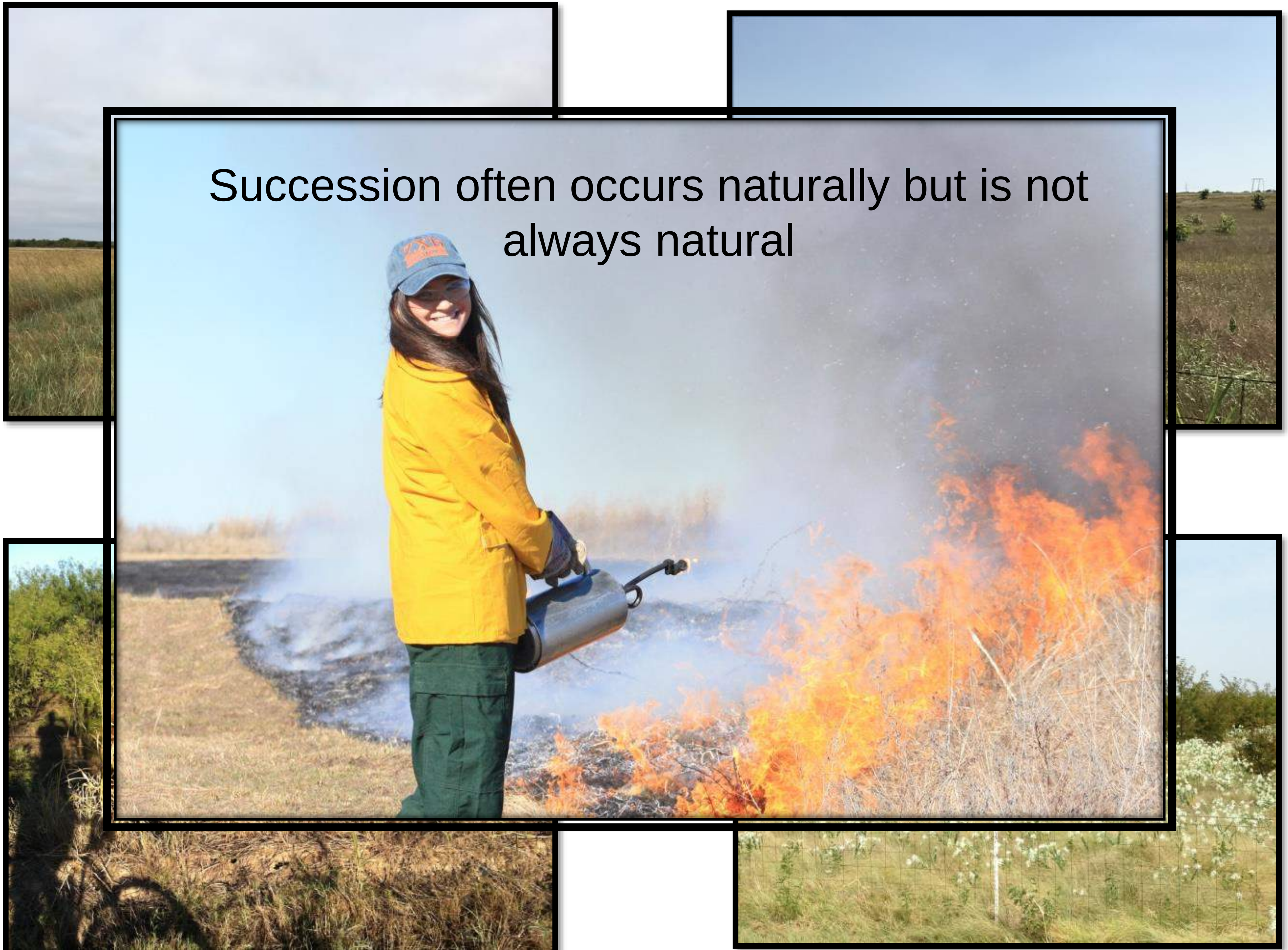
Michael Pidwirny, Associate Professor

University of British Columbia Okanagan

http://www.physicalgeography.net/fundamentals/images/succession.gif



Succession often occurs naturally but is not always natural



Community Ecology Summary

Niche requirements + species interactions result in some species but not others in any given location.

Some ecosystems are naturally more diverse than other ecosystems.

Ecosystem function declines when species diversity is reduced below the natural diversity.

Human typically decimate species diversity.

Succession can cause predictable, long-term changes in community composition.

Community Ecology

Outline

- Types of interactions among species
  - Competition
  - Predation
  - Mutualism
  - Coevolution
- Species diversity
  - How does species diversity affect ecosystem functioning?
  - Factors that reduce diversity
- Succession

Notes, studying, etc.

Kearin Ever Cook/Pratt Institute

Common difficulties reported by first-year college students

30%	Understanding what professor wants
45%	Developing effective study skills
40%	Adjusting to academic demands
61%	Managing time

College success

Spend your time intentionally (you decide how)

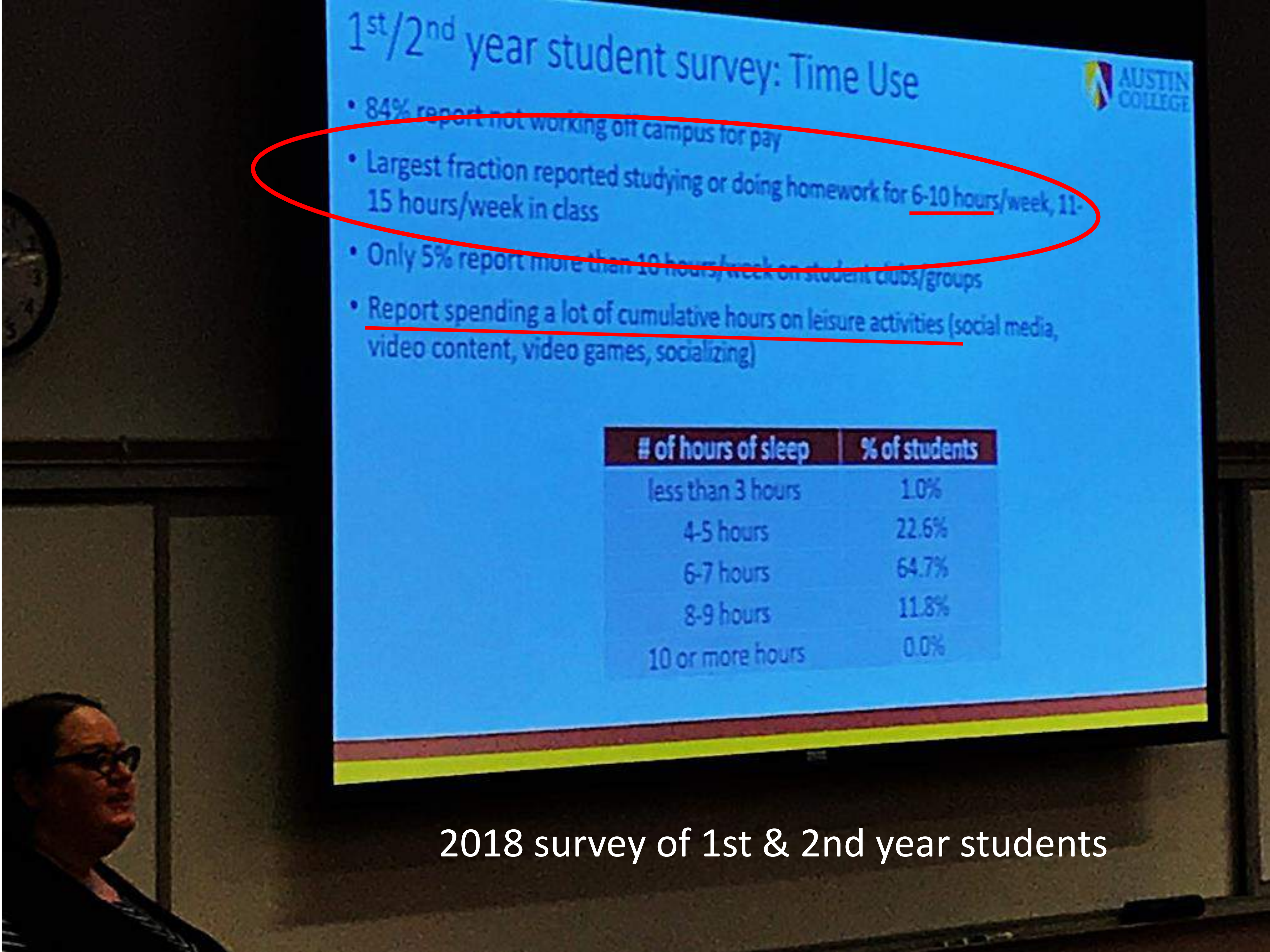
Think about what to study

Think about how you study

Why are you in this, or any other, class?

J. David Bamberger –

“The only place success comes before work is in the dictionary.”



2018 survey of 1st & 2nd year students

"Hey Helen, how many hours per week do you think you spent studying in college?"

"…. Um, about 26, no, more. At least 4 hours per weekday and 10 more on the weekend. About 30."

PCS:

3-4 per weekday, probably more

3-4 Saturday

~ 10 Sunday (most productive day)

Total: ~30.

Venn diagram

* or otherwise excel academically

Also:

$10,000/year "scholarship"

Either:

A: Someone gives the college $10,000 year every year to reduce your cost, or

B: Someone gives the college $250,000, which the college invests & then draws $10,000 from (4%) per year to cover your discount.

Either way: the donor could have done something else with the money.

PSYCHOLOGICAL SCIENCE

Research Article

Self-Discipline Outdoes IQ in Predicting Academic Performance of Adolescents

Angela L. Duckworth and Martin E.P. Seligman

Positive Psychology Center, University of Pennsylvania

Duckworth A.L. & M.E.P. Seligman, 2005, *Psychological Science*, 16:939-944.

The New York Times

ON CAMPUS

College Advice I Wish I'd Taken

By Susan Shapiro

Oct. 17, 2017

517

Kearin Ever Cook/Pratt Institute

Thomas Edison (inventor of light bulb, etc.)

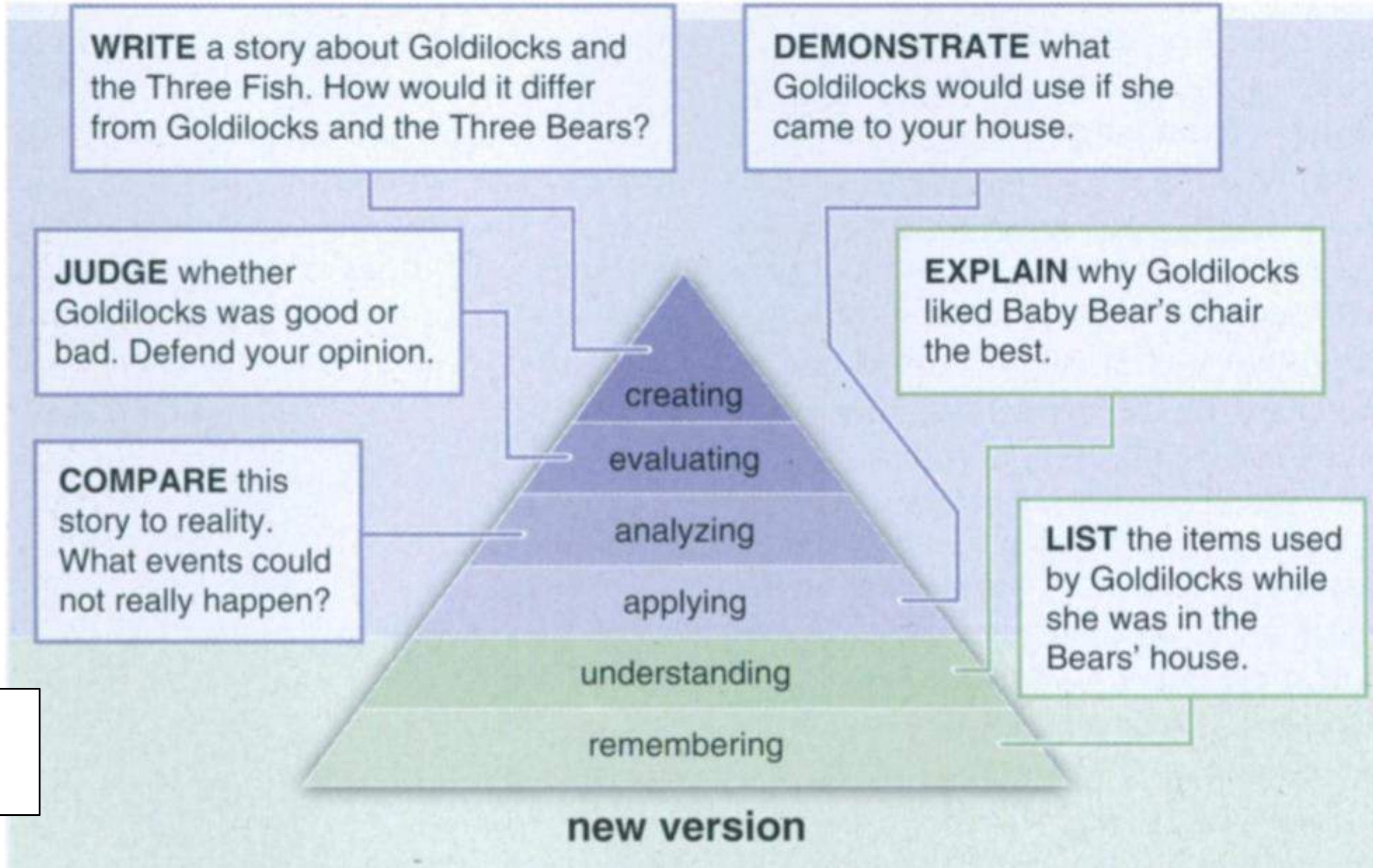
"Genius is 2% inspiration and 98% perspiration."

How do you know when you know something?

Can you explain it to someone else so that they understand it?

How do you know if you can explain it?

Memorizing is not sufficient



Bloom's Taxonomy attempts to break down learning into its levels. In its older version from the 1950s *(top)*, the steps were labeled from rote-memorization knowledge at the bottom through to evaluation at learning's highest levels. Recently the taxonomy has been revised and verbs are used to describe the levels, with the top two steps being reversed *(bottom)*. Using a simple example of how the taxonomy can be applied to "Goldilocks and the Three Bears" *(white boxes)*, students are able to understand the distinction between the levels and how to apply the taxonomy to their own learning.

Hoffman & McGuire, (2010) *American Scientist* 98: 378-382

How to take notes, improve notes, and study

<u>Before class</u>: do the day's assigned reading. Study it. Don't just skim it.

(How should you approach reading assignments?)

<u>During class</u>: expect to work hard taking notes and engaging in any discussion during the entire class period. Being in class should be hard work. Your hand should get tired.

Take notes on everything in class. Do not guess what is or is not important.

(by hand unless you cannot)

<u>After class but before next class</u>: develp your original notes and any slides into a new, improved set of notes supplemented by slides

(again, by hand unless you cannot)

As you do so, develop any incomplete explanations, writing in complete sentences & paragraphs, not bullets

But, overcome gaps in understanding before preparing improved notes.

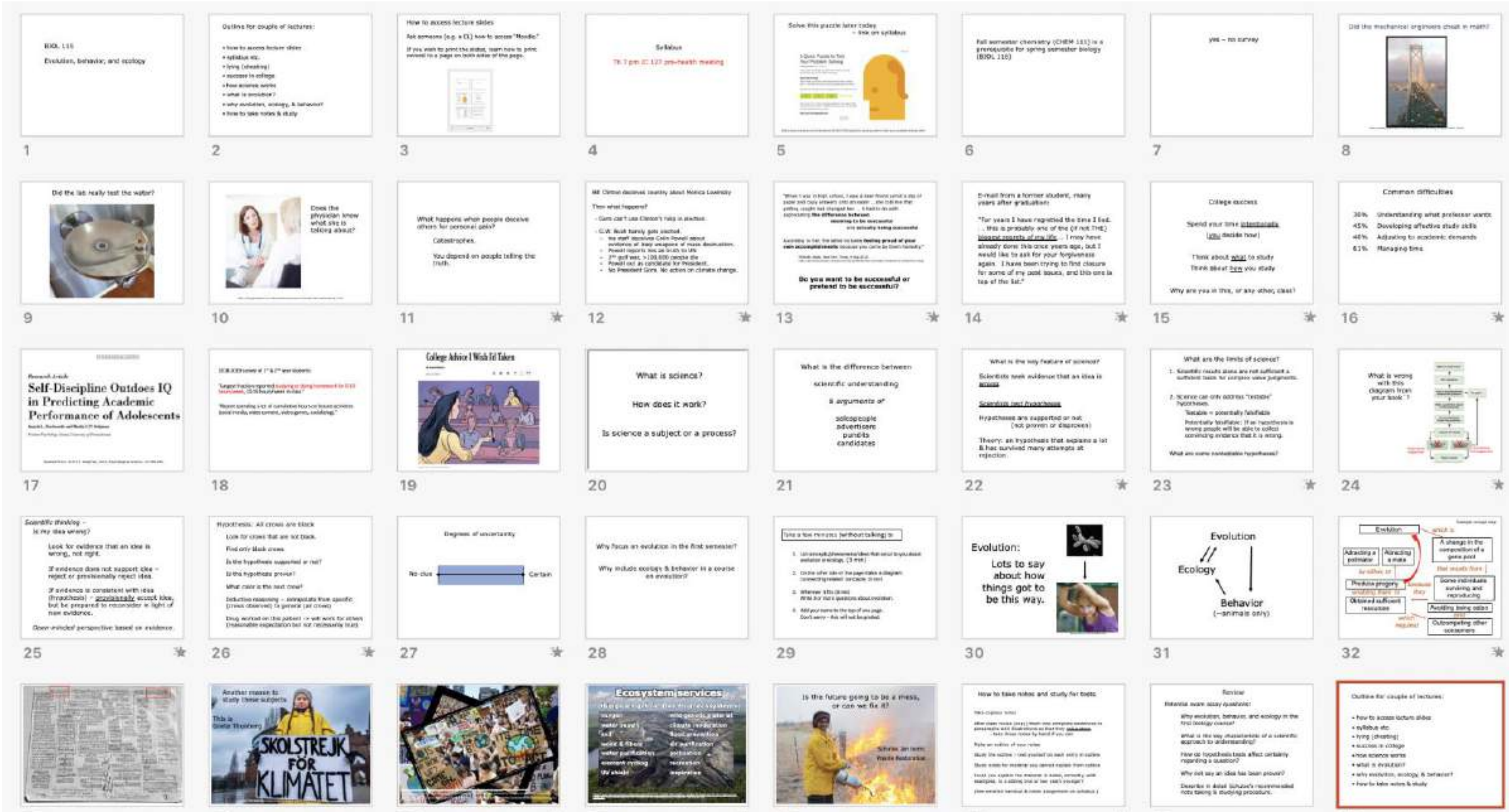
(book, classmates, instructor)

Make a bulleted <u>outline</u> of the notes.

(a list of topics and subtopics, without any explanations)

Review the outline entries, asking yourself what you can explain about each

Review the notes carefully whenever the prompt of the outline is not sufficient for you.



What was the point of each slide? (Why was it included?)
Could you explain it to a high school student?
How do the slides go together?
Why are they organized as they are?
How do they tell a story (explain things)?
Can you write those explanations?
Would you give a concert or play a sport without practicing?

Monday, September 8, 2008

Outline

I. How science works

II. Notes + Studying

III. Evolution - The Basics

- A) 3 circumstances and 2 consequences
- B) Observations of evolution in action
  1. Artificial selection
  2. Antibiotic resistance
  3. Pesticide resistance
  4. Superlice
  5. Galapagos finches
- C) Indirect evidence for evolution
  1. Galapagos finches
  2. Fossils
  3. Molecular homologies
  4. Anatomical ___
  5. ___ (to be repeated later in lecture)

Lecture Notes

I. How Science Works

Science functions by attempting to reject hypotheses - BY SEEKING EVIDENCE THAT EXPLANATIONS ARE INCORRECT, not explanations that are correct (most of the time, this is not how situations work in real life - we are used to proving that something is true)

What are the limits of science? Science can only address "potentially falsifiable" hypotheses. "Potentially falsifiable" meaning if something is wrong, people will be able to collect convincing evidence that it is indeed wrong.

Here are some example questions:

a. Question - True or False. The following is a potentially falsifiable

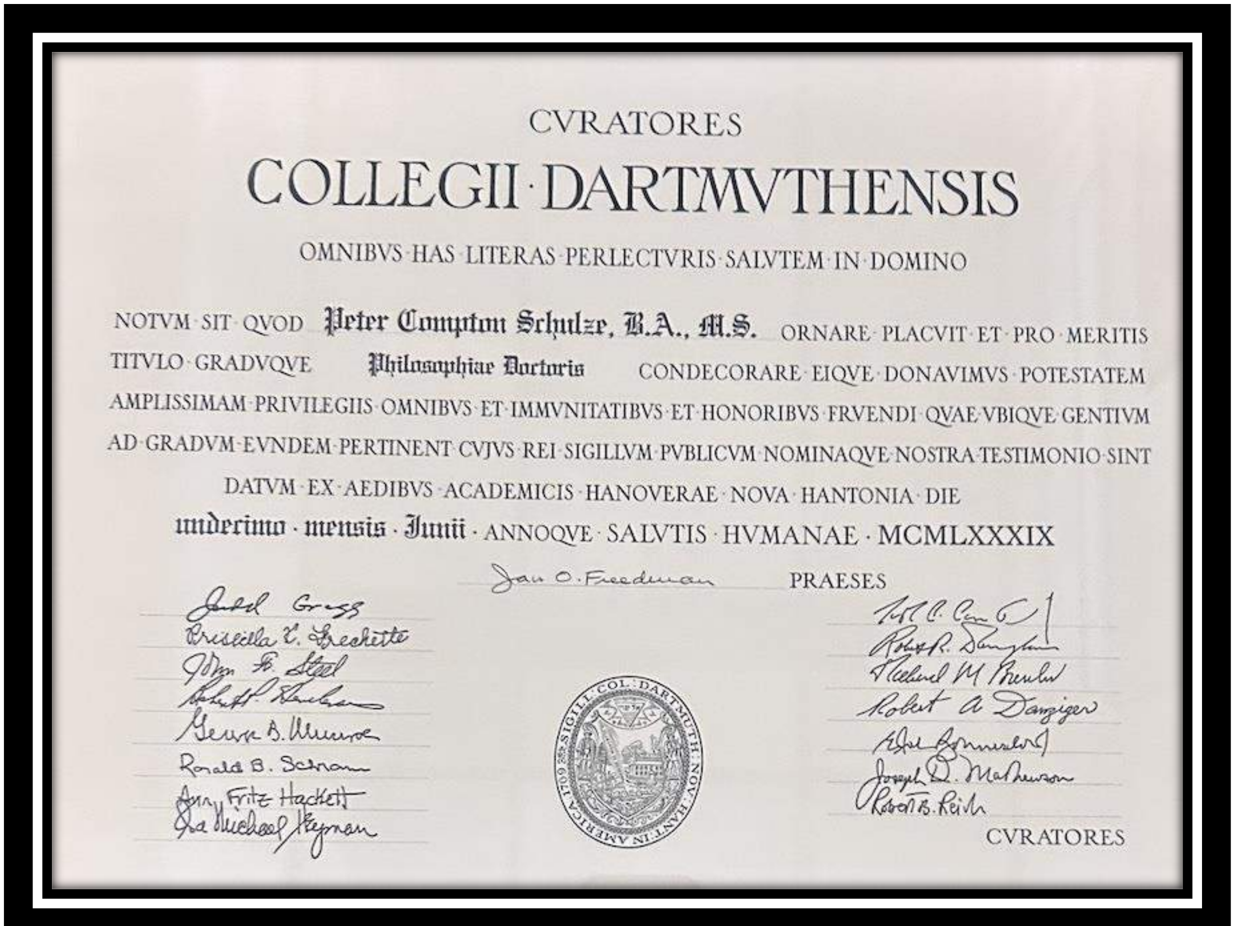
Very good notes, but even better if one outline (on separate pages) for the entire semester – to help see how topics of various days relate to tell one big story

Trust

Earned in drops, lost in buckets

yes-no survey

How much would your Austin College diploma be worth if it was widely understood that cheating is rampant here?



People conclude one president can't be trusted.

His VP can't use the former president's help with campaign

VP arguably loses that election because of no boost from former president

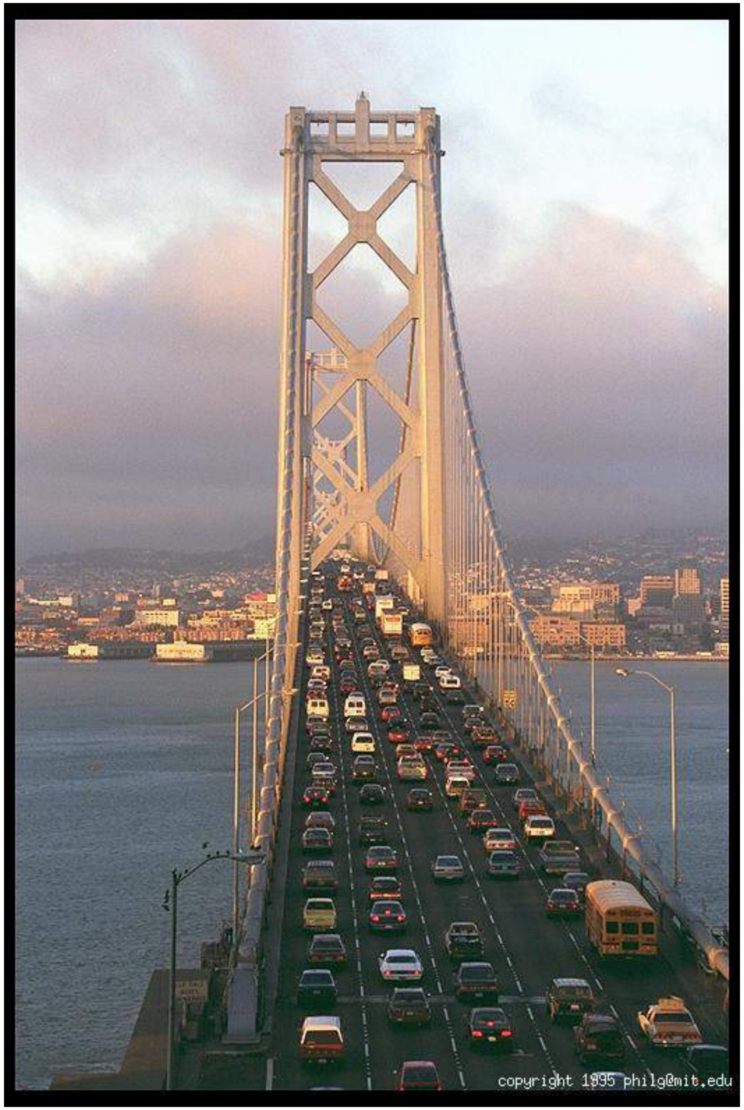
"Winning" candidate starts 2nd Iraq war (on a pretense) & does nothing about climate change

Several thousand US military personnel and perhaps as many as 500,000 Iraqis killed.

US action on climate change delayed for decades as the problem worsens

Times of Israel photo

Did the engineers cheat in math?



http://philip.greenspun.com/images/pcd1359/bay-bridge-traffic-18.tcl

Did the lab really test the water?

Does she know what she is talking about?

http://blogs.einstein.yu.edu/teaching-doctors-to-break-bad-news-part-2-of-2/

You depend on people telling the truth.

E-mail from a former student, many years after graduation:

“For years I have regretted the time I lied. . . this is probably one of the (if not THE) biggest regrets of my life.... I may have already done this once years ago, but I would like to ask for your forgiveness again. I have been trying to find closure for some of my past issues, and this one is top of the list.”

Two options for people, including you and me:

Deceive others for personal gain or not.

Civilization hangs in the balance.

You get (have) to make your own choice.

This isn’t high school anymore.

Answers to the question:

What is evolution and how does it work?

(Actual answers from Bio 115 exams)

Precisely correct:

Evolution is a change in the composition of a gene pool.*

Evolution results from natural & artificial selection, processes that cause some individuals to leave more offspring than other individuals. Individuals that happen to be best suited to their environment (or favored by human actions) tend to leave the most offspring. This process is called natural selection when it is a result of natural processes and artificial selection when it is driven by human actions. When some individuals leave more offspring than others, the composition of the population's gene pool changes.

*Gene pool: all the genes in a population[#].

[#]Population: a group of members of the same species with opportunities to interbreed.

When you write an answer that includes a technical term from the class, define the term to demonstrate you know the term's meaning.

Could you have written this answer? If not, why not?

What is evolution and how does it work?

“Evolution is the development of all aspects of nature and how things change and adapt over time. Some things that affect how evolution happens are natural selection and predators.”

What does the writer mean by “all aspects of nature?”

What “things” does the writer have in mind?

What is “natural selection?”

About 25% credit.

~~Evolution is a theory. The easiest way to explain this theory is that~~ humans were all once monkeys and later evolved into humans. The way it works is that an animal goes through a series of slow changes, but later evolves into a different animal or creature.

The struckthrough text does not address the question.

An (erroneous) example is not a definition (humans were not monkeys). “The way it works” does not really explain the way it works? What causes the series of changes?

Maybe 10% credit (for ‘series of slow changes’)

To some, evolution is a simply amazing way to explain how and why we exist in the world today. I see it as rather, an amazingly simple explanation instead. While it is true that the results of evolution are nothing less than astounding; one need only to look at how it works, to be mystified over its simplicity. Evolution is the result of many micro changes."

Total BS. Zero credit.

Evolution is how life has changed over time. Life changes so it can survive.

If you knew nothing about evolution would this definition help you understand it?

The second sentence is a common view but is wrong.

The answer does not address the question of how evolution works.

Maybe 25% credit.

The growth and change of any species through adaptation.

This answer is not a bad start, but the meaning of key terms is unclear (the writer requires the reader to insert definitions of key terms), and the writer does not attempt to explain how evolution works.

What does the writer mean by growth? What is an adaptation?

How does adaptation work?

Explain your reasoning. Finish your thoughts.

About 50% credit.

Evolution is the process of continuous change throughout the ecosystem.

Too vague for credit.

Change in what?

No attempt to explain how evolution works.

Zero credit.

Evolution occurs when environments change, climates alter or an unpredicted predator appears. Animals must change and adapt the best way to survive by gaining/losing certain characteristics.

The first sentence is correct but does not address the question.

Evolution never defined.

Not all creatures are animals.

Must change or what? Changes are not necessarily or even often “best.” What does the writer mean by “adapt”? Evolution does not occur because species must change.

About 25% credit.

Development of a living organism throughout time. As resources around [a] living organism change [evolution occurs].

What does “development” mean? (In biology, development normally refers to growth and maturation of an individual.

The second sentence states one factor that may cause evolution, but does not explain how the change occurs.

Write complete sentences.

About 25% credit.

Evolution is the study of all living things and how they connect with each other and how they evolve or transform over time. Through research and studying, scientists learn how evolution works. Evolution is important because it allows us not only to learn about the species around us, but of ourselves as well. The study of evolution is vital to our species because our past allows us to create our present.

Evolution is not a “study.”

Do not use the root of a word (evolve) to define the word (evolution).

“…how they connect with each other…” is too vague to be instructive.

The last 3 sentences are true but do not address the question.

Think before writing. Do not blindly write about the general topic. Read the question carefully and answer the question asked.

Zero credit.

Question: Explain the example of the three-spined stickleback. Describe the relevant information and interpret that information in the context of topics covered so far in this class.

Very good answer: **“**Three-spined sticklebacks in the Pacific Ocean have armor-like covering. The fish migrate up streams to spawn. Some fish have colonized freshwater lakes. The populations in lakes lose their armor but are more maneuverable than the armored, marine fish. The armor is an effective defense against marine (ocean) predators, but maneuverability is more valuable against freshwater predators. In other words, armored fish leave more offspring in the ocean but maneuverable fish without armor leave more offspring in lakes. Thus, natural selection has selected for different morphologies in the different habitats.”

Question: Explain the example of the three-spined stickleback. Describe the relevant information and interpret that information in the context of topics covered so far in this class.

Solid answer, full credit: "The three-spined stickleback is a fish prevalent in the Pacific Northwest. In the ocean this fish has thick scales and a large dorsal fin that serve as protection from predators. However, in freshwater lake environments, this organism has reduced armor and smaller dorsal fins which allow it to be faster and hide better in various parts of the lake. It has been noticed that these changes occur within 10 years of a switch in environment. This is a fascinating organism because it responds very quickly to its environment and evolves to accommodate these changes. Natural selection allows the fishes with the appropriate genes for the ocean / lake to survive the longest and thus reproduce, carrying that gene into the next generation."

Question: Explain the example of the three-spined stickleback. Describe the relevant information and interpret that information in the context of topics covered so far in this class.

½ Credit Answer: "The three-spined stickleback in different environments has adapted ~~to better survive~~. For example, when there are larger fish, evolution has created a stickleback fish that has armor ~~so~~ that ~~it~~ has a better chance of survival. Whereas, when there are faster prey the armor is no longer existent in order to allow quick turns in water. The stickleback fish also has sharp spines facing towards the back so that a predator could not sneak behind them and eat them, which allows it to see predators head on or in its peripheral vision giving it time to swim away which is an adaptable change."

Why didn't this answer receive full credit? What is wrong with the struck-through material?

Question: Explain the example of the three-spined stickleback. Describe the relevant information and interpret that information in the context of topics covered so far in this class.

½ Credit Answer: "The fish have been losing their characteristics by each generation due to natural selection. For instance, they used to be fully armored but now their armor slightly since it was waste of their energy."

Why didn't this answer receive full credit?

When writing exam essays:

Think before beginning to write.

Make notes about your answer before writing if the answer will be long.

Answer all parts of the question.

Define any terms that you use in your answer that were taught in the course (that are not common knowledge).

Avoid vague terms.

Review your answer to ensure it says what you mean and explains your reasoning.

Don’t find yourself pondering a question for the first time. Anticipate questions and practice answering them while preparing for the exam.

Science

How Science Works

What is the point of the puzzle?

SHARE

A Quick Puzzle to Test Your Problem Solving

By DAVID LEONHARDT and YOU JULY 2, 2015

A short game sheds light on government policy, corporate America and why no one likes to be wrong.

Here's how it works:

We've chosen a rule that some sequences of three numbers obey — and some do not. Your job is to guess what the rule is.

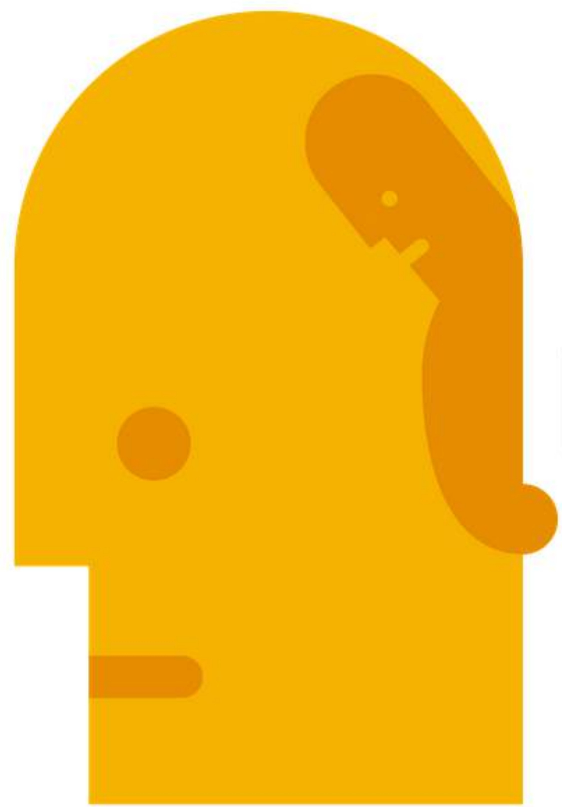
We'll start by telling you that the sequence 2, 4, 8 obeys the rule:

2	4	8	**Obeys the rule**

Now it's your turn. Enter a number sequence in the boxes below, and we'll tell you whether it satisfies the rule or not. You can test as many sequences as you want.

Enter your first sequence here:

			Check



http://www.nytimes.com/interactive/2015/07/03/upshot/a-quick-puzzle-to-test-your-problem-solving.html

What is science?

How does it work?

Is science a subject or a process?

What is the difference between

scientific understanding

& arguments of

salespeople
advertisers
pundits
candidates

What is the key feature of science?

Scientists seek evidence that an idea is wrong.

Scientists test hypotheses

Hypotheses are supported or not (not proven or disproven)

Theory: an hypothesis that:

(i) explains a lot &

(ii) has survived many attempts at rejection.

What are the limits of science?

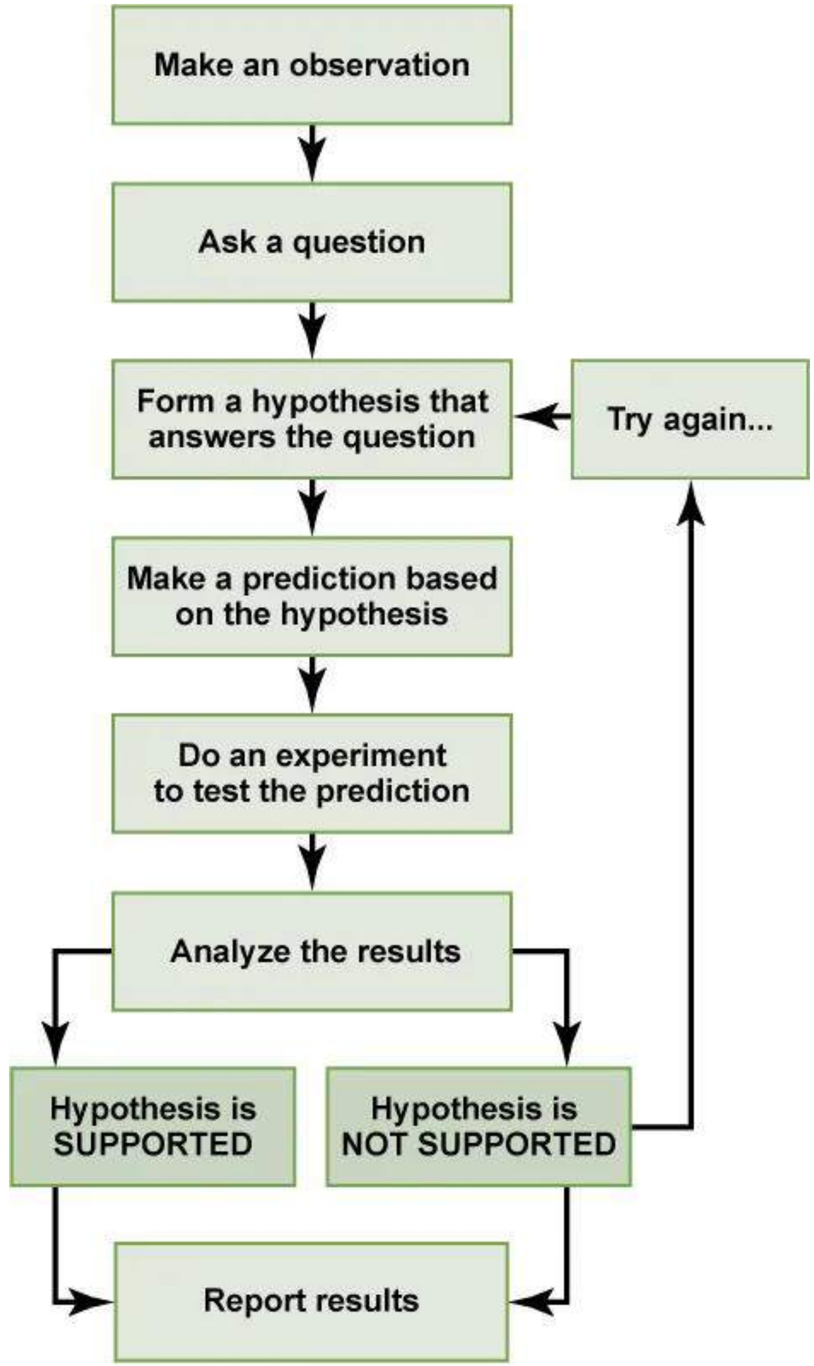
1. Scientific results alone are not a sufficient basis for value judgments. What should we do?

2. Science can only address “testable” hypotheses.

   Testable = *potentially* falsifiable

   Potentially falsifiable: If an hypothesis is wrong, people will be able to collect convincing evidence that it is wrong.

What are some non-testable hypotheses?


Make an observation
Ask a question
Form a hypothesis that answers the question
Try again...
Make a prediction based on the hypothesis
Do an experiment to test the prediction
Analyze the results
Hypothesis is SUPPORTED
Hypothesis is NOT SUPPORTED
Report results

Scientific thinking –

Is my idea (hypothesis) wrong?

Look for evidence that an idea is wrong, not right.

If evidence does not support idea: reject or provisionally reject idea.

If evidence is consistent with idea, then provisionally accept idea (hypothesis), but be prepared to reconsider in light of new evidence.

Open-minded perspective based on *evidence*.

Hypothesis: All crows are black

Look for crows that are *not* black.

Find only black crows.

Is the hypothesis supported or not?

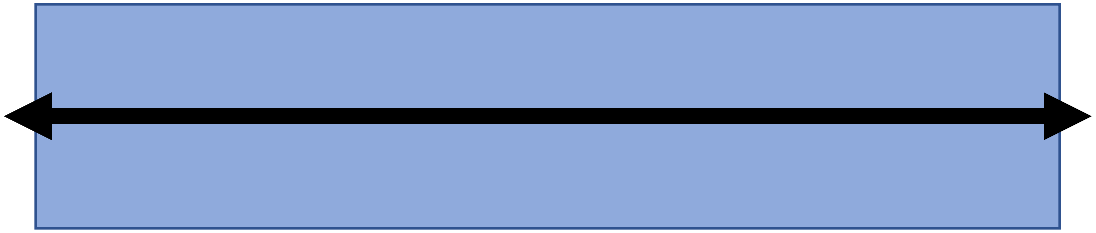
Is the hypothesis proven?

Do you know the color of the next crow you will see?
Can you predict its color?

Science is based on inductive reasoning – extrapolating from specific (crows observed) to general (all crows)

Drug worked on this patient -> will it work for others
(Reasonable expectation but not necessarily true)

Degrees of uncertainty

No clue  Certain

Questions about what science is or how it works?

Statistics

What are statistics?

What are they good for?

What are their limitations?

Critical Thinking

(from Paul & Elder's pamphlet, http://www.criticalthinking.org/)*

A critical thinker:

- raises vital questions & problems, formulating them clearly and precisely:
- gathers and assesses relevant information [data], using abstract ideas [hypotheses & theories] to <u>interpret them effectively</u>;
- <u>comes to well-reasoned [defensible] conclusions and solutions, testing them against relevant criteria and standards</u>;
- thinks openmindedly within alternative systems of thought, recognizing and assessing, as need be, assumptions, implications, and practical consequences; and
- communicates effectively with others in figuring out solutions to complex problems.

Statistical tests are helpful here

*Note: pdf of pamphlet is online at this web address, but I am not sure whoever loaded it to the internet had the authors' permission to do so. http://think.hanover.edu/Resources/MiniGuidetoCT.pdf)

Descriptive vs. Experimental Statistics

Descriptive statistics merely describe data

e.g. Mean
Standard deviation
Variance
Sample size (n)

Experimental statistics test for the statistical significance of a relationship among variables.

e.g. Regression
Analysis of Variance
Chi-square test
Kruskal-Wallis test
Paired t-test

2 categories of experiments

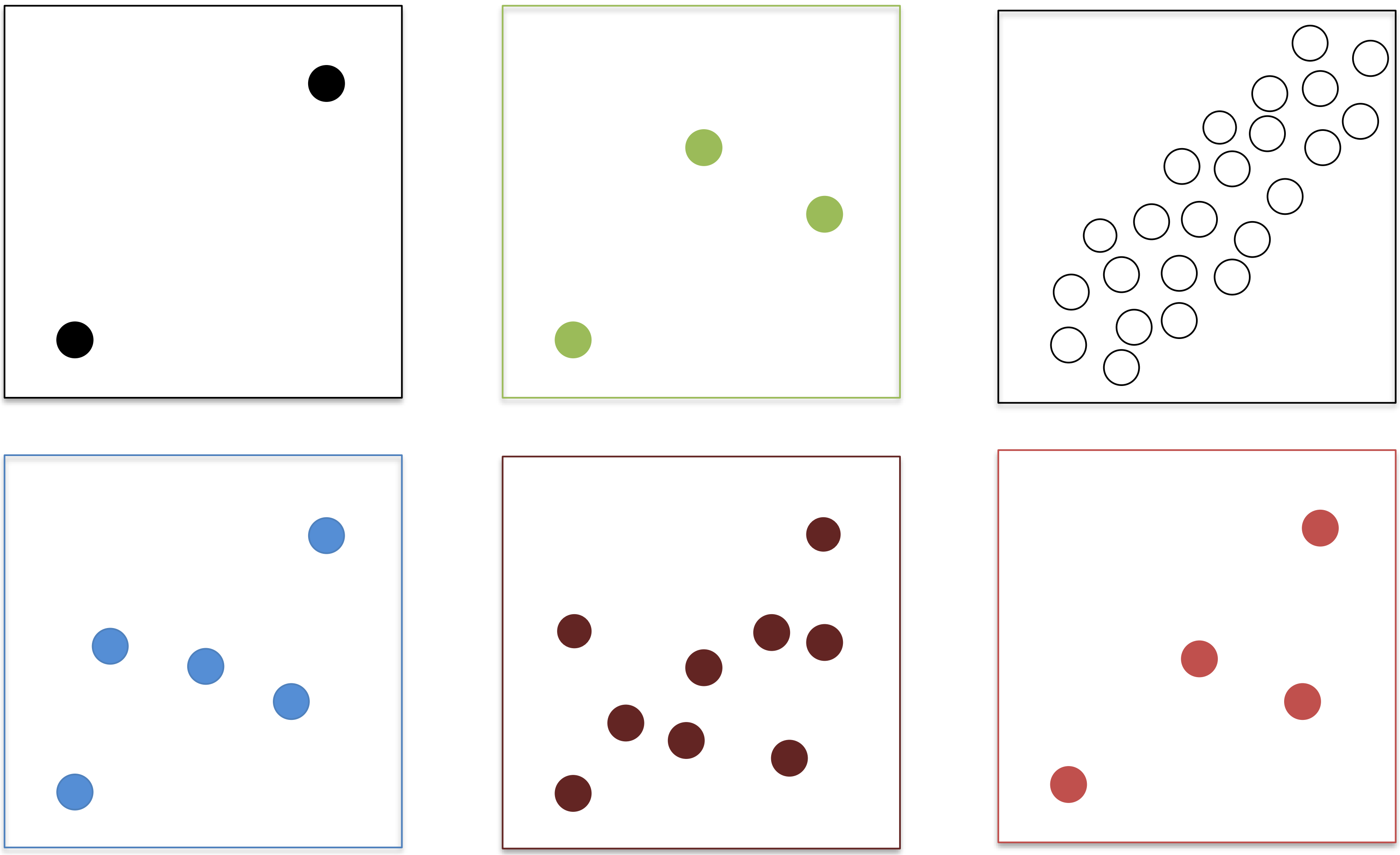
- Experiments with highly repeatable results

  No need for statistical tests here

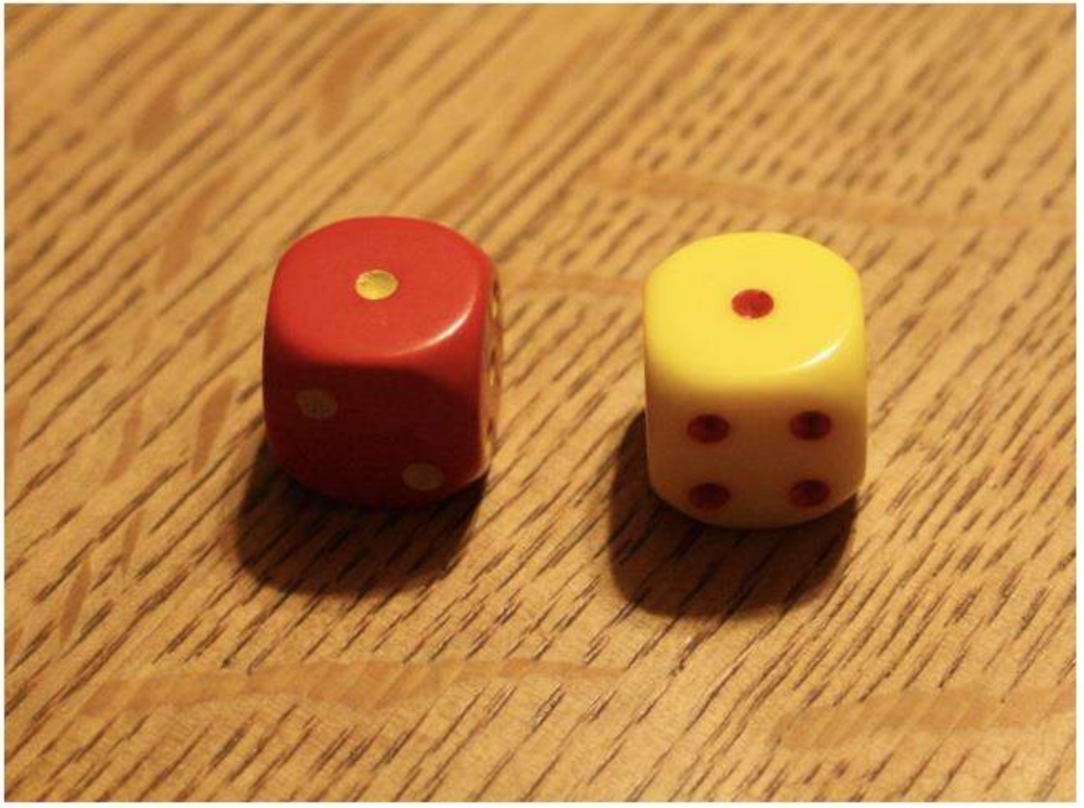
- Experiments with substantial replicate-to-replicate variation within treatments

  Statistical tests are useful here

Experimental statistics test for quantitative evidence of relationships among variables



All conventional statistical tests calculate the likelihood of obtaining as pronounced a pattern in data on the basis of chance alone.



Statistical tests compute a ‘p-value’

p-value =

the probability of obtaining at least as pronounced a pattern in data on the basis of random variation.

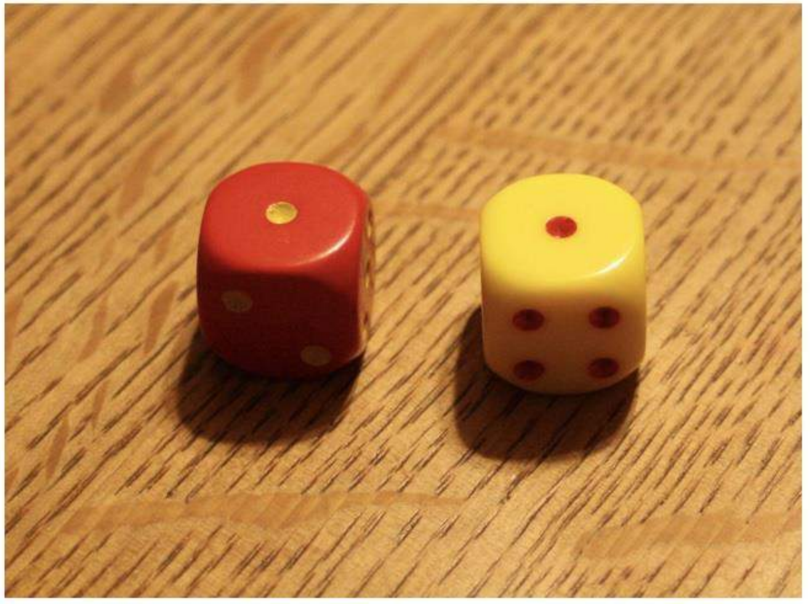
(Time to roll dice & discuss results)

p-value is **not**

The probability that the data are due to chance.

What is wrong with this statement?

P-values is the probability that the data are due to chance.



P-value definition (again)

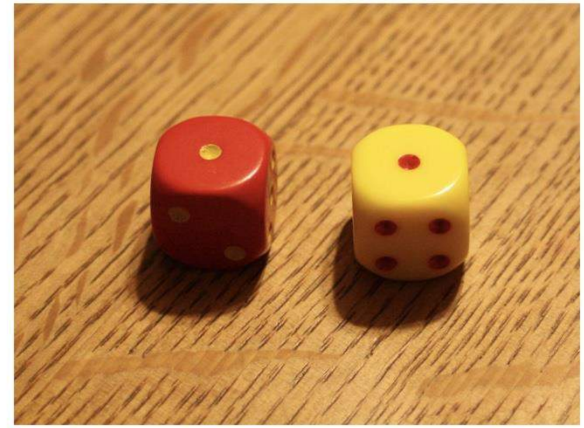
The probability of obtaining at least as pronounced a pattern in data on the basis of random variation.

Chance of 2 ones: $p = (1/6)(1/6) = 1/36 = 0.028$

1. Unlikely events occur randomly, but statistical tests will suggest unlikely random data are consistent with the hypothesis of one variable affecting another. These are termed ‘type I’ statistical errors.

2. Experiments cannot always detect effects of treatments
- too few replicates
- measurements not sufficiently precise
- too much noise (uncontrolled independent variables)
- too little time for effect to occur
- p-value cutoff guarantees many “type II” errors

The limitations of statistics



Type 1 error (false positive)

Incorrect conclusion that variables are associated ($p < 0.05$ but actually random) (dice rolled but conclude they were placed)

Type II error (false negative)

Failure to detect that variables are associated ($p > 0.05$ but variables related) (dice placed but determine insufficient evidence to conclude that)

If $p > 0.05$ conclude, “No evidence of a relationship,” not, “No relationship.”

If $p < 0.05$ conclude, “…consistent with the hypothesis that independent variable affects the dependent variable (not ”proof”).

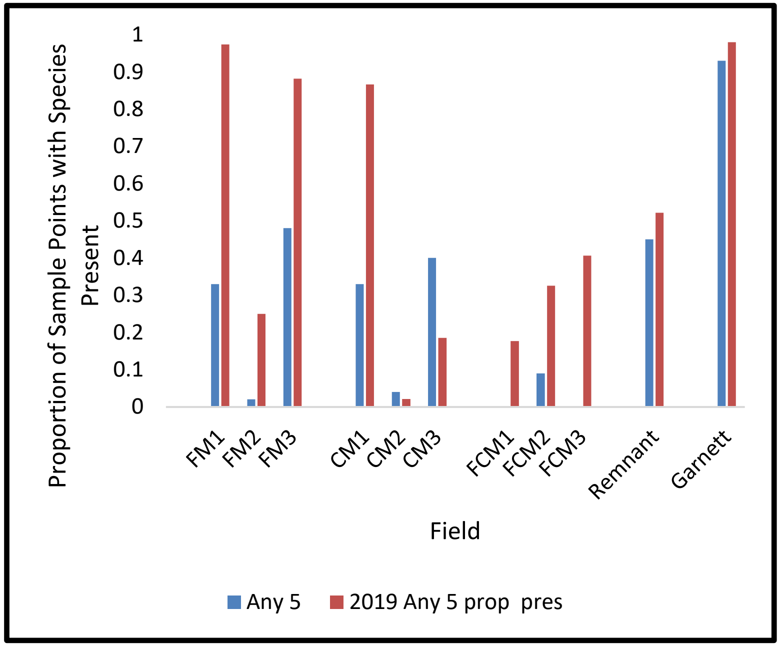
Statistics

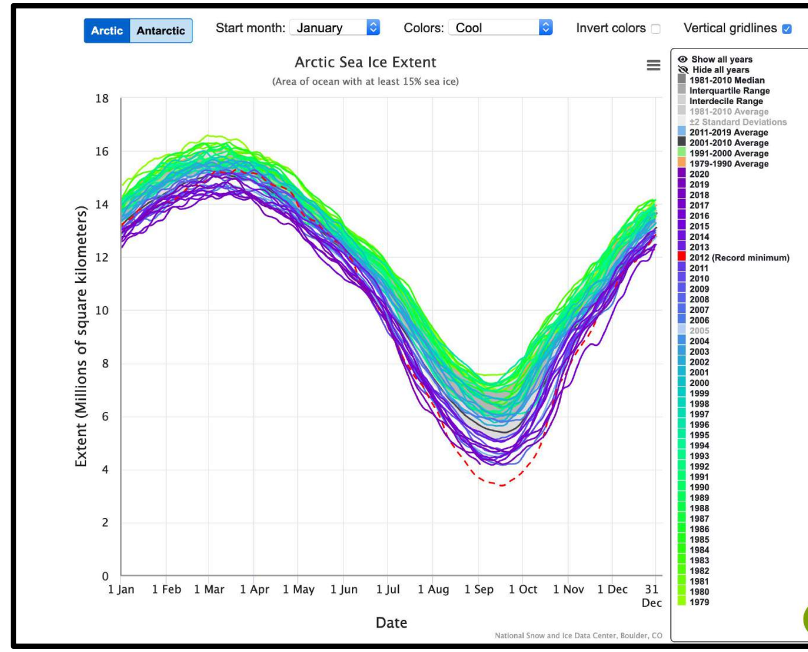
What are experimental statistics?

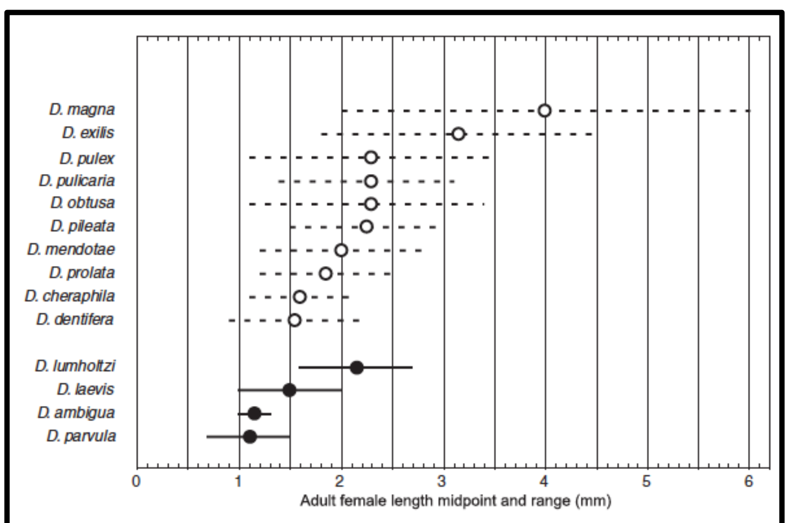
What are they good for?

What are their limitations?

The key step in analyzing data: Describing results







Purpose:

Provide you a systematic method for identifying noteworthy features of data.

Organization of a pre-publication version of a scientific article (and of lab reports)

- An informative (not merely cute or clever) **title**
- Author name(s), date, organization (if not obvious)
- **Introduction**

  Question and why the question is of interest (context).
- **Methods**

  So others can evaluate their appropriateness and potential repeat the study.
- **Results**

  Text description of notable features of results, with references to tables and figures.
- **Discussion**

  Analysis of the relevance of the results to the motivating question and its larger context.
- Tables (if any)
- **Figures**
- Acknowledgments (everyone who helped – except the instructor)
- References (if any)

What vs. why (results vs. discussion)

What (results)

a description of the data

So what (discussion)

the relevance of the data to the larger context, including potential (speculative) explanations for both expected and surprising features of the data, and articulation of new hypotheses.

Describing Results

Purpose:

1. Learn a systematic approach to identifying notable features of results.

2. Practice making defensible statements *and* not making indefensible statements (writing nuanced, correct descriptions & conclusions).

The 3 features of data to describe in results sections of laboratory reports

1. Magnitudes and ranges of measurements

2. Obvious or statistically significant patterns in data
   (patterns that can't easily be attributed to random variation)

3. Any surprising or otherwise noteworthy features of data [such as a lack patterns, apparent "outliers" (be reluctant to attribute these to unidentified errors), or unanticipated observations.]

Do not waste the reader's time with arguable or statistically non-significant "trends" because even random data always have "trends".)

Carefully distinguish certain (definitive) statements from speculation based upon inference from what is known to related matters.

Both of the following statements are definitive (they leave no question). *One is fine. The other is not. Which is which and why?*

> “The patient’s second blood pressure measurement was higher than their first measurement.”
>
> “The patient’s blood pressure increased.”

Figures (graphs) usually plot an independent variable on the X axis (a manipulated variable whose effect is measured) vs. a dependent variable on the Y axis (a variable whose value may depend on the independent variable.

Dependent variable

Independent variable

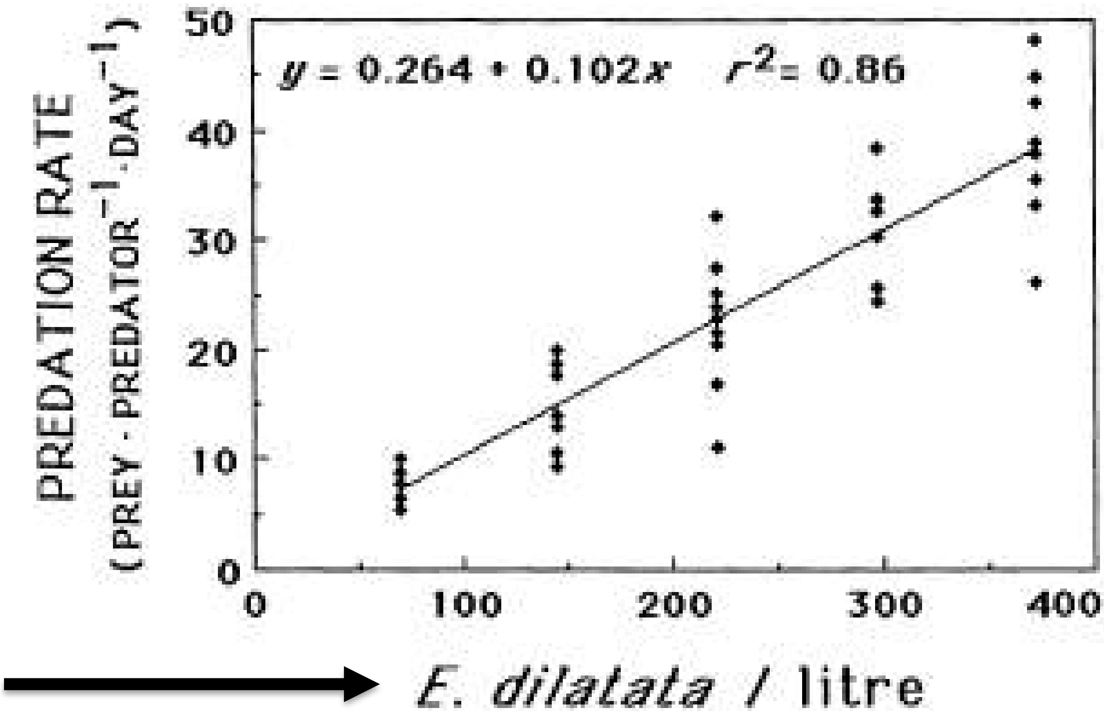


FIG. 12. The effect of initial prey (*Euchlanis*) density on the *Epischura* predation rate. A minimum of 11 replicates were included at each initial prey density (several points are overlapping on the figure). The line and the equation represent the linear regression fit to the data. This experiment was performed on 9 September 1987.

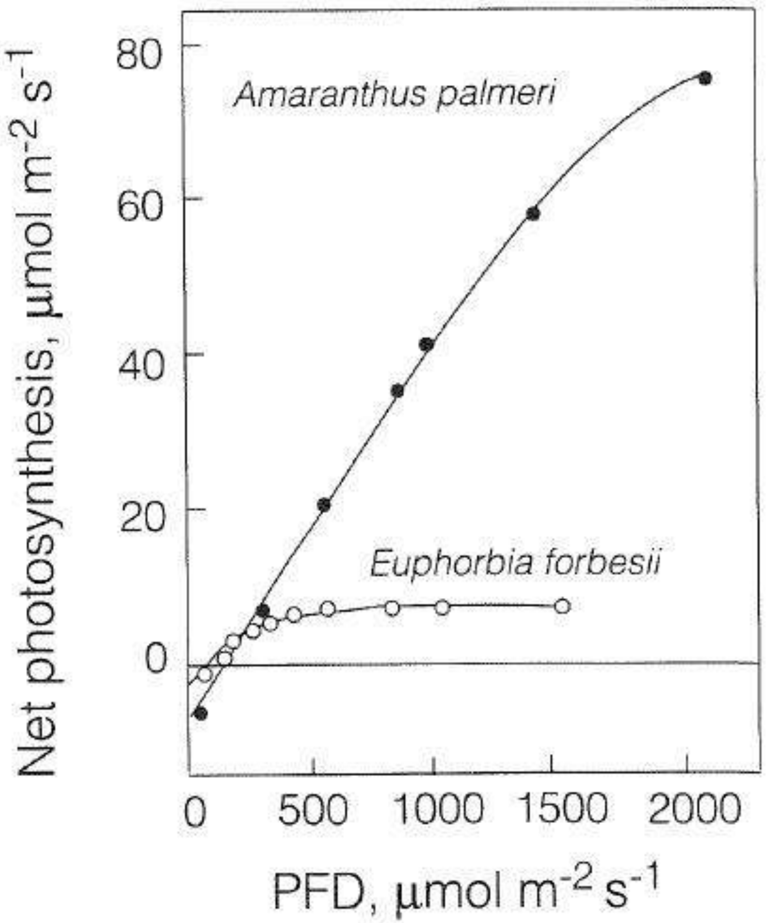
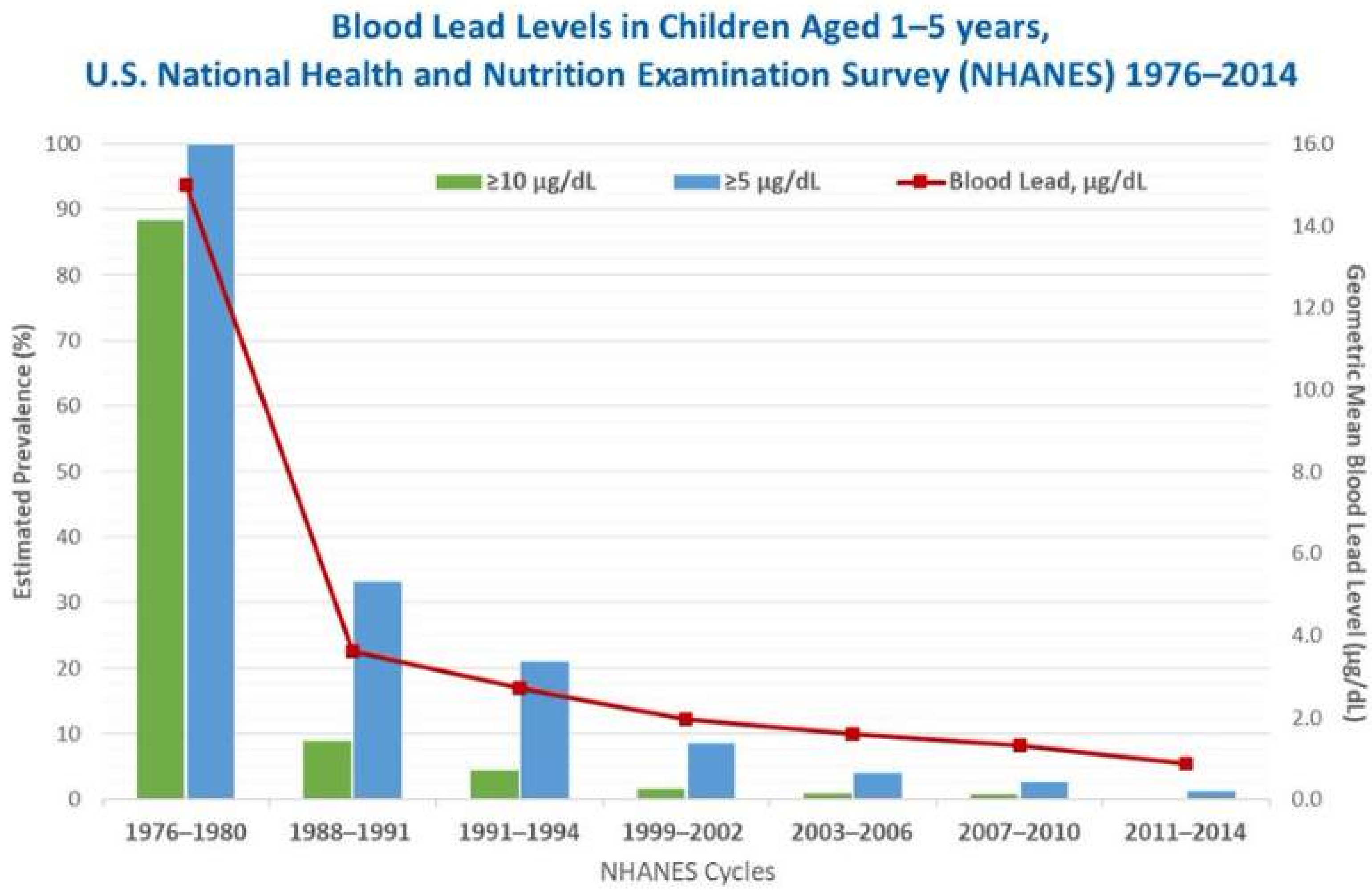
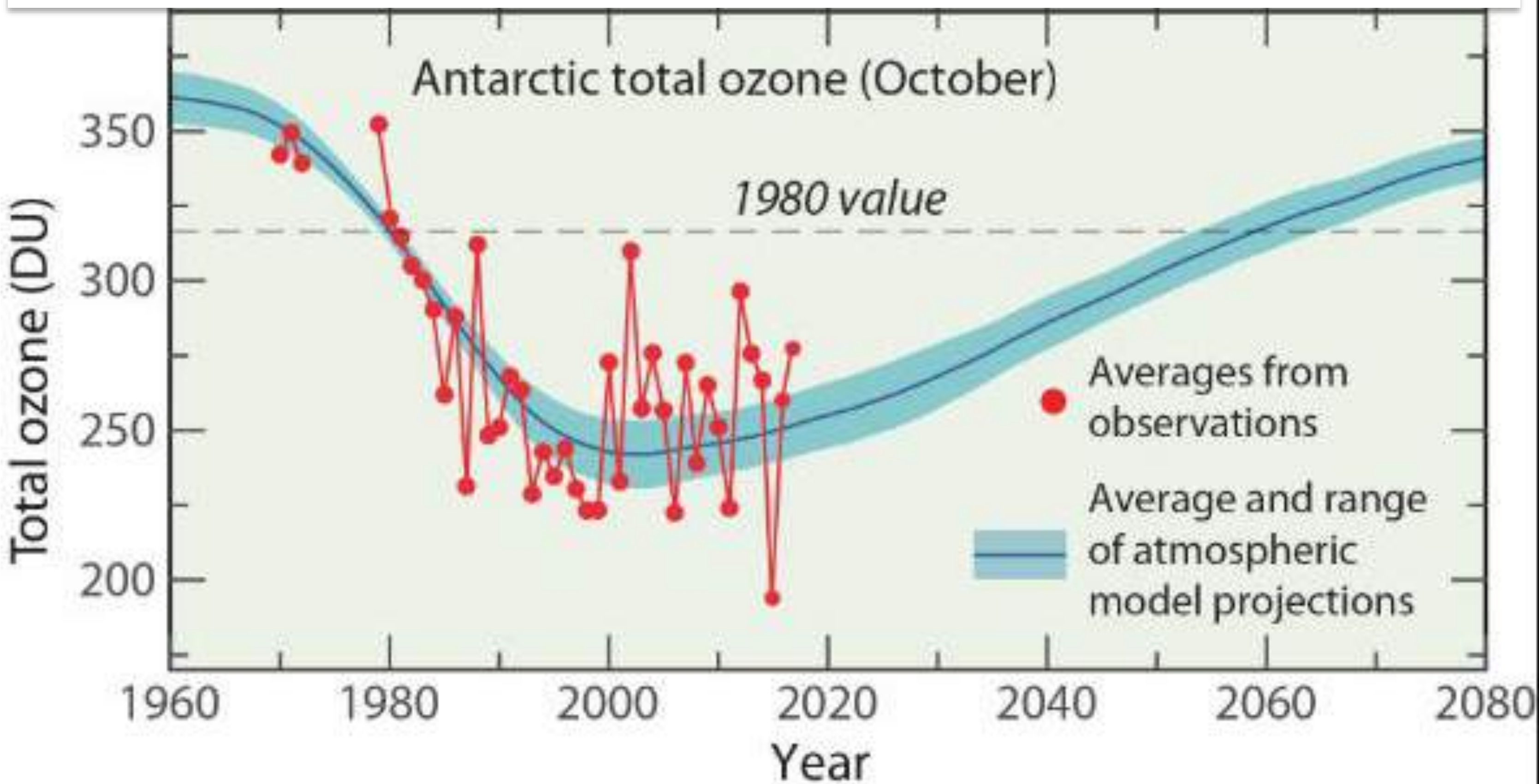


FIGURE 3.2 The response of photosynthesis (as measured by carbon dioxide fixation rate) to changes in the sunlight (photon fluxdensity, PFD) for two C_4 species adapted to different light conditions. *Amaranthus palmeri* is a desert annual, adapted to high-light environments. *Euphorbia forbesii* is a shade-adapted species from the forests of Hawaii. Note the correlation between maximum photosynthetic rate and sunlight level at which photosynthesis saturates. Modified from Pearcy and Ehleringer (1984).

Ehlinger and Sandquist p. 43-58 in Falk et al. Foundations of Restoration Ecology


Blood Lead Levels in Children Aged 1–5 years,
U.S. National Health and Nutrition Examination Survey (NHANES) 1976–2014
≥10 µg/dL
≥5 µg/dL
Blood Lead, µg/dL
Estimated Prevalence (%)
Geometric Mean Blood Lead Level (µg/dL)
0
10
20
30
40
50
60
70
80
90
100
0.0
2.0
4.0
6.0
8.0
10.0
12.0
14.0
16.0
1976–1980
1988–1991
1991–1994
1999–2002
2003–2006
2007–2010
2011–2014
NHANES Cycles



Antarctic total ozone (October)
1980 value
Total ozone (DU)
350
300
250
200
1960
1980
2000
2020
2040
2060
2080
Year
Averages from observations
Average and range of atmospheric model projections

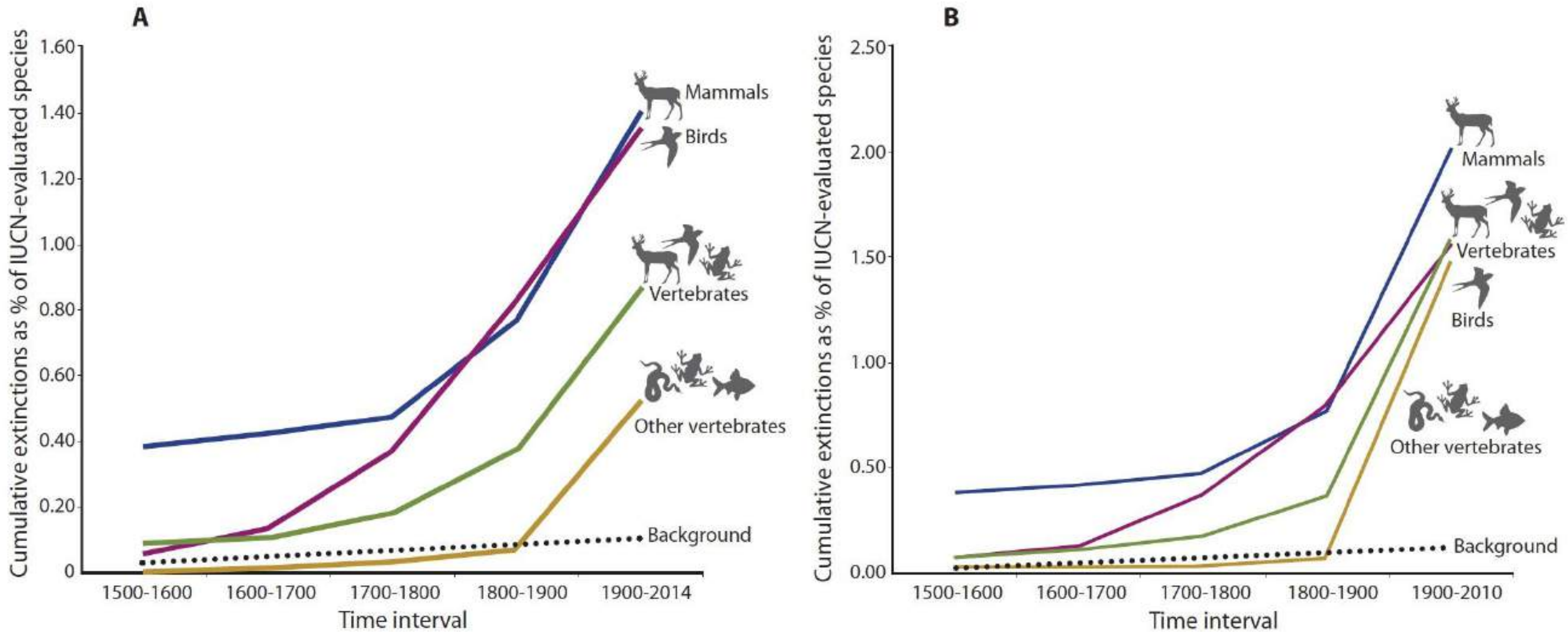
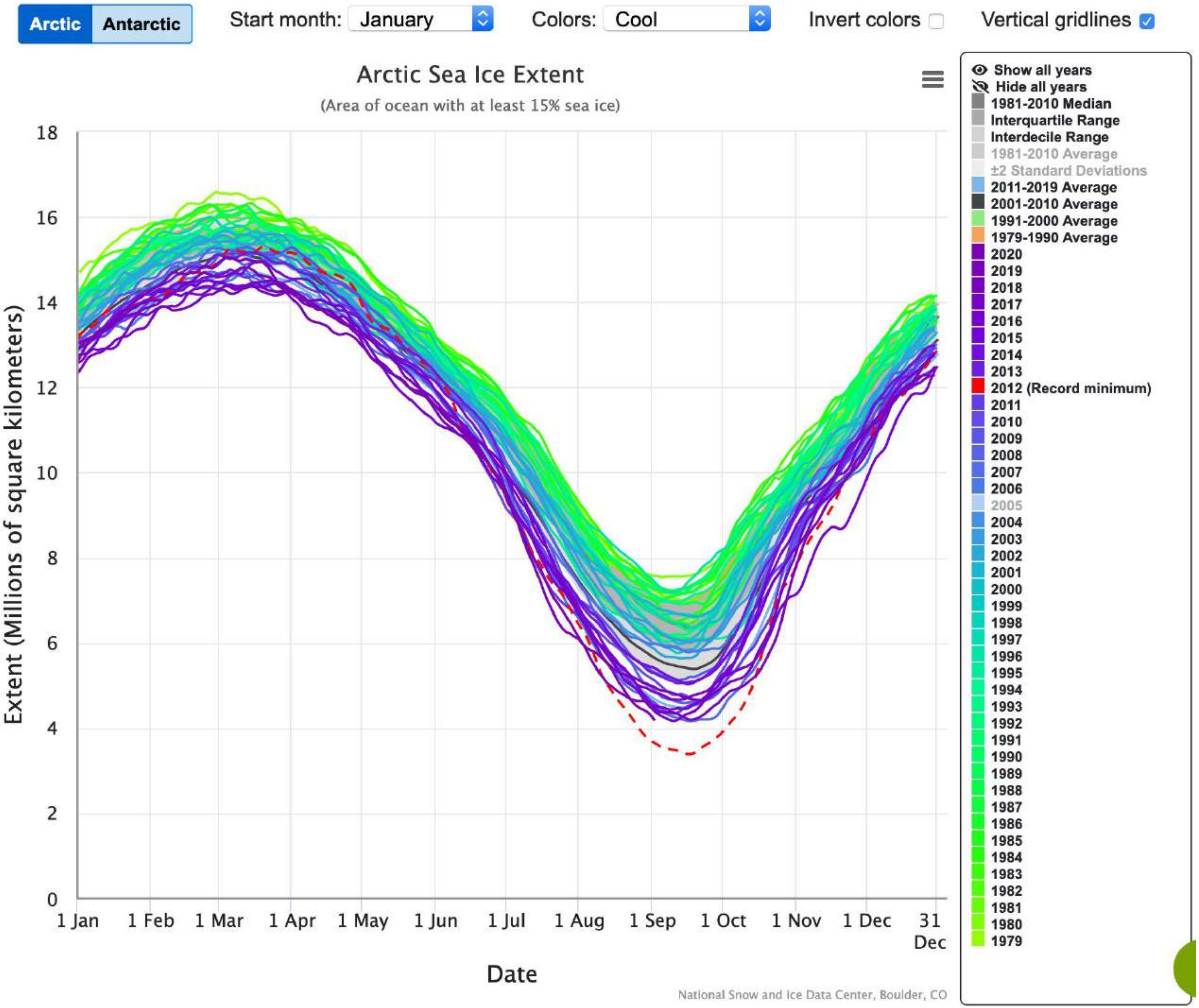


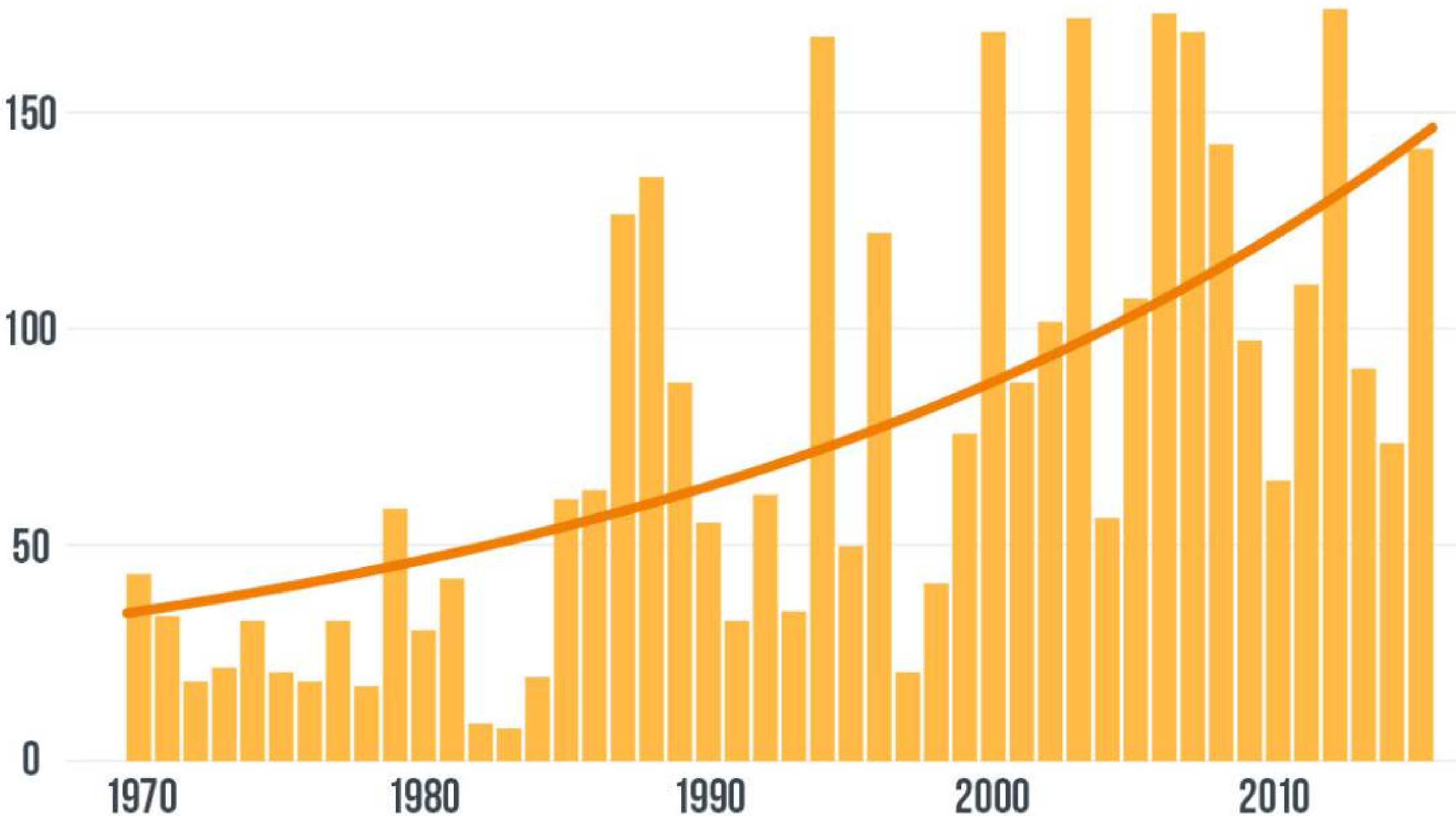
Fig. 1. Cumulative vertebrate species recorded as extinct or extinct in the wild by the IUCN (2012). Graphs show the percentage of the number of species evaluated among mammals (5513; 100% of those described), birds (10,425; 100%), reptiles (4414; 44%), amphibians (6414; 88%), fishes (12,457; 38%), and all vertebrates combined (39,223; 59%). Dashed black curve represents the number of extinctions expected under a constant standard background rate of 2 E/MSY. (**A**) Highly conservative estimate. (**B**) Conservative estimate.

Ceballos, P. R. Ehrlich, A. D. Barnosky, A. García, R. M. Pringle, T. M. Palmer, Accelerated modern human–induced species losses: Entering the sixth mass extinction. Sci. Adv. 1, e1400253 (2015).

https://nsidc.org/arcticseaicenews/charctic-interactive-sea-ice-graph/



Number of fires larger than 1,000 acres per year on U.S. Forest Service land



Source: Climate Central analysis of U.S. Forest Service records

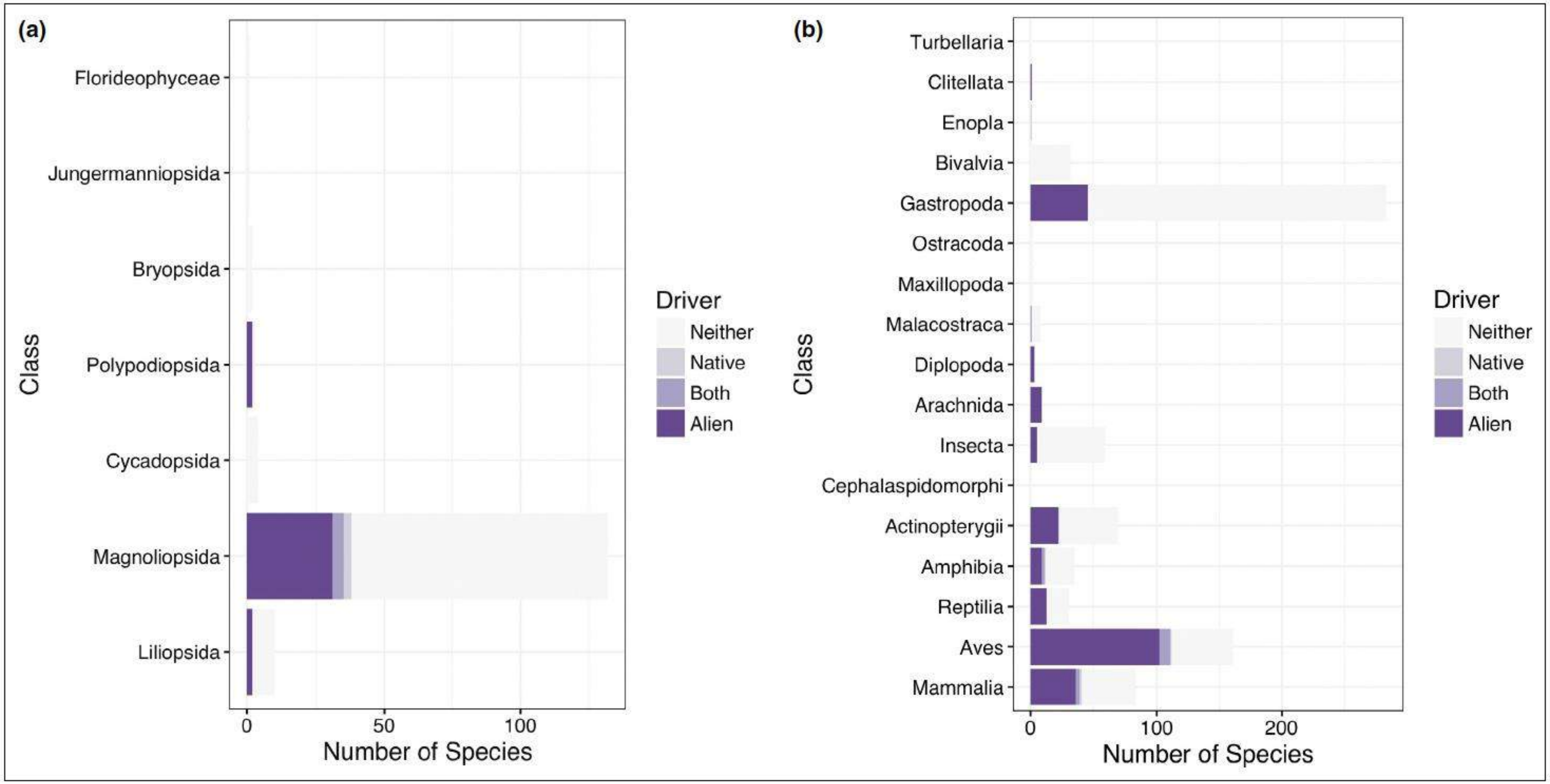


Figure 1. The number of recently extinct (International Union for Conservation of Nature [IUCN] categories "extinct" [EX] and "extinct in the wild" [EW]) species in each (a) plant and (b) animal class, along with recorded extinctions for which alien species, native species, both alien and native species, or neither are listed as associated extinction drivers (from data in WebTable 1).

Alien versus native species as drivers of recent extinctions, Tim M Blackburn, Céline Bellard, and Anthony Ricciardi, *Frontiers in Ecology and Evolution*, 2019; 17(4):203–207, doi:10.1002/fee.2020

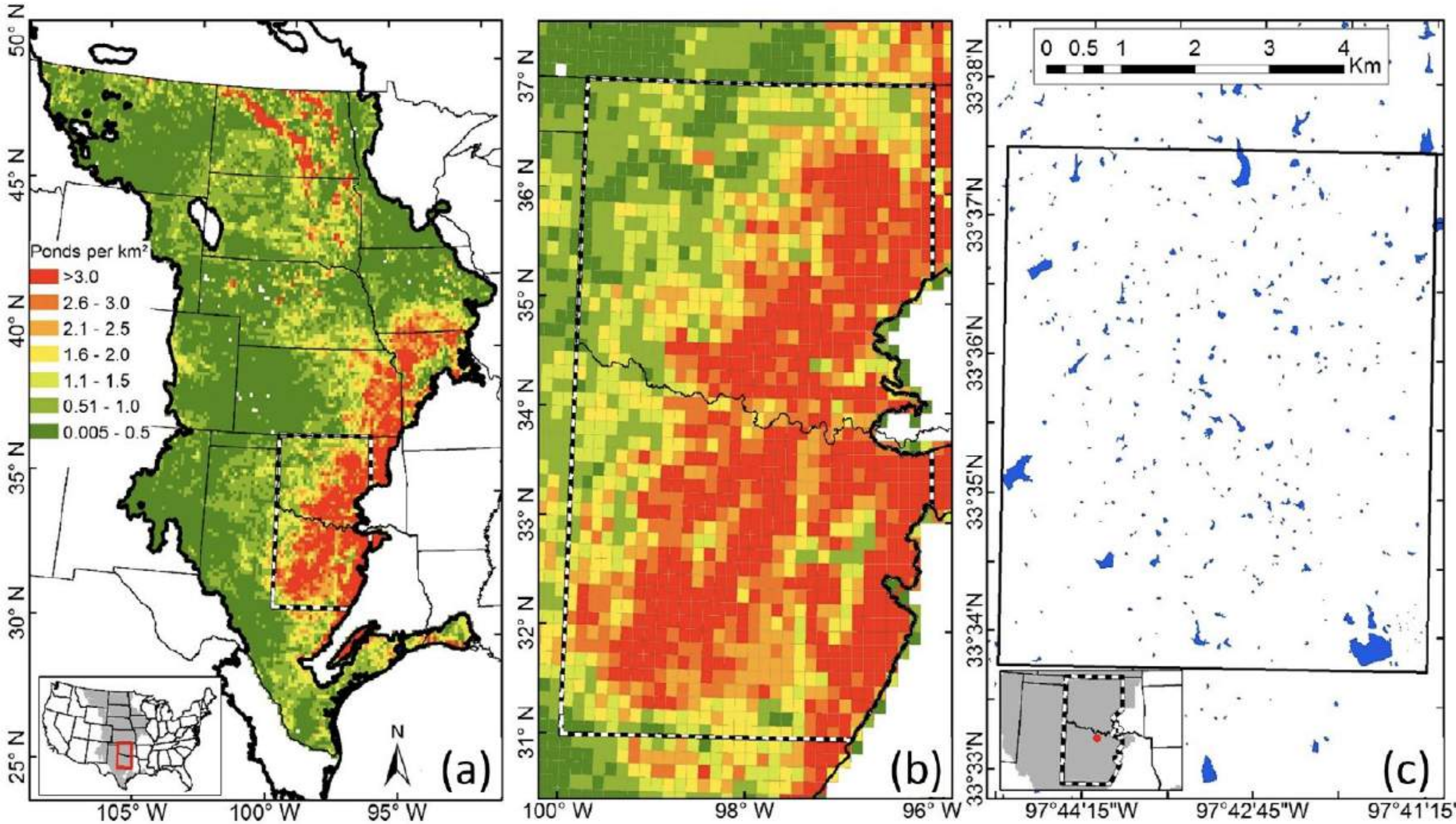


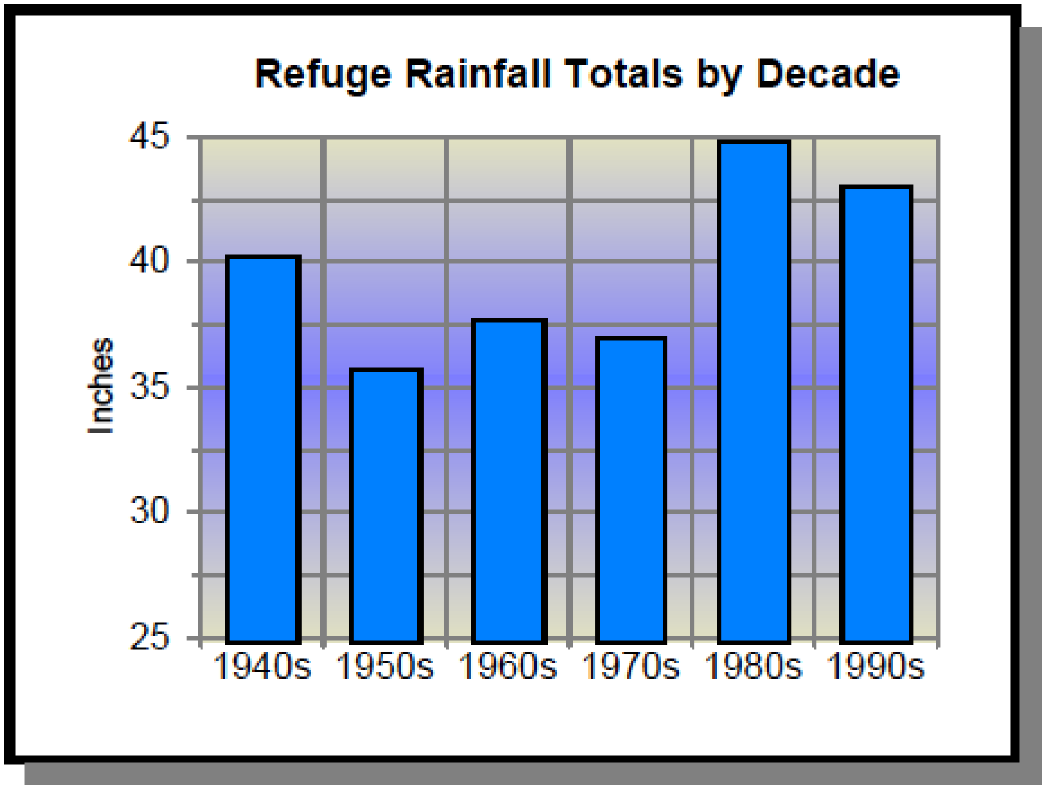
Fig. 1. (a) Density of lentic waterbodies ≤10 ha in the US Great Plains, (b) density of lentic waterbodies ≤10 ha in our study area, and (c) ponds in one-quarter quadrangle in Throckmorton County, TX. The boundaries of our study area within the Great Plains are indicated by a checkered black border. Lentic waterbody data are from the National Hydrology Dataset.

DOI: 10.5268/IW-6.2.954

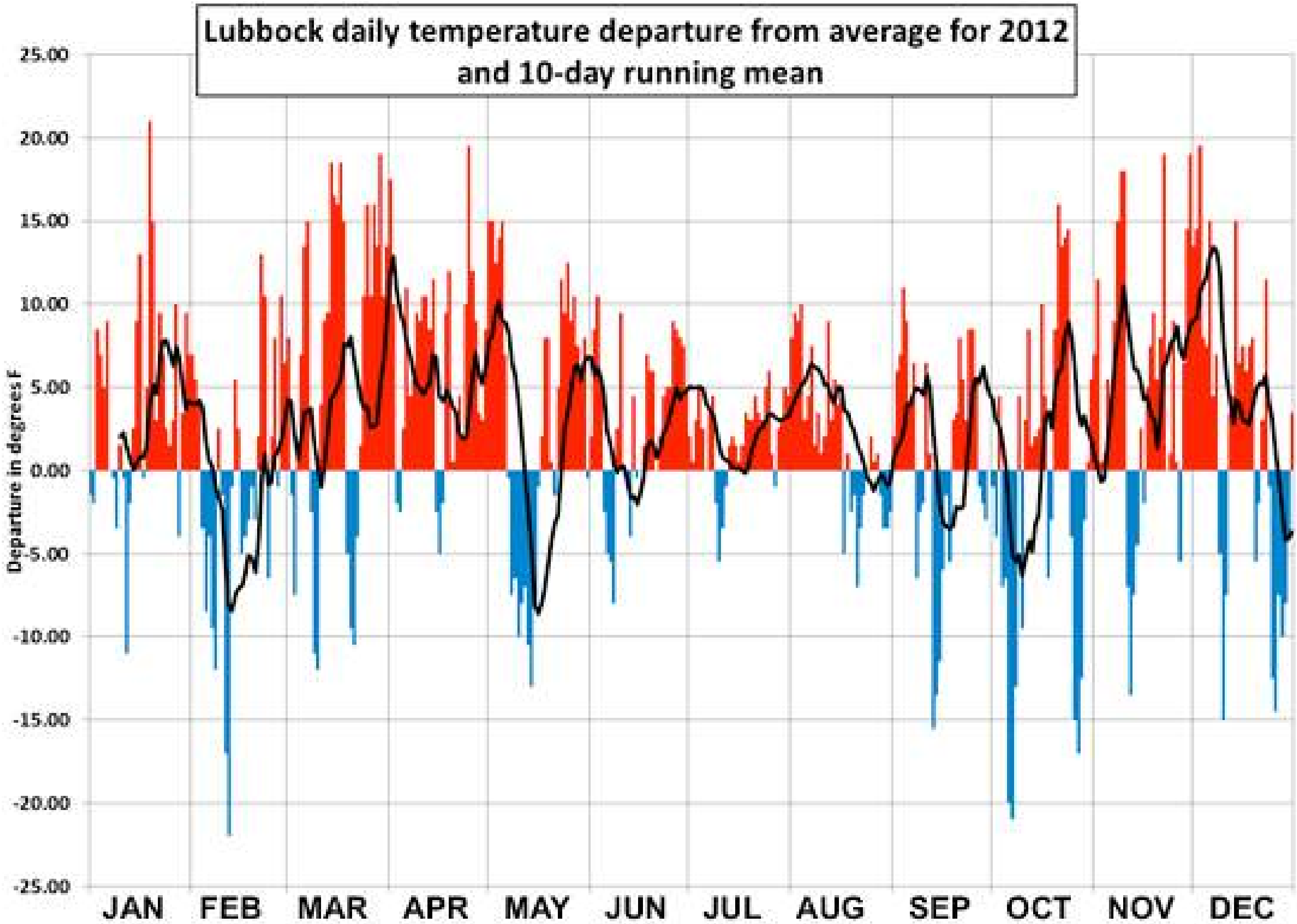
Inland Waters (2016) **6**, pp.258-264

M. M. Chumchal, R W. Drenner, and K. J. Adams

Find the misleading feature of this graph



Annual average rainfall for six recent decades. p. 47, Hagerman National Wildlife Refuge 2006 management plan, https://www.fws.gov/uploadedFiles/Hagerman%20CCP.pdf



http://www.srh.weather.gov/lub/?n=events-2012-20121231-summary constituted mainly as a fitting interlude between Octobers, and I suspect that dogs, and perhaps grouse, share the same view.

November

If I Were the Wind

The wind that makes music in November corn is in a hurry. The stalks hum, the loose husks whisk skyward in half-playful swirls, and the wind hurries on.

In the marsh, long windy waves surge across the grassy sloughs, beat against the far willows. A tree tries to argue, bare limbs waving, but there is no detaining the wind.

On the sandbar there is only wind, and the river sliding seaward. Every wisp of grass is drawing circles on the sand. I wander over the bar to a driftwood log, where I sit and listen to the universal roar, and to the tinkle of wavelets on the shore. The river is lifeless: not a duck, heron, marsh-hawk, or gull but has sought refuge from wind.

* * *

Out of the clouds I hear a faint bark, as of a far-away dog. It is strange how the world cocks its ears at that sound, wondering. Soon it is louder: the honk of geese, invisible, but coming on.

The flock emerges from the low clouds, a tattered banner of birds, dipping and rising, blown up and blown down, blown together and blown apart, but advancing, the wind wrestling lovingly with each winnowing wing. When the

flock is a blur in the far sky I hear the last honk, sounding taps for summer.

* * *

It is warm behind the driftwood now, for the wind has gone with the geese. So would I—if I were the wind.

Axe-in-Hand

The Lord giveth, and the Lord taketh away, but He is no longer the only one to do so. When some remote ancestor of ours invented the shovel, he became a giver: he could plant a tree. And when the axe was invented, he became a taker: he could chop it down. Whoever owns land has thus assumed, whether he knows it or not, the divine functions of creating and destroying plants.

Other ancestors, less remote, have since invented other tools, but each of these, upon close scrutiny, proves to be either an elaboration of, or an accessory to, the original pair of basic implements. We classify ourselves into vocations, each of which either wields some particular tool, or sells it, or repairs it, or sharpens it, or dispenses advice on how to do so; by such division of labors we avoid responsibility for the misuse of any tool save our own. But there is one vocation—philosophy—which knows that all men, by what they think about and wish for, in effect wield all tools. It knows that men thus determine, by their manner of thinking and wishing, whether it is worth while to wield any.

* * *

November is, for many reasons, the month for the axe. It is warm enough to grind an axe without freezing, but cold enough to fell a tree in comfort. The leaves are off the hardwoods, so that one can see just how the branches intertwine, and what growth occurred last summer. Without this clear view of treetops, one cannot be sure which tree, if any, needs felling for the good of the land.

I have read many definitions of what is a conservationist, and written not a few myself, but I suspect that the best one is written not with a pen, but with an axe. It is a matter of what a man thinks about while chopping, or while deciding what to chop. A conservationist is one who is humbly aware that with each stroke he is writing his signature on the face of his land. Signatures of course differ, whether written with axe or pen, and this is as it should be.

I find it disconcerting to analyze, *ex post facto,* the reasons behind my own axe-in-hand decisions. I find, first of all, that not all trees are created free and equal. Where a white pine

and a red birch are crowding each other, I have an *a priori* bias; I always cut the birch to favor the pine. Why?

Well, first of all, I planted the pine with my shovel, whereas the birch crawled in under the fence and planted itself. My bias is thus to some extent paternal, but this cannot be the whole story, for if the pine were a natural seedling like the birch, I would value it even more. So I must dig deeper for the logic, if any, behind my bias.

The birch is an abundant tree in my township and becoming more so, whereas pine is scarce and becoming scarcer; perhaps my bias is for the underdog. But what would I do if my farm were further north, where pine is abundant and red birch is scarce? I confess I don't know. My farm is here.

The pine will live for a century, the birch for half that; do I fear that my signature will fade? My neighbors have planted no pines but all have many birches; am I snobbish about having a woodlot of distinction? The pine stays green all winter, the birch punches the clock in October; do I favor the tree that, like myself, braves the winter wind? The pine will shelter a grouse but the birch will feed him; do I consider bed more important than board? The pine will ultimately bring ten dollars a thousand, the birch two dollars; have I an eye on the bank? All of these possible reasons for my bias seem to carry some weight, but none of them carries very much.

So I try again, and here perhaps is something; under this pine will ultimately grow a trailing arbutus, an Indian pipe, a pyrola, or a twin flower, whereas under the birch a bottle gentian is about the best to be hoped for. In this pine a pileated woodpecker will ultimately chisel out a nest; in the birch a hairy will have to suffice. In this pine the wind will sing for me in April, at which time the birch is only rattling naked twigs. These possible reasons for my bias carry weight, but why? Does the pine stimulate my imagination and my hopes more deeply than the birch does? If so, is the difference in the trees, or in me?

The only conclusion I have ever reached is that I love all trees, but I am in love with pines.

As I said, November is the month for the axe, and, as in other love affairs, there is skill in the exercise of bias. If the birch stands south of the pine, and is taller, it will shade the pine's leader in the spring, and thus discourage the pine weevil from laying her eggs there. Birch competition is a minor affliction compared with this weevil, whose progeny kill the pine's leader and thus deform the tree. It is interesting to meditate that this insect's preference for squatting in the sun determines not only her own continuity as a species, but also the future figure of my pine, and my own success as a wielder of axe and shovel.

Again, if a drouthy summer follows my removal of the birch's shade, the hotter soil may offset the lesser competition for water, and my pine be none the better for my bias.

Lastly, if the birch's limbs rub the pine's terminal buds during a wind, the pine will surely be deformed, and the birch must either be removed regardless of other considerations, or else it must be pruned of limbs each winter to a height greater than the pine's prospective summer growth.

Such are the pros and cons the wielder of an axe must foresee, compare, and decide upon with the calm assurance that his bias will, on the average, prove to be something more than good intentions.

The wielder of an axe has as many biases as there are species of trees on his farm. In the course of the years he

imputes to each species, from his responses to their beauty or utility, and their responses to his labors for or against them, a series of attributes that constitute a character. I am amazed to learn what diverse characters different men impute to one and the same tree.

Thus to me the aspen is in good repute because he glorifies October and he feeds my grouse in winter, but to some of my neighbors he is a mere weed, perhaps because he sprouted so vigorously in the stump lots their grandfathers were attempting to clear. (I cannot sneer at this, for I find myself disliking the elms whose resproutings threaten my pines.)

Again, the tamarack is to me a favorite second only to white pine, perhaps because he is nearly extinct in my township (underdog bias), or because he sprinkles gold on October grouse (gunpowder bias), or because he sours the soil and enables it to grow the loveliest of our orchids, the showy lady's-slipper. On the other hand, foresters have excommunicated the tamarack because he grows too slowly to pay compound interest. In order to clinch this dispute, they also mention that he succumbs periodically to epizootics of saw-fly, but this is fifty years hence for my tamaracks, so I shall let my grandson worry about it. Meanwhile my tamaracks are growing so lustily that my spirits soar with them, skyward.

To me an ancient cottonwood is the greatest of trees because in his youth he shaded the buffalo and wore a halo of pigeons, and I like a young cottonwood because he may some day become ancient. But the farmer's wife (and hence the farmer) despises all cottonwoods because in June the female tree clogs the screens with cotton. The modern dogma is comfort at any cost.

I find my biases more numerous than those of my neighbors because I have individual likings for many species that they lump under one aspersive category: brush. Thus I like the wahoo, partly because deer, rabbits, and mice are so avid to eat his square twigs and green bark and partly because his cerise berries glow so warmly against November snow. I like the red dogwood because he feeds October robins, and the prickly ash because my woodcock take their daily sunbath under the shelter of his thorns. I like the hazel because his October purple feeds my eye, and because his November catkins feed my deer and grouse. I like the bitter-sweet because my father did, and because the deer, on the 1st of July of each year, begin suddenly to eat the new leaves, and I have learned to predict this event to my guests. I cannot dislike a plant that enables me, a mere professor, to blossom forth annually as a successful seer and prophet.

It is evident that our plant biases are in part traditional. If your grandfather liked hickory nuts, you will like the hickory tree because your father told you to. If, on the other hand, your grandfather burned a log carrying a poison ivy vine and recklessly stood in the smoke, you will dislike the species, no matter with what crimson glories it warms your eyes each fall.

It is also evident that our plant biases reflect not only vocations but avocations, with a delicate allocation of priority as between industry and indolence. The farmer who would rather hunt grouse than milk cows will not dislike hawthorn, no matter if it does invade his pasture. The coon-hunter will not dislike basswood, and I know of quail hunters who bear no grudge against ragweed, despite their annual bout with hayfever. Our biases are indeed a sensitive index to our affections, our tastes, our loyalties, our generosities, and our manner of wasting weekends.

Be that as it may, I am content to waste mine, in November, with axe in hand.

A Mighty Fortress

Every farm woodland, in addition to yielding lumber, fuel, and posts, should provide its owner a liberal education. This crop of wisdom never fails, but it is not always harvested. I here record some of the many lessons I have learned in my own woods.

*   *   *

Soon after I bought the woods a decade ago, I realized that I had bought almost as many tree diseases as I had trees. My woodlot is riddled by all the ailments wood is heir to. I began to wish that Noah, when he loaded up the Ark, had left the tree diseases behind. But it soon became clear that these same diseases made my woodlot a mighty fortress, unequaled in the whole county.

My woods is headquarters for a family of coons; few of my neighbors have any. One Sunday in November, after a new snow, I learned why. The fresh track of a coon-hunter and his hound led up to a half-uprooted maple, under which one of my coons had taken refuge. The frozen snarl of roots and earth was too rocky to chop and too tough to dig; the holes under the roots were too numerous to smoke out. The hunter had quit coonless because a fungus disease had weakened the roots of the maple. The tree, half tipped over by a storm, offers an impregnable fortress for coondom. Without this 'bombproof' shelter, my seed stock of coons would be cleaned out by hunters each year.

My woods houses a dozen ruffed grouse, but during

February

Good Oak

There are two spiritual dangers in not owning a farm. One is the danger of supposing that breakfast comes from the grocery, and the other that heat comes from the furnace.

To avoid the first danger, one should plant a garden, preferably where there is no grocer to confuse the issue.

To avoid the second, he should lay a split of good oak on the andirons, preferably where there is no furnace, and let it warm his shins while a February blizzard tosses the trees outside. If one has cut, split, hauled, and piled his own good oak, and let his mind work the while, he will remember much about where the heat comes from, and with a wealth of detail denied to those who spend the week end in town astride a radiator.

* * *

The particular oak now aglow on my andirons grew on the bank of the old emigrant road where it climbs the sandhill. The stump, which I measured upon felling the tree, has a diameter of 30 inches. It shows 80 growth rings, hence the seedling from which it originated must have laid its first ring of wood in 1865, at the end of the Civil War. But I know from the history of present seedlings that no oak grows above the reach of rabbits without a decade or more of getting girdled each winter, and re-sprouting during the following summer. Indeed, it is all too clear that every sur-

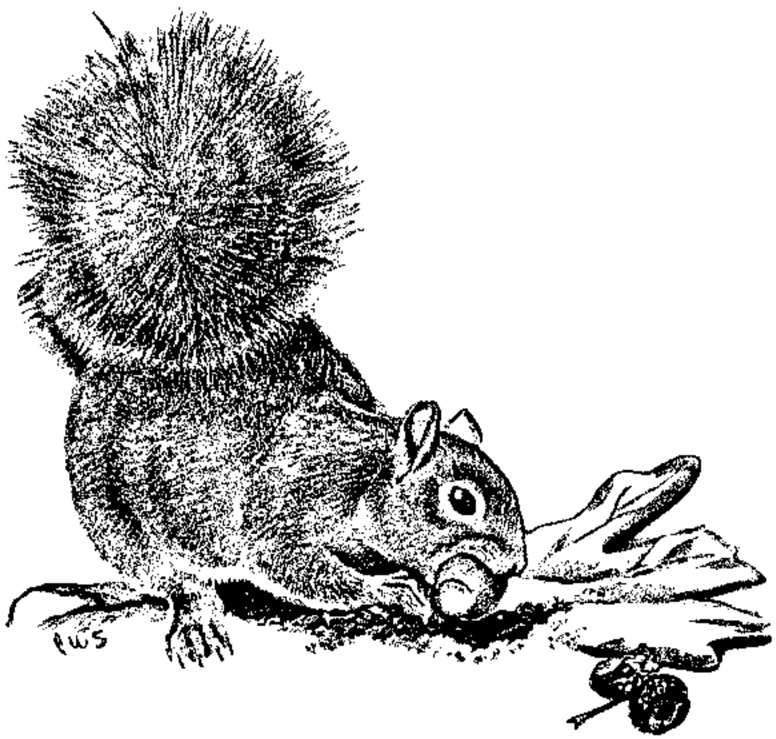
viving oak is the product either of rabbit negligence or of rabbit scarcity. Some day some patient botanist will draw a frequency curve of oak birth-years, and show that the curve humps every ten years, each hump originating from a low in the ten-year rabbit cycle. (A fauna and flora, by this very process of perpetual battle within and among species, achieve collective immortality.)

It is likely, then, that a low in rabbits occurred in the middle 'sixties, when my oak began to lay on annual rings, but that the acorn that produced it fell during the preceding decade, when the covered wagons were still passing over my road into the Great Northwest. It may have been the wash and wear of the emigrant traffic that bared this roadbank, and thus enabled this particular acorn to spread its first leaves to the sun. Only one acorn in a thousand ever grew large enough to fight rabbits; the rest were drowned at birth in the prairie sea.

It is a warming thought that this one wasn't, and thus lived to garner eighty years of June sun. It is this sunlight that is now being released, through the intervention of my axe and saw, to warm my shack and my spirit through eighty gusts of blizzard. And with each gust a wisp of smoke from my chimney bears witness, to whomsoever it may concern, that the sun did not shine in vain.

My dog does not care where heat comes from, but he cares ardently that it come, and soon. Indeed he considers my ability to make it come as something magical, for when I rise in the cold black pre-dawn and kneel shivering by the hearth making a fire, he pushes himself blandly between me and the kindling splits I have laid on the ashes, and I must touch a match to them by poking it between his legs. Such faith, I suppose, is the kind that moves mountains.

It was a bolt of lightning that put an end to wood-making by this particular oak. We were all awakened, one night in July, by the thunderous crash; we realized that the bolt must have hit near by, but, since it had not hit us, we all



went back to sleep. Man brings all things to the test of himself, and this is notably true of lightning.

Next morning, as we strolled over the sandhill rejoicing with the cone-flowers and the prairie clovers over their fresh accession of rain, we came upon a great slab of bark freshly torn from the trunk of the roadside oak. The trunk showed a long spiral scar of barkless sapwood, a foot wide

and not yet yellowed by the sun. By the next day the leaves had wilted, and we knew that the lightning had bequeathed to us three cords of prospective fuel wood.

We mourned the loss of the old tree, but knew that a dozen of its progeny standing straight and stalwart on the sands had already taken over its job of wood-making.

We let the dead veteran season for a year in the sun it could no longer use, and then on a crisp winter's day we laid a newly filed saw to its bastioned base. Fragrant little chips of history spewed from the saw cut, and accumulated on the snow before each kneeling sawyer. We sensed that these two piles of sawdust were something more than wood: that they were the integrated transect of a century; that our saw was biting its way, stroke by stroke, decade by decade, into the chronology of a lifetime, written in concentric annual rings of good oak.

* * *

It took only a dozen pulls of the saw to transect the few years of our ownership, during which we had learned to love and cherish this farm. Abruptly we began to cut the years of our predecessor the bootlegger, who hated this farm, skinned it of residual fertility, burned its farmhouse, threw it back into the lap of the County (with delinquent taxes to boot), and then disappeared among the landless anonymities of the Great Depression. Yet the oak had laid down good wood for him; his sawdust was as fragrant, as sound, and as pink as our own. An oak is no respecter of persons.

The reign of the bootlegger ended sometime during the dust-bowl drouths of 1936, 1934, 1933, and 1930. Oak smoke from his still and peat from burning marshlands must have clouded the sun in those years, and alphabetical conservation was abroad in the land, but the sawdust shows no change.

Rest! cries the chief sawyer, and we pause for breath.

* * *

Now our saw bites into the 1920's, the Babbittian decade when everything grew bigger and better in heedlessness and arrogance—until 1929, when stock markets crumpled. If the oak heard them fall, its wood gives no sign. Nor did it heed the Legislature's several protestations of love for trees: a National Forest and a forest-crop law in 1927, a great refuge on the Upper Mississippi bottomlands in 1924, and a new forest policy in 1921. Neither did it notice the demise of the state's last marten in 1925, nor the arrival of its first starling in 1923.

In March 1922, the 'Big Sleet' tore the neighboring elms limb from limb, but there is no sign of damage to our tree. What is a ton of ice, more or less, to a good oak?

Rest! cries the chief sawyer, and we pause for breath.

* * *

Now the saw bites into 1910-20, the decade of the drainage dream, when steam shovels sucked dry the marshes of central Wisconsin to make farms, and made ash-heaps instead. Our marsh escaped, not because of any caution or forbearance among engineers, but because the river floods it each April, and did so with a vengeance—perhaps a defensive vengeance—in the years 1913-16. The oak laid on wood just the same, even in 1915, when the Supreme Court abolished the state forests and Governor Phillip pontificated that 'state forestry is not a good business proposition.' (It

did not occur to the Governor that there might be more than one definition of what is good, and even of what is business. It did not occur to him that while the courts were writing one definition of goodness in the law books, fires were writing quite another one on the face of the land. Perhaps, to be a governor, one must be free from doubt on such matters.)

While forestry receded during this decade, game conservation advanced. In 1916 pheasants became successfully established in Waukesha County; in 1915 a federal law prohibited spring shooting; in 1913 a state game farm was started; in 1912 a 'buck law' protected female deer; in 1911 an epidemic of refuges spread over the state. 'Refuge' became a holy word, but the oak took no heed.

Rest! cries the chief sawyer, and we pause for breath.

* * *

Now we cut 1910, when a great university president published a book on conservation, a great sawfly epidemic killed millions of tamaracks, a great drouth burned the pineries, and a great dredge drained Horicon Marsh.

We cut 1909, when smelt were first planted in the Great Lakes, and when a wet summer induced the Legislature to cut the forest-fire appropriations.

We cut 1908, a dry year when the forests burned fiercely, and Wisconsin parted with its last cougar.

We cut 1907, when a wandering lynx, looking in the wrong direction for the promised land, ended his career among the farms of Dane County.

We cut 1906, when the first state forester took office, and fires burned 17,000 acres in these sand counties; we cut 1905 when a great flight of goshawks came out of the North and ate up the local grouse (they no doubt perched in this tree to eat some of mine). We cut 1902-3, a winter of bitter cold; 1901, which brought the most intense drouth of record (rainfall only 17 inches); 1900, a centennial year of hope, of prayer, and the usual annual ring of oak.

Rest! cries the chief sawyer, and we pause for breath.

* * *

Now our saw bites into the 1890's, called gay by those whose eyes turn cityward rather than landward. We cut 1899, when the last passenger pigeon collided with a charge of shot near Babcock, two counties to the north; we cut 1898 when a dry fall, followed by a snowless winter, froze the soil seven feet deep and killed the apple trees; 1897, another drouth year, when another forestry commission came into being; 1896, when 25,000 prairie chickens were shipped to market from the village of Spooner alone; 1895, another year of fires; 1894, another drouth year; and 1893, the year of 'The Bluebird Storm,' when a March blizzard reduced the migrating bluebirds to near-zero. (The first bluebirds always alighted in this oak, but in the middle 'nineties it must have gone without.) We cut 1892, another year of fires; 1891, a low in the grouse cycle; and 1890, the year of the Babcock Milk Tester, which enabled Governor Heil to boast, half a century later, that Wisconsin is America's Dairyland. The motor licenses which now parade that boast were then not foreseen, even by Professor Babcock.

It was likewise in 1890 that the largest pine rafts in history slipped down the Wisconsin River in full view of my oak, to build an empire of red barns for the cows of the prairie states. Thus it is that good pine now stands between

the cow and the blizzard, just as good oak stands between the blizzard and me.

Rest! cries the chief sawyer, and we pause for breath.

* * *

Now our saw bites into the 1880's; into 1889, a drouth year in which Arbor Day was first proclaimed; into 1887, when Wisconsin appointed its first game wardens; into 1886, when the College of Agriculture held its first short course for farmers; into 1885, preceded by a winter 'of unprecedented length and severity'; into 1883, when Dean W. H. Henry reported that the spring flowers at Madison bloomed 13 days later than average; into 1882, the year Lake Mendota opened a month late following the historic 'Big Snow' and bitter cold of 1881-2.

It was likewise in 1881 that the Wisconsin Agricultural Society debated the question, 'How do you account for the second growth of black oak timber that has sprung up all over the country in the last thirty years?' My oak was one of these. One debater claimed spontaneous generation, another claimed regurgitation of acorns by southbound pigeons.

Rest! cries the chief sawyer, and we pause for breath.

* * *

Now our saw bites the 1870's, the decade of Wisconsin's carousal in wheat. Monday morning came in 1879, when chinch bugs, grubs, rust, and soil exhaustion finally convinced Wisconsin farmers that they could not compete with the virgin prairies further west in the game of wheating land to death. I suspect that this farm played its share in the game, and that the sand blow just north of my oak had its origin in over-wheating.

This same year of 1879 saw the first planting of carp in Wisconsin, and also the first arrival of quack-grass as a stowaway from Europe. On 27 October 1879, six migrating prairie chickens perched on the rooftree of the German Methodist Church in Madison, and took a look at the growing city. On 8 November the markets at Madison were reported to be glutted with ducks at 10 cents each.

In 1878 a deer hunter from Sauk Rapids remarked prophetically, 'The hunters promise to outnumber the deer.'

On 10 September 1877, two brothers, shooting Muskego Lake, bagged 210 blue-winged teal in one day.

In 1876 came the wettest year of record; the rainfall piled up 50 inches. Prairie chickens declined, perhaps owing to hard rains.

In 1875 four hunters killed 153 prairie chickens at York Prairie, one county to the eastward. In the same year the U.S. Fish Commission planted Atlantic salmon in Devil's Lake, 10 miles south of my oak.

In 1874 the first factory-made barbed wire was stapled to oak trees; I hope no such artifacts are buried in the oak now under saw!

In 1873 one Chicago firm received and marketed 25,000 prairie chickens. The Chicago trade collectively bought 600,000 at $3.25 per dozen.

In 1872 the last wild Wisconsin turkey was killed, two counties to the southwest.

It is appropriate that the decade ending the pioneer carousal in wheat should likewise have ended the pioneer carousal in pigeon blood. In 1871, within a 50-mile triangle spreading northwestward from my oak, 136 million pigeons are estimated to have nested, and some may have nested in it, for it was then a thrifty sapling 20 feet tall. Pigeon hunters by scores plied their trade with net and gun, club and salt lick, and trainloads of prospective pigeon pie moved southward and eastward toward the cities. It was the last big nesting in Wisconsin, and nearly the last in any state.

This same year 1871 brought other evidence of the march of empire: the Peshtigo Fire, which cleared a couple of counties of trees and soil, and the Chicago Fire, said to have started from the protesting kick of a cow.

In 1870 the meadow mice had already staged their march of empire; they ate up the young orchards of the young state, and then died. They did not eat my oak, whose bark was already too tough and thick for mice.

It was likewise in 1870 that a market gunner boasted in the *American Sportsman* of killing 6000 ducks in one season near Chicago.

Rest! cries the chief sawyer, and we pause for breath.

* * *

Our saw now cuts the 1860's, when thousands died to settle the question: Is the man-man community lightly to be dismembered? They settled it, but they did not see, nor do we yet see, that the same question applies to the man-land community.

This decade was not without its gropings toward the larger issue. In 1867 Increase A. Lapham induced the State Horticultural Society to offer prizes for forest plantations. In 1866 the last native Wisconsin elk was killed. The saw now severs 1865, the pith-year of our oak. In that year John Muir offered to buy from his brother, who then owned the home farm thirty miles east of my oak, a sanctuary for the wildflowers that had gladdened his youth. His brother declined to part with the land, but he could not suppress the idea: 1865 still stands in Wisconsin history as the birth-year of mercy for things natural, wild, and free.

We have cut the core. Our saw now reverses its orientation in history; we cut backward across the years, and outward toward the far side of the stump. At last there is a tremor in the great trunk; the saw-kerf suddenly widens; the saw is quickly pulled as the sawyers spring backward to safety; all hands cry 'Timber!'; my oak leans, groans, and crashes with earth-shaking thunder, to lie prostrate across the emigrant road that gave it birth.

* * *

Now comes the job of making wood. The maul rings on steel wedges as the sections of trunk are up-ended one by one, only to fall apart in fragrant slabs to be corded by the roadside.

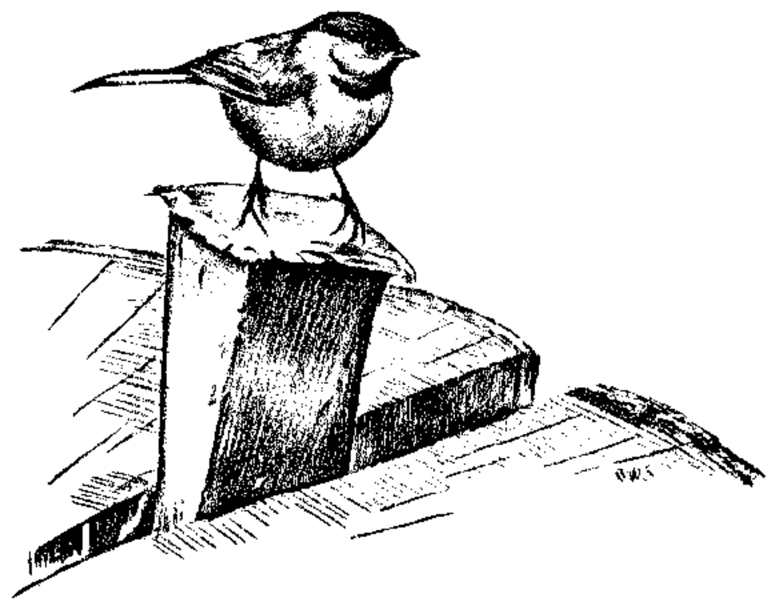
There is an allegory for historians in the diverse functions of saw, wedge, and axe.

The saw works only across the years, which it must deal with one by one, in sequence. From each year the raker teeth pull little chips of fact, which accumulate in little piles, called sawdust by woodsmen and archives by historians; both judge the character of what lies within by the character of the samples thus made visible without. It is not until the transect is completed that the tree falls, and the stump yields a collective view of a century. By its fall the tree attests the unity of the hodge-podge called history.

The wedge, on the other hand, works only in radial splits; such a split yields a collective view of all the years at once, or no view at all, depending on the skill with which the plane of the split is chosen. (If in doubt, let the section season for a year until a crack develops. Many a hastily driven

wedge lies rusting in the woods, embedded in unsplittable cross-grain.)

The axe functions only at an angle diagonal to the years, and this only for the peripheral rings of the recent past. Its special function is to lop limbs, for which both saw and wedge are useless.



The three tools are requisite to good oak, and to good history.

* * *

These things I ponder as the kettle sings, and the good oak burns to red coals on white ashes. Those ashes, come spring, I will return to the orchard at the foot of the sandhill. They will come back to me again, perhaps as red apples, or perhaps as a spirit of enterprise in some fat October squirrel, who, for reasons unknown to himself, is bent on planting acorns.

March

The Geese Return

One swallow does not make a summer, but one skein of geese, cleaving the murk of a March thaw, is the spring.

A cardinal, whistling spring to a thaw but later finding himself mistaken, can retrieve his error by resuming his winter silence. A chipmunk, emerging for a sunbath but finding a blizzard, has only to go back to bed. But a migrating goose, staking two hundred miles of black night on the chance of finding a hole in the lake, has no easy chance for retreat. His arrival carries the conviction of a prophet who has burned his bridges.

A March morning is only as drab as he who walks in it without a glance skyward, ear cocked for geese. I once knew an educated lady, banded by Phi Beta Kappa, who told me that she had never heard or seen the geese that twice a year proclaim the revolving seasons to her well-insulated roof. Is education possibly a process of trading awareness for things of lesser worth? The goose who trades his is soon a pile of feathers.

The geese that proclaim the seasons to our farm are aware of many things, including the Wisconsin statutes. The southbound November flocks pass over us high and haughty, with scarcely a honk of recognition for their favorite sandbars

and sloughs. 'As a crow flies' is crooked compared with their undeviating aim at the nearest big lake twenty miles to the south, where they loaf by day on broad waters and filch corn by night from the freshly cut stubbles. November geese are aware that every marsh and pond bristles from dawn till dark with hopeful guns.

March geese are a different story. Although they have been shot at most of the winter, as attested by their buckshot-battered pinions, they know that the spring truce is now in effect. They wind the oxbows of the river, cutting low over the now gunless points and islands, and gabbling to each sandbar as to a long-lost friend. They weave low over the marshes and meadows, greeting each newly melted puddle and pool. Finally, after a few *pro-forma* circlings of our marsh, they set wing and glide silently to the pond, black landing-gear lowered and rumps white against the far hill. Once touching water, our newly arrived guests set up a honking and splashing that shakes the last thought of winter out of the brittle cattails. Our geese are home again!

It is at this moment of each year that I wish I were a muskrat, eye-deep in the marsh.

Once the first geese are in, they honk a clamorous invitation to each migrating flock, and in a few days the marsh is full of them. On our farm we measure the amplitude of our spring by two yardsticks: the number of pines planted, and the number of geese that stop. Our record is 642 geese counted in on 11 April 1946.

As in fall, our spring geese make daily trips to corn, but these are no surreptitious sneakings-out by night; the flocks move noisily to and from corn stubbles through the day. Each departure is preceded by loud gustatory debate, and each return by an even louder one. The returning flocks,

Bio 115 study questions

Limited utility of study questions:

These questions are intended as a supplement to the procedure that I have recommended in another handout regarding taking, improving, and studying your notes. There is no way to create a comprehensive list of study questions so there is a risk that a student might think, "If I can answer these then I can answer every possible question on an exam." That would be an errant conclusion. <u>This is not an exhaustive list of topics that might serve as the basis for questions</u>. Rather, this list is intended to help you anticipate the <u>sorts</u> of questions that you will encounter on exams. That said, a well-prepared student will be able to answer all of these questions before arriving for an exam. As you work to answer them, make sure your answers are precise and thorough. Check them with classmates or others.

These study questions are based on the course lectures alone. They do not include questions regarding material that is covered in the assigned readings but not during lecture, and they do not explicitly cover the material in the EvoBeaker (SimUText) simulations. You should also study and answer any questions at the end of the text chapters that pertain to assigned readings, the questions in the simulation workbooks, and try to make up your own study questions for other text material and other readings especially any major (lengthy) topics in the readings that were not covered during class.

These questions generally do not include examples but exams may ask you to describe particular examples. As you study the various questions review the applicable examples and make sure you understand those examples. Note that definition ≠ explanation ≠ example. A question may ask for a definition, an explanation, and one or more examples for any given phenomenon, such as, say, convergent evolution.

EvoBeaker (SimUText) material on exams:

Also, be able to answer any of the questions of understanding in the EvoBeaker (SimUText) simulations. If I have not returned one or more of your simulation workbook pages when you are studying for the exam, remember that you have access to the workbooks and the questions, so you can study the material even if you do not have a workbook that you already completed.

Readings:

As noted above, these study questions are drawn from course lectures and discussions, not from the readings or SimUText material.

Know the main point, fundamental argument, and main evidence of every reading assignment.

Understand the major points made in any textbook readings, both those that are covered during class sessions and those that are not covered during class sessions.

(Reading assignments are chosen intentionally but are not necessarily covered during class.)

Exam format:

Exams will typically have 2-4 essay questions and about 35 multiple choice or other short answer questions.

How to work with these study questions:

Read the following questions carefully and then *write out* precise, specific, articulate, thorough answers to essay questions. Then describe particular examples. Resist the temptation to simply look at the questions and say to yourself, "I know that."

Work on answering the essay questions precisely and completely while omitting any tangential or unnecessary information. Avoid "brain dumps." In other words, avoid simply writing everything you know about a general topic. Brain dumps take too long and may not actually answer the particular question asked.

In some cases, it might be useful to supplement written answers with drawings.

After you answer the following questions, compare your answers with those of a friend and see if your friend understands your answers.

Study questions:

INTRODUCTION TO COURSE

Why do we teach evolution and ecology in the same course?

What sorts of difficulties do first-year students report? Which particular difficulty do students most often report?

What must you be able to do to be confident that water is safe to drink, an electrical device will not shock you, a set of blood test results are correct, etc.

How can one distinguish science from non-science?

What are the limits of science?

What does it mean for a hypothesis to be "potentially falsifiable?"

Describe *in detail* (all the steps of) Dr. Schulze's recommended procedure for producing excellent notes.

Describe *in detail* (all the steps of) Dr. Schulze's recommended procedure for using those notes to prepare for an exam.

What good does it do to read the book if you already have good notes from class?

INTRODUCTION TO EVOLUTION & NATURAL SELECTION

What is evolution? (Define it precisely).

Define gene, allele, gene pool, and population.

What is natural selection?

What combination of circumstances result in natural selection?

What is the relationship between natural selection and evolution?

What is artificial selection and how does it help us understand natural selection?

Describe several different examples of natural selection that have been directly observed? (Get together will classmates & see how many examples you can list & describe. Do the same for other similar study questions that ask about examples. Make sure you can describe and understand each example.)

Describe several different types of historical evidence that are consistent with the theory of evolution by natural selection. Make sure not to omit any that were discussed in class or in the assigned reading.

Describe several cases of artificial selection.

(Note regarding examples – examples provide evidence for ideas, so scholars love examples. Make sure you understand each example that is discussed in class or in an assigned reading, but realize that an example of a phenomenon is not the same as an explanation of a phenomenon. An example is often useful for illustrating an explanation, but the two are not synonymous.)

NATURAL SELECTION & OTHER PROCESSES THAT ALTER ALLELE FREQUENCIES

What four types of processes alter allele frequencies?

Explain the mechanism of each of those processes (how each process works, under what conditions it occurs, etc.). Which of the four processes are usually adaptive?

Define allele.

Define dominant allele

Define recessive allele

Define homozygote

Define heterozygote

Define fitness.

Why is fitness a useful concept for studying and understanding natural selection and evolution?

What is the ultimate source of new genetic variation?

Define mutation.

What is the significance of mutations?

Why is inbreeding dangerous to individuals? (Give a detailed explanation that defines inbreeding *and does not omit any key steps* of the explanation.) (For example, the following explanation is incomplete. What is missing? "Inbreeding fosters expression of deleterious, recessive alleles because inbred individuals are often homozygous for such alleles.")

Explain the apparent conundrum that mutations are generally harmful to individuals but enable populations to adapt to new circumstances?

What are stabilizing, directional, and disruptive (= diversifying) selection? Under what general circumstances would you expect each to occur?

What examples of each of these were discussed in class? In the book? Explain each example.

Might stabilizing selection occur after directional selection? Why or why not?

What is sexual selection and what circumstances cause it to occur?

Which gender is usually the choosiest about mates? Why? (Explain in detail.)

What would be the evolutionary consequences of choosing mates badly? (What would it mean, from an evolutionary perspective, for a wild creature, to choose mates badly? In other words, how would we identify a bad choice?)

What is gene flow & how can it alter allele frequencies in a population (cause evolution)? Is gene flow adaptive?

What is genetic drift & how can it alter allele frequencies in a population (cause evolution)? Is genetic drift adaptive? How and why does genetic drift depend on population size?

Under what circumstances would genetic drift be likely to substantially alter allele frequencies?

What is a population bottleneck and why is the concept of a population bottleneck relevant to genetic drift and thus evolution?

What is the founder effect and how is the founder effect important to allele frequencies?

Maintenance of Genetic Diversity in Populations

What 5 factors prevent natural selection from eliminating genetic variation?

How does each of these factors have the effect of increasing or preserving genetic variation?

Provide a real or hypothetical example of each of the processes and situations that prevent natural selection from eliminating genetic variation.

Does evolution lead to perfect organisms?

No. Why not? You should be able to offer at least 3 reasons.

Genetic Diversity in Small Populations

What are the two genetic risks to small populations?

Why is genetic drift particularly relevant to small populations?

SPECIATION

Define “species.”

Define “population.”

Read your definitions and make sure they are not identical. What is the difference between them?

Which of the following statements is correct? Which is incorrect? Why? A species can have multiple populations. A population can have multiple species.

What 3 different ways do biologists use to determine whether two individuals are members of the same species? How does each work? What are the limitations of each?

Define allopatric speciation.

Define sympatric speciation.

What is adaptive radiation?

Describe several cases of adaptive radiation.

What factors facilitate adaptive radiation? Why do they have that effect?

Among what kind of organisms is sympatric speciation common?

Describing Results

What three features should you describe in the text of a results section of a scientific (e.g. laboratory) report.

Practice applying the above to the graphs in the set of PowerPoint slides that correspond to this material.

---- end of coverage for first 2023 mid-term exams ----

HISTORY AND FUTURE OF BIOLOGICAL DIVERSITY

According to present understanding, what are some of the most important events in the history of life on the planet, and when did they occur? (I expect you to know the events included on my PowerPoint slides.)

From the perspective of most species, what is the most important difference between the early conditions on the planet and present conditions?

What are the three domains of life? What are their fundamental characteristics?

Explain the endosymbiont hypothesis and the evidence consistent with the endosymbiont hypothesis.

How has the diversity of life varied through time?

What was the Cambrian Explosion and when did it occur? Why is it considered so significant to subsequent evolution?

What is a mass extinction and what is the evidence for mass extinctions?

What are the main proposed causes for previous mass extinctions?

When was the most recent mass extinction (not counting the present mass extinction)?

What notable species went extinct at the time of that most recent (not present) mass extinction?

What is thought to have been the cause of that mass extinction? What is the evidence for that hypothesis?

What human action is most responsible for current extinctions? What human impact on the environment is expected to be most responsible for extinctions in the near future (next few hundred years)?

What features or circumstances make species particularly susceptible to extinction? (Study the relevant PowerPoint slide so that you interpret the term “features” appropriately. In this context, “feature” does not refer merely to anatomical or physiological features.)

Imagine a situation where at one time a species has only one population, then later a second population forms. Imagine the two populations are initially in separate locations but later have overlapping ranges, as might happen, for example, if their ranges expand. While separated, the two populations would evolve independently in response to the circumstances where they each occur. If such a process continues for a sufficient time, one or both populations may become different species, but there will be a gray area between the time where the two populations are definitely members of the same species and later when there are clearly two different species. What are some of the mechanisms that could prevent interbreeding among members of the two populations during that interim when the populations have diverged somewhat but are not obviously two different species?

EVOLUTIONARY ANCESTRY OF HUMANS

What organisms constitute the primates? What characteristics distinguish primates from other mammals? Which extant (not extinct) primates exist?

What group of organisms gave rise to the primates? Approximately when did this occur?

What present-day primates are most similar to the earliest primates?

Which ape species are most closely related to other ape species? To humans?

Explain the leading hypothesis to account for the rise of bipedalism in human ancestors, and the hypothesis regarding the subsequent interplay between bipedalism, tool use, and selection for intelligence. What did climate change have to do with all of this?

What genus was the ancestor to the genus *Homo*? Approximately when did that genus occur?

When did the first members of genus *Homo* arise? Where have their earliest fossils been found? Approximately when did the various *Homo* species reach other continents? Wha Play the top of all the timet is the relationship of *Homo sapiens* to *Homo neanderthalis*?

What is the most recently discovered species of *Homo*?

Is there any biological basis for the concept of human races?

ECOLOGY: INTRODUCTION, CLIMATES, AND BIOMES

Draw and explain the diagram that shows the human economy as a subset of the Earth system. Include and explain the various flows of resources, energy, and wastes.

What is an ecosystem service? What are some examples of ecosystem services?

How large is the human population? What is the history of its growth?

Write Herman Daly's guidelines for sustainability and explain their logic?

Are we respecting Dr. Daly's guidelines? What is your evidence?

What is a biome? What are the major biome types? What are their basic characteristics? (I did not review the latter two questions here. Check your readings.)

How do climatic factors affect the distribution of biomes? Which factors are most important?

What are the various factors that determine the distribution of temperature and precipitation around the planet?

Why are there seasons on Earth?

What is a Hadley Cell? Explain the air and moisture movement associated with Hadley Cells.

What is a mountain rain shadow and why do they occur? What is the significance of mountain rain shadows for the distribution of biomes?

How do coastal climates compare to inland (continental) climates? How does that comparison differ between summer and winter?

Why is Europe so much warmer than Hudson's Bay, Canada, even though the two are at the same latitude?

How have humans affected the distribution of biomes?

---- end of material for 2nd 2023 mid-term exam ----

POPULATION ECOLOGY

What is a niche and how is an understanding of niche requirements helpful to understanding a species distribution?

Give some examples of ways that organism's behavior or other adaptations to expand the range of habitats that meet their niche requirements.

What is meant by life history?

Describe some life history adaptations that expand niche boundaries.

What are the two potential explanations for the absence of a species from a particular area?

Why is dispersal selected for?

How might a small population grow?

Describe the exponential model of population growth, both as an equation and in words. What does it predict?

What does it assume?

What is competition (as the term is used by ecologists)?

What is carrying capacity?

Would you expect a population to grow according to the predictions of the exponential model? If so, for how long? If not, why not? What would be a more reasonable expectation for population growth? Why?

Define regulation?

Do you suppose populations frequently experience regulation? Why or why not?

What sorts of processes can regulate populations? Don't just list examples here. Explain the particular criterion that determines whether a process is regulatory.

What sorts of processes cannot regulate populations?

How has the human population managed to continue to expand exponentially when other species populations do not? (Think back to the questions about Herman Daly's guidelines for sustainability.)

COMMUNITY ECOLOGY

Define the different types of interspecific interactions

Define an ecological community

Explain the example of *Chthamalus* and *Semibalanus*.

Distinguish between the fundamental and the realized niche. Use the *Chthamalus* and *Semibalanus* example to illustrate your explanation.

Define “character displacement” and explain an example.

Explain how character displacement involves both interspecific competition and evolution.

Which of the following are examples of predation?

- A lion eating a gazelle
- A robin eating a worm
- A cow eating grass
- A tapeworm living in a mammal’s gut

Explain some reasons why predators rarely wipe out prey populations.

Describe and explain the population dynamics of hares and lynx in the boreal forest of Canada.

Describe some of the consequences of humans acting as predators. Have humans done a good job of sustainably harvesting prey populations? Why do you draw that conclusion?

What is mutualism?

Describe some actual examples of mutualistic interactions.

What is coevolution?

Describe some examples of coevolution. Hint: See your examples of mutualism.

What circumstances, factors, or processes tend to decrease species diversity? Why do those phenomena have that effect?

How do ecologists define “disturbance?” Give some examples of disturbances and describe their effects on species diversity.

What is succession?

Why does succession occur?

ANIMAL BEHAVIOR

Why do animals behave the way they do?

Describe the typical vertical migration behavior of zooplankton.

Distinguish the proximate cue and the ultimate cause of vertical migration.

Describe some of the evidence that behaviors are genetically based.

Contrast instinct and learning.

Support or refute the following statement on the basis of evolutionary logic. Behaviors do not need to be perfect; they just need to be effective. Also, what does effective mean in this context?

Describe the curious features of nest defense by male sticklebacks.

What are some advantages of living in a group? What are some disadvantages?

Under what general circumstance would you expect an individual animal to live as a member of a group (rather than by itself)? (General circumstance – criterion – not mere examples of potential situations). Hint – why do animals behave as they do?

Under what circumstances would you expect an animal to behave in a way that helps another animal but puts itself at risk?

FLOW OF ENERGY AND CYCLES OF ELEMENTS IN ECOSYSTEMS

Describe the first and second laws of thermodynamics and explain their basic implications.

What is the source of energy for most ecosystems (except deep sea vents)?

Define primary production.

How and why do ecosystems vary in primary productivity?

How do rates of primary production constrain the abundance of herbivores and carnivores?

How does the second law of thermodynamics affect the energy available to species farther up a food web?

What are the possible fates of energy that is ingested by an individual?

What are the key features of natural cycles of elements (materials)?

How does the present use of materials by humans differ from the flow of materials in natural ecosystems? Is the difference important? Why or why not?

ECOLOGY AND ECOSYSTEM SERVICES – SYNTHESIS & REVIEW FROM ECOLOGY INTRODUCTION

Give some examples of non-sustainable impacts upon ecosystem services.

Draw my diagram of the dependence of the economy on its planetary setting.

Contrast key features of natural ecosystems and the human economy. Hint: Materials and energy.

Describe Jared Diamond's thesis regarding the causes of collapse of civilizations. Hint: You should be able to identify five key factors that may or may not interact.

What does Bill McKibben mean when he writes, "Bears are like golden retrievers now?"

Finally…

How does evolution affect ecological interactions?

How do ecological interactions affect the future course of evolution?

What does animal behavior have to do with either of the previous two questions?

Biology 115D Schulze 2023

Evolution, Behavior, & Ecology Quiz #1

Name (printed) ______________________________________

I completed this work in accordance with the Austin College academic integrity policy.

_______________________________________ (signature)

- Read each question carefully.
- If a question appears ambiguous, ask for clarification.
- Keep an eye on the clock. Do not get bogged down on difficult questions when relatively easy questions remain.
- Write legibly and try to confine your answers to the space provided. If you must have more space, continue elsewhere on the exam – but indicate that you have done so.
- Written answers should explain reasoning or evidence, not simply make unsubstantiated claims.
- If you finish early, review your essay answers to ensure they say what you mean.

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1. Define both (i) evolution and (ii) natural selection. Then explain how the two are related. (5 points)

Evolution is a change in the composition of a gene pool. A gene pool is the complete set of a population's genes. A population is a set of individuals of a species that have opportunities to interbreed.

Natural selection refers to the ecological processes and circumstances that cause some individuals (those best suited to the features of a given environment) to be most likely to survive and reproduce.

The two are related because natural selection eliminates some gene copies while allowing others to persist. In other words, it causes evolution. Meanwhile, organisms' suitability to their environments is largely a function of their prior evolution (the adaptations they have inherited).

2. Explain the claim that the wings of bats and birds provide examples of both anatomical homology and convergent evolution. (5 points)

Anatomical homology refers to a similarity between two species that is the consequence of inheritance from a common ancestor (descent with modification from the same ancestor). The bons in bird and bat wings have the same bones because both taxa (categories of organisms) inherited their bone structure from the same ancestral species (an ancestor they share in common), and that ancestors had those bones in its forelegs.

The wings themselves, however, provide an example of convergent evolution: when two species independently developing (evolving) similar adaptations in response to similar selective pressures. The common ancestor of bats and birds lacked wings, but over millions of years, wings independently evolved in both groups.

Multiple Choice Questions. Choose the single best answer. *Do not select 2 or more answers. 2 points each.*

3. Which of the following is not one of the circumstances that leads to natural selection

___ Individuals in a population are not identical.
_x_ **Some mutations (errors when cells copy their genes) have no effect on an individual’s potential to survive and reproduce.**
___ Some variation among individuals is genetically based
___ Populations produce more offspring than the environment can support.
___ None of the above (which in this case means that all the above are circumstances that lead to natural selection).
___ All of the above (which in this case means natural selection does not result from any of these things).

4. You should finish an antibiotic prescription even if you feel better because…

___ if lots of people fail to finish antibiotics, resistant bacteria are more likely to become abundant.
___ some bacteria may be less vulnerable to the antibiotic than others.
___ even though you may feel better after a few days, some bacteria may still survive and have the potential to grow a large population that will make you (and potentially others) sick if you stop taking the antibiotic.
_x_ all the above.

5. Which of the following are products of artificial selection?

___ Broccoli
___ German Shepherds
___ Angus cattle
___ Roses
___ Calico cats
_x_ All of the above
___ None of the above

6. Which of the following is an adaptation of a human population discussed in an assigned reading?

___ Tolerance of lactose (milk sugar)
___ Immunity to malaria
_x_ Tolerance of arsenic contamination
___ Immunity to West Nile Virus
___ All of the above
___ None of the above

7. To safely fly from Denver to Dallas, Schulze had to be able to

___ Trust the pilot to do her job correctly.
___ Ditto for the copilot.
___ Trust that any number of mechanics did their jobs correctly.
___ Trust that the air traffic controllers were competent and on task.
___ Trust that the ground control personnel were competent and on task.
___ Trust that the manufacturers of the airplane’s components were capable and trustworthy.

___ Trust that no one in any of those roles cut corners on safety to save money or effort, or for any other reason.

_x_ All of the above.

Biology 115D Schulze 2023
Evolution, Behavior, & Ecology Exam #1

Name (printed) ____________________________________

I completed this exam in accordance with the Austin College academic integrity

policy. ________________________________ (your signature)

- Read each question carefully.
- If a question appears ambiguous, ask for clarification.
- Keep an eye on the clock. Do not get bogged down on difficult questions when relatively easy questions remain to be answered.
- Write legibly and try to confine your answers to the space provided. If you must have more space, continue elsewhere on the exam – but indicate that you have done so.

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1. Evolution is a result of three circumstances and one consequence of those circumstances. Define evolution, list the 3 circumstances, and explain how the consequence of those circumstances results in evolution. Use natural processes, not intentional human processes, as the basis of your explanation. (15 points)

The three circumstances are more offspring are born than the environment can support, individual offspring vary from one another, and some of that variation is heritable. The first consequence of this is that those offspring that happen to be best suited to surviving and reproducing in their environment will tend to leave the most offspring (this is natural selection). The consequence of natural selection is that more copies of some alleles than others will make it into the next generation. In other words, allele frequencies (and thus the composition of the gene pool) will change – which is the definition of Evolution.

(Evolution can also occur as a result of some other processes that we have studied, but this process is most important.)

2. Explain three reasons why genetic diversity persists within populations despite the processes that cause evolution. (15 points)

We discussed five.

Diploidy (zygotes that have two alleles for each gene) causes rare recessive alleles to persist in populations carried by herterozygotic individuals. Because these alleles are not expressed, they are not selected against.

Selection pressures can change with time, causing different alleles to be favored at different times. This can cause an allele that has become rare under one set of environmental conditions to become more abundant under a new set of conditions.

Some variation among alleles has not fitness consequences, so the various alleles are not selected for or against.

Mutations add new genetic variation to populations.

Sometimes heterozygotes have the highest fitness (higher than either homozygote). This causes heterozygotes to pass on both alleles, so both persist in the population.

Correct answers were indicated on the multiple choice questions. See my answers below to the questions that required brief written answers.

Multiple choice and similar questions. Choose the <u>single</u> best answer. Do not select 2 or more answers. (2 points unless noted otherwise)

3. Is a mutation ever helpful?
___ No, because mutations are random.
___ No, because mutations are rapidly eliminated in the next generation.
___ Yes, because some mutations increase fitness and genetic diversity of populations.
___ Yes, because mutations are only harmful when they are dominant.

4. Adaptive radiation is most likely if…
___ many reproductively-isolated populations exist
___ different populations experience different selective conditions
___ small numbers of individuals found the various populations
___ all the above
___ none of the above

5. The definition of an allele is …
___ an ancestral form of a gene.
___ a variant of a gene.
___ anything that causes a gene to give its bearer higher fitness.
___ all the above.
___ none of the above.

6. Which of the following is an example of an anatomical homology?

___ The vertical orientation of whale tail flukes (fins).
___ The pattern of gradual change in horse fossils.
___ The similarities in the body shapes of a shark and a whale.
___ The bones of your arm and a bird wing.
___ All the above
___ None of the above

7. Which is <u>most</u> likely to <u>reduce</u> the genetic diversity of a population?

___ mutations
___ gene flow
___ genetic drift
___ a bottleneck event
___ all the above
___ none of the above

8. Which is true of the guppies modeled in the guppy spot simulation

___ The males have bright spots after several generations when few predators are present because females select for bright males.
___ Camouflaged guppies always have the highest fitness.
___ The females are most brightly colored after several generations with predators present because the predators avoid the toxic females.
___ The males have bright colors when dangerous predators are present because the coloration serves as a warning that the males are toxic to predators.
___ All of the above.
___ None of the above.

9. Which of the following two organisms would you expect to have the most similar amino acid sequences in their hemoglobin molecules? (You do not need to know anything about hemoglobin, including what it is, to answer this question.)

___ a cat and a frog
___ a tiger and a leopard
___ a human and a trout
___ a salamander and an elephant
___ none of the above – none of them would be expected to have any similarities in the amino acid sequences of their hemoglobin molecules.

10. What is the <u>purpose</u> of a mutation?

___ To create new genetic variants.
___ To enable populations to develop genetic diversity.
___ To ensure that natural selection occurs.
___ Mutations do not have a purpose. They have consequences (effects), but do not occur on purpose.

11. Natural selection acts upon___________.

___ phenotypes
___ genotypes
___ recessive alleles
___ heterozygotes
___ homozygotes
___ None of the above

12. Which of the following is correct?

___ When sticklebacks move from lakes to the ocean, they lose their armor because in the ocean they need to maneuver quickly to catch prey.
___ When sticklebacks move from the ocean to lakes, they evolve more armor because armor protects them from freshwater predators.
___ When sticklebacks move from the ocean to lakes their teeth evolve from adapted to crushing to adapted to tearing.
___ All of the above.
___ None of the above.

13. The text discusses side-blotched lizards as an example of

___ molecular homology
___ frequency dependent selection
___ non-random mating
___ punctuated equilibrium
___ all the above
___ none of the above

14. Medical officials recommend flu and coronavirus vaccines, but if you get the shots you may still get ill. What is the basic reason (described in the assigned reading) that a flu shot may be ineffective?

The virus may have mutated since the vaccine was prepared. Your immune response to the vaccine may not be as effective against the new strain as against the strain that served as the basis for the vaccinie.

(Not this this has some similarities to but is not the same process as that responsible for antibiotic resistance.)

15. Choose the best scientific definition of theory.

___ Someone's idea regarding the workings of something.
___ An idea that may be right or wrong.
___ A hypothesis that has been proven correct.
___ An idea for which there is not yet any strong evidence.
___ A synonym for a hypothesis. In other words, all hypotheses are theories, and vice-versa.
___ A hypothesis that explains a great deal and is supported by extensive evidence.
___ None of the above.

16. If an individual has two different alleles for a gene that individual is

________________________________ for that gene.

17. Compared to large populations, small populations are at a higher risk for___________.

___ Mutation
___ Inbreeding depression
___ Natural selection
___ Heterozygosity
___ Gene flow
___ All of the above
___ None of the above

18. Is it possible to prove that every bluebird has blue feathers? Why or why not? (4 points)

No because you can never be certain that you have seen every bluebird.

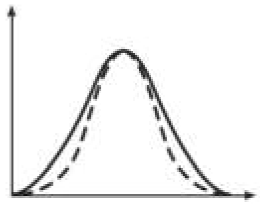
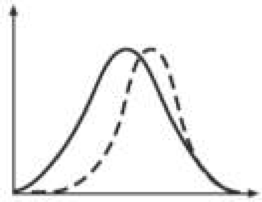
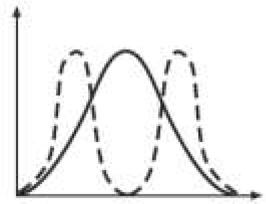
19. If the 10-meter width of our classroom represents the time since life first arose on Earth until the present, the most recent two hundred of years, since the beginning of the industrial revolution and thus the first substantial use of fossil fuels, the invention of plastics, electronics and the great majority of toxic chemicals, the invention of air travel and space flight, etc. all occurred in the last

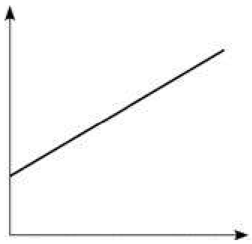
____ 1 meter
____ 1 centimeter (a bit less than ½ inch)
____ 1 millimeter (about the width of a pen tip)
____ 100 micrometers (about the width of a piece of paper)
____ 1 micrometer (about $1/20^{th}$ of the diameter of a human hair)

20. Which of the following is true of mutations

____ As far as anyone can tell they occur randomly
____ When expressed in the phenotype they are more likely to reduce than increase individual fitness
____ They are the ultimate source of new genetic variation
____ They increase the genetic diversity of populations and thus the potential of populations to evolve in response to new circumstances
____ All the above
____ None of the above

21. Which graph (some may be on the next page) represents directional selection? [The solid line is the earlier situation. The dotted line is the later situation. The x-axis is a quantitative (numerical) measure of the phenotype. The y-axis is the frequency of individuals with any given x-axis value.]

A___  B___  C ___ 

D___  E___ None of the above.

22. Which of the following examples was described as a case of stabilizing selection?
___ horn lengths of longhorn cattle.
___ selection for sickle cell heterozygotes in areas with malaria.
___ beak depths of Galapagos finches on the island Daphne Major.
___ birth weight of human babies.
___ all the above.
___ none of the above.

23. Inbreeding is harmful because it
___ maximizes the chance that deleterious dominant alleles will occur in homozygotes
___ maximizes the chance that deleterious dominant alleles will occur in heterozygotes
___ maximizes the chance that deleterious recessive alleles will occur in heterozygotes
___ causes mutations
___ all the above
___ none of the above

24. What is <u>*the*</u> key characteristic of science done well?
___ Science focuses upon natural phenomena.
___ Science is based on running controlled experiments.
___ Science is restricted to questions of great importance to society.
___ Science focuses on natural processes
___ All of the above
___ None of the above are the key characteristic of science done well.

25. Convergent evolution requires
___ that humans determine which individuals survive and reproduce.
___ recent common ancestors.
___ similar selective forces acting upon different species.
___ complex organisms such as vertebrates.
___ All of the above.
___ None of the above.

26. Genetic drift is most important to ___________ populations.

___ small
___ large
___ adaptive
___ migratory
___ nonmigratory

27. Succinctly but precisely explain the difference between the definitions of a species and a population.

A species is a group of organisms with the potential to produce fertile offspring under natural conditions if they have an opportunity to do so.

A population is a group of organisms with both the potential and opportunity to produce fertile offspring under natural conditions.

28. Which of the following does ***not*** make sense given the logic of evolution by natural (question should have said "or artificial") selection and what you have learned about the species in question?

___ Commercial fishing with nets will lead to an increase in the size a maturity of harvested fish species.
___ If an El Niño causes a drought in the Galapagos Islands, then the bills of the finches on Daphne Island will evolve to a larger size.
___ If a new antibiotic is invented and widely used, it will eventually become useless.
___ If a new herbicide is invented to replace Roundup and widely used, weeds will eventually become resistant to it.
___ None of the above make sense.
___ All of the above make sense.

29. What is the difference between micro- and macroevolution?

___ Microevolution describes the evolution of small organisms, such as insects, while macroevolution describes the evolution of large organisms, like people and elephants.
___ Microevolution describes the evolution of microscopic entities, such as molecules and proteins, while macroevolution describes the evolution of whole organisms.
___ Microevolution describes the evolution of populations, while macroevolution describes the evolution of new species.
___ Microevolution describes the evolution of individual organisms over their lifetimes, while macroevolution describes the evolution of organisms over multiple generations.
___ None of the above. All the above are wrong.

30. Which of the following was used in class, the text, or simulations as example of directional selection?

___ horns of cattle
___ finch bills

___ ~~sizes of African Seedcracker finches~~
___ peppered moths
___ all the above
___ none of the above

31. Which of the following does not cause evolution?
___ genetic drift
___ use of herbicides
___ gene flow
___ mutations
___ commercial fishing
___ All of the above cause evolution.
___ None of the above cause evolution.

32. An individual's complete set of genes is its __________________________________.

33. The expression of an individual's genes is that individual's ____________________.

34. Which of the following ***does not prevent*** evolution from resulting in perfect organisms?
___ The environment frequently changes and natural selection has no means of anticipating changes.
___ Natural selection can only act upon existing genetic variation (can only select for or against individuals with existing traits).
___ Adaptations involve trade-offs.
___ All of the above prevent evolution from resulting in perfect organisms.
___ None of the above prevent evolution from resulting in perfect organisms.

35. Fitness (as the term is used by evolutionary biologists) *is*
___ the relative number of offspring an individual contributes to the next generation.
___ an organism's strength.
___ the age at which an organism dies.
___ the average life span of an individual's offspring.
___ all the above.
___ none of the above.

36. *Deleterious recessive* alleles accumulate in populations because of all the following except
___ Since they are recessive they cannot affect an organism's fitness and therefore are never selected against.
___ Unless inbreeding occurs, they are rarely expressed and therefore are rarely selected against.
___ Mutations are often harmful.
___ Most large populations are not inbred, they are outbred, because evolution selects against inbred mating.
___ All of the above are false.
___ None of the above are false. All the above statements are correct.

37. Neotropical birds called Jacanas are unusual in that the males raise the young. Based on just that information and your understanding of evolution, it is safe to predict that

____ the population is undergoing disruptive selection.

____ the population will go extinct because the male's behavior will be selected against and all the males display the same behavior.

____ the males are choosier than the females when selecting mates.

____ the population is undergoing directional selection.

____ all the above

____ none of the above

Some common fall-flowering plants that we may encounter during our pollination lab

Flowers in this guide are arranged by color.
Some species produce flowers in a variety of colors, and are therefore included more than once in this guide.

The next page has some notes on three genera that are difficult to distinguish

How to distinguish *Impatiens, Phlox*, & *Vinca*

Growing in heavy shade and/or serrated leaf edges -> Impatiens

Growing in full or partial sun and smooth leaf edges -> Phlox or Vinca

Leaves relatively long and narrow -> Phlox

Leaves teardrop shaped or small (1” long or so) -> Vinca

Impatiens flowers are flat when viewed from the side, while Vinca flowers appear bell-shaped when viewed from the side.

Pink, Purple, & Blue Flowers

Pennsylvania smartweed, *Polygonum pennsylvanicum*, lower 48 native

https://www.wildflower.org/gallery/species.php?id_plant=POPE2

Basil, *Ocimum basilicum*, non-native

http://blackgold.bz/wp-content/uploads/2013/04/Ocimum-basilicum-Cinnamon-JaKMPM.jpg

http://www.howtogrowbasil.com/wp-content/uploads/2013/09/holy_basil_flower-750x380.jpg

Mint, *Mentha longifolia,* non-native

https://en.wikipedia.org/wiki/Mentha#/media/File:Mint_2014-06-01_00-53.jpg

https://jekkasherbfarm.files.wordpress.com/2012/04/pm31-mint-tashkent-flower.jpg

Passion flower, *Passiflora*, lower 48 native

http://f.tqn.com/y/houseplants/1/W/Y/2 /-/-/Passion-Flower.Verdesam.Flickr.jpg

http://www.hotel-r.net/im/hotel/it/la-passiflora-13.jpg

Obedient plant, lower 48 native

http://aggie-horticulture.tamu.edu/ornamentals/cornell_herbaceous/plants/Physostegiavirginiana2096.jpg

http://www.missouribotanicalgarden.org/PlantFinder/FullImageDisplay.aspx?documentid=2515

Rock rose, *Pavonia lasiopetala*, lower 48 native

http://www.wildflower.org/gallery/result.php?id_image=23593

http://www.wildflower.org/plants/result.php?id_plant=PALA13

Texas Sage, lower 48 native

http://1.bp.blogspot.com/-8-2790n-SQ0/ULQs9mbPHVI/AAAAAAAAJHo/I8BARVjkiak/s1600/Driveway+sage,+mfg,+autumn+sage+(2048x1365).jpg

http://www.sbs.utexas.edu/bio406d/images/pics/scr/Leucophyllum%20frutescens%20flor.jpg

Butterfly penta, non-native

http://www.magicoflife.org/flower_photos/Pentas.html

http://www.zilkergarden.org/gardens/blooming/blooming2010Aug.html

Mexican bush sage, non-native

http://www.klru.org/ctg/wp-content/uploads/2014/09/mexican_bush_sage.jpg

http://agrilifecdn.tamu.edu/etg/files/2011/10/Salvia_leucantha_close_copy.jpg

Mist flower, lower 48 native

http://monarchbutterflygarden.net/wp-content/uploads/2013/07/mass-monarchs-mistflower-dale-clark.jpg

http://npsot.org/wp/wp-content/uploads/2009/09/blue_mistflower.jpg

Crepe Myrtle, horticulure

- http://www.fast-growing-trees.com/CrapeMyrtles.htm
- http://fineartamerica.com/featured/purple-crape-myrtle-close-up-zulfiya-stromberg.html

Western Ironweed, *Vernonia baldwinii, lower 48 native*

https://courses.missouristate.edu/pbtrewatha/western_ironweed.htm

https://courses.missouristate.edu/pbtrewatha/western_ironweed.htm

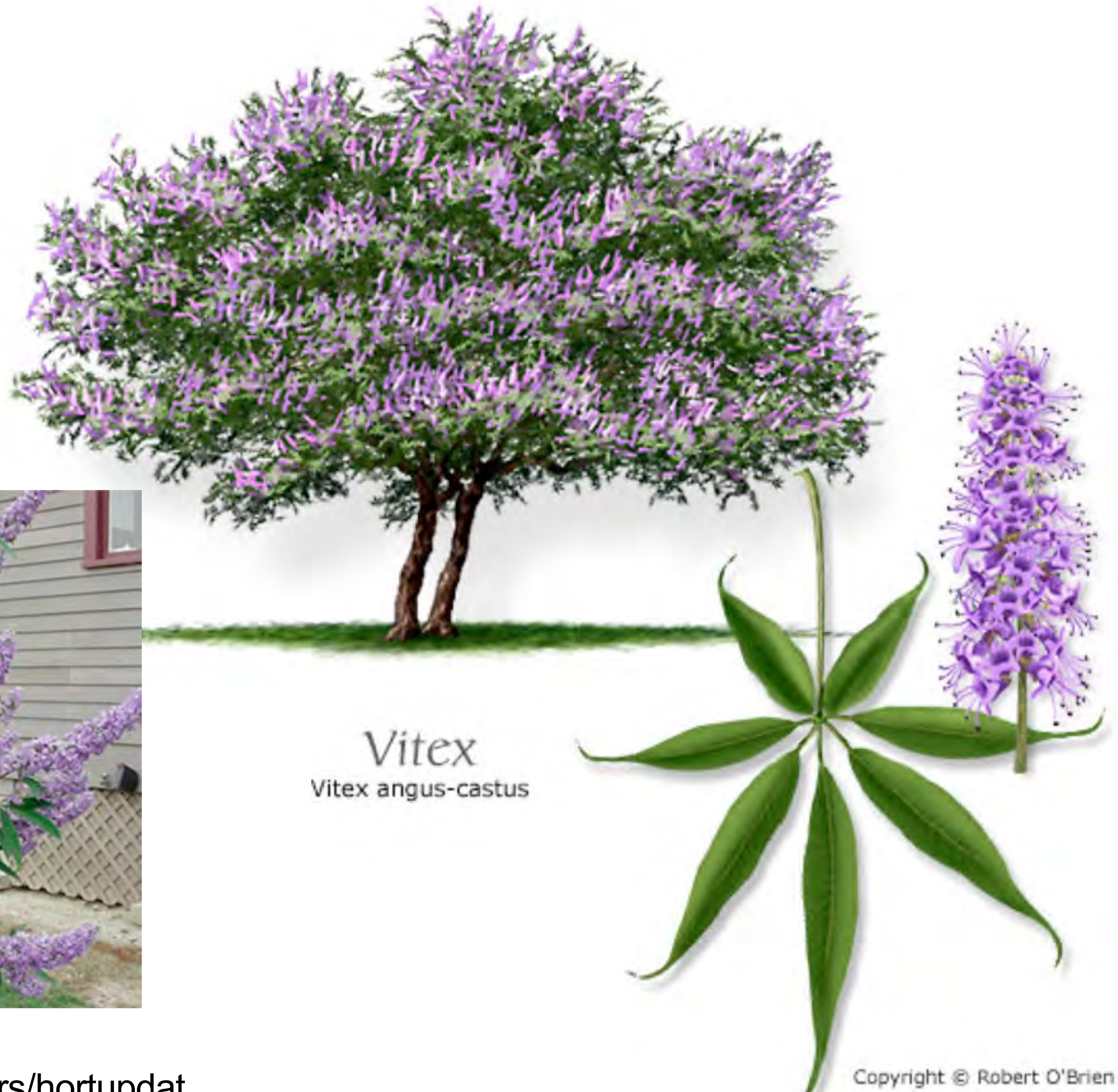
Cat mint, *Nepeta cataria*, non-native

[http://pantrygardenherbs.com/files/2011/02/Catmint-](http://pantrygardenherbs.com/files/2011/02/Catmint-Walkers-Low.jpg)
Walkers-Low.jpg

[http://fay.iniminimo.com/her](http://fay.iniminimo.com/herb_pics/catmint_close4.jpg)
b_pics/catmint_close4.jpg

Vitex (Chaste tree), lower 48 native

http://aggie-horticulture.tamu.edu/newsletters/hortupdate/2008/jun08/Vitex.jpg



http://texastreeplanting.tamu.edu/treepictures/vitex.jpg

Fall aster, lower 48 native

http://i2.wp.com/austinnativelandscaping.com/site/wp-content/uploads/2011/07/Symphyotrichum-oblongifolium_Fall_Aster_Aromatic__Flowerbed_Design_Xeriscape_Plants.jpg

http://austinnativelandscaping.com/site/Pictures/Fall_Aster_Texas_Native_Landcape_Designer.jpg

Liriope, horticulture

https://extension.msstate.edu/sites/default/files/sg100826_200.jpg

http://m1.i.pbase.com/o4/26/411626/1/66427091.sWYqoUZw.060905001Liriope.jpg

Fragrant phlox, *Phlox Pilosa, lower 48 native*

http://grownative.org/plant-picker/plant/downy-phlox/

http://wisflora.herbarium.wisc.edu/taxa/index.php?taxon=4483

Zinnia, horticulture

http://www.fortticonderoga.org/blog/wp-content/uploads/2013/12/DSC04725.jpg

http://www.lifeseedcompany.com/sites/default/files/01878.01.G.DahliaViolet.cat_.jpg

Lantana, non-native

https://mtlawleyshire.files.wordpress.com/2012/07/photo-challenge_purple_11.jpg

http://img08.deviantart.net/1bc4/i/2013/342/6/8/purple_lantana_lantana_montevidensis___by_kiloueka-d6x8fu0.jpg

Mealy blue sage, lower 48 native

https://en.wikipedia.org/wiki/Salvia_farinacea

Pansy, horticulture

http://previews.123rf.com/images/dancaskey/dancaskey1206/dancaskey120600002/14219881-field-of-pansies-Stock-Photo.jpg

https://sanctuarywithoutwalls.files.wordpress.com/2011/04/pansy-purpleblue.jpg

Prairie spiderwort, *Tradescantia occidentalis*, lower 48 native

https://www.wildflower.org/gallery/species.php?id_plant=TROC

Meely Sage, *Salvia farinacea*, lower 48 native

http://www.wildflower.org/gallery/result.php?id_image=8870

Pansy, horticulture

http://www.asergeev.com/pictures/archives/2016/1778/jpeg/10.jpg

https://s-media-cache-ak0.pinimg.com/564x/e9/ac/bd/e9acbd4813e66ba1deeb08b0f5c4ca06.jpg

Asiatic dayflower, *Commelina communis*, non-native

https://www.illinoiswildflowers.info/weeds/plants/asia_dayflower.htm

Orange & Yellow Flowers

Mexican Hat, lower 48 native

Lantana, non-native

- http://austinnativelandscaping.com/lantana-urticoides-texas-lantana/
- http://www.gardencrossings.com/_ccLib/image/plants/IONE-1276.jpg

Zinnia, horticulture

http://www.benary.com/article-images/zinnia-elegans-zinnita-orange-y1630-2.jpg

https://palmraeurbanpotager.files.wordpress.com/2013/07/2011-front-yard-orange-zinnia-veggies-sept-9th-011_edited-1.jpg

Lantana, non-native

http://www.ceapdesign.com.br/images/familias_botanicas/verbenaceae/lantana_montevidensis.jpg

http://homelygarden.com/img/pot_flower_lantana_73_279.jpg

Zinnia, horticulture

http:/ / www.parkswholesaleplants.com/ wp-content/uploads/2009/03/zinnias9.jpg

http://www.applewoodseed.com/wp-content/uploads/2013/12/ZECB-1001.jpg

Partridge Pea, lower 48 native

http://grownative.org/wp-content/uploads/2012/11/partridge_pea_mat.jpg

https://www.minnesotawildflowers.info/flower/partridge-pea

Pansy, horticulture

http://budujesz.info/pliki/image/artykuly/nasiona/duze/zolte-bratki-z-czarnym-srodkiem4789.jpg

http://mabtongarden.com/files/2013/10/yellow-n-brown-pansy.jpg

Canada Goldenrod, *Solidago canadesis,* lower 48 native

http://www.sustainable-gardening.com/images/goldenrod300_000.jpg

http://www.plantsystematics.org/users/kcn2/9_12_04/2004_09_12_up/Solidago_canadensis_1.jpg

Lindheimer's Senna, *Senna lindheimeriana*, lower 48 native

https://www.gardensource.org/products/lindheimer-senna

http://sites.stedwards.edu/biodiversityconservation-fall2016/2016/09/06/lindheimers-senna/

Maximilian Sunflower, lower 48 native

http://2.bp.blogspot.com/-Ft30V4_jkuk/UkSoC3tSX5I/AAAAAAAAChE/w7XnatPH9lU/s1600/DSCN2118.JPG

http://rockies.audubon.org/sites/g/files/amh431/f/wp-content/uploads/2013/10/maxsunflower.jpg

Zexmenia, lower 48 native

https://austintexas.gov/sites/default/files/Zexmenia.jpg

http://www.wildflower.org/image_archive/640x480/JAM6151/6151_IMG03399.JPG

Black-eyed Susan, *Rudbeckia hirta*, lower 48 native (also called Brown-eyed Susan)

http://www.bio.brandeis.edu/fieldbio/Sylvain/susan.html

http://www.bio.brandeis.edu/fieldbio/Sylvain/susan.html

Butterfly bush, non-native

http://www.theplantingtree.com/media/catalog/product/cache/1/image/1920x/043d080fa2c94223fead33caa313382/h/o/honeycomb-butterfly-bush--5.jpg

http://www.wholesaleplants.biz/Plant%20Database/Butterfly%20Bush/'Honeycomb'%20Butterfly%20Bush.jpg

Yellow dill, *Anethum graveolens*, non-native

http://www.mariquita.com/recipes/dill.html

White Flowers

Texas Sumac, *Rhus lanceolata,* lower 48 native

https://www.wildflower.org/gallery/species.php?id_plant=rhla3

Bee-brush, *Aloysia gratissima,* lower 48 native

https://www.wildflower.org/plants/result.php?id_plant=algr2

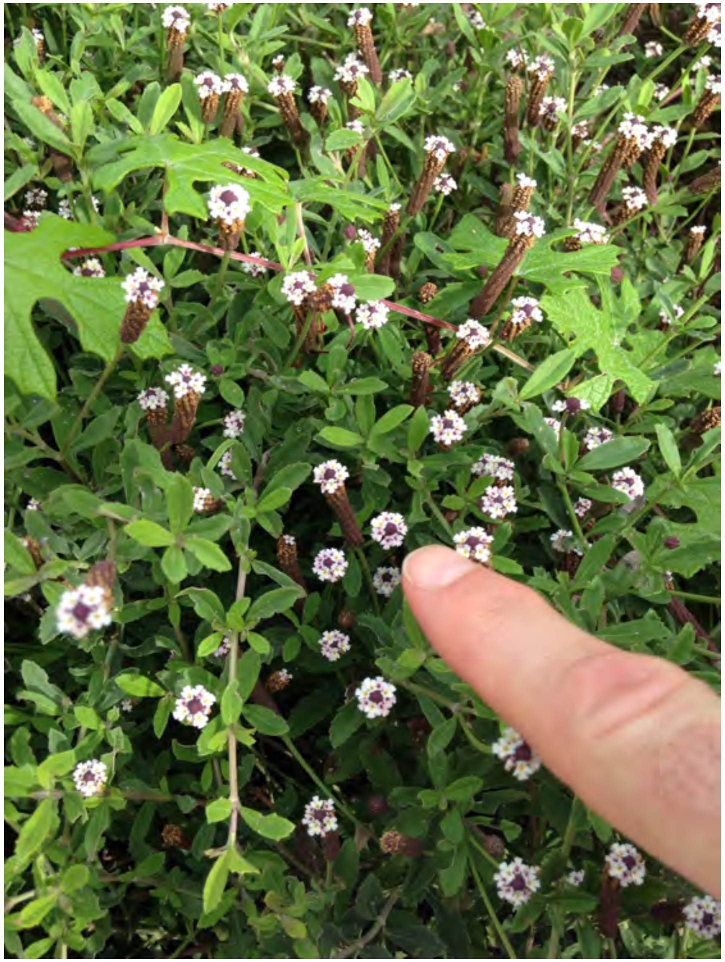
http://www.backyardnature.net/n/w/aloysia.htm

Angel trumpet, *Datura wrightii*, lower 48 native

http://swbiodiversity.org/seinet/taxa/index.php?taxon=Datura%20wrightii

https://es.wikipedia.org/wiki/Datura

Frog fruit, lower 48 native



Lantana, non-native

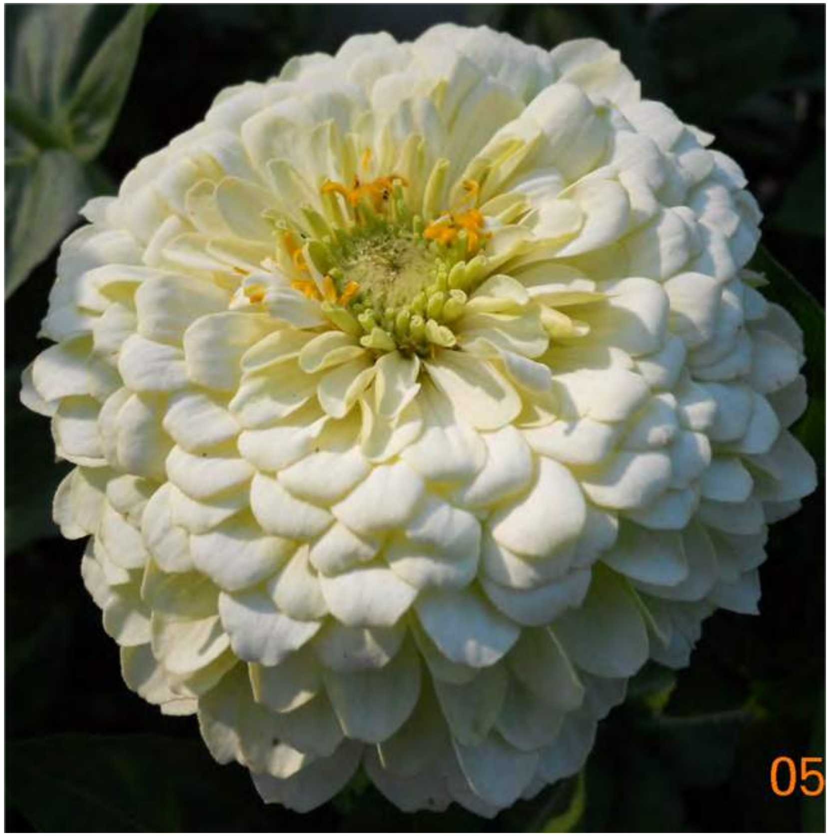
http://www.brownswoodnursery.com/uploads/1/0/3/7/10377456/5364841.jpg

http://www.morrisplantnursery.com/uploads/7/9/3/3/7933273/s213617356499155040_p58_i1_w2048.jpeg

Zinnia, horticulture

https://www.edenbrothers.com/store/media/Seeds-Flowers/resized/SFZIN123-1_medium.jpg

http://4.bp.blogspot.com/-A4Yzoy4wen0/TeFyB4RJ9wI/AAAAAAAAAZU/KOoPja1ax6g/s1600/DSCN4897.JPG



Pansy, horticulture

http://previews.123rf.com/images/dancaskey/dancaskey1206/dancaskey120600002/14219881-field-of-pansies-Stock-Photo.jpg

http://huntersgardencentre.com/wp-content/uploads/2010/10/Pansy-Field-Grown-White-and-Purple.jpg

Glossy Abelia, non-native

http://www.plantes-et-nature.fr/11656-thickbox_default/abelia-grandiflora-semperflorens-abelia-a-grandes-fleurs-semperflorens.jpg

http://gardenblog.winterthur.org/wp-content/uploads/2012/08/glossy-abelia-close-up-august-14-2012-kls-005.jpg

Kidneywood, lower 48 native

http://www.discounttreesofbrenham.com/files/8314/2592/4046/Tx_Kidneywood.JPG

http://aggie-horticulture.tamu.edu/ornamentals/natives/shrubs/eysentex3846.jpg

Lindheimer's beeblossom, *Oenothera lindheimeri, lower 48*

http://www.southwestdesertflora.com/Website Folders/Images/ Onagraceae/Gaura%20lindheimeri,%20Lindheimer's%20Beeblossom/3988Gaura-lindheimeri,-Lindheimer's-Beeblossom700x467.jpg

http://worldoffloweringplants.com/wp-content/uploads/2014/11/Oenothera-lindheimeri-Indian-Feather1.jpg

Red Flowers

Standing cypress, *Ipomopsis rubra,* lower 48

https://www.inaturalist.org/taxa/62659-Ipomopsis-rubra

https://nativelubbock.org/

Crossvine, *Bignonia capreolata,* lower 48 native

https://www.monrovia.com/plant-catalog/plants/358/tangerine-beauty-crossvine/

https://www.tnnursery.net/cross-vine-plant-for-sale/

Coral honeysuckle, *Lonicera sepervirens*, lower 48 native

http://vnps.org/wildflowers-of-the-year/wildflower-year-2014-coral-honeysuckle-lonicera-sempervirens/

https://www.wildflower.org/gallery/result.php?id_image=23147

Autumn sage, *Salvia greggii,* lower 48 native

https://delange.org/AutumSage/AutumSage.htm

http://publicgarden.ucdavis.edu/public-garden/what-to-do-in-your-garden-this-march

Crepe Myrtle, horticulture

https://www.thetreecenter.com/flowering-trees/crape-myrtle-trees/

https://www.reference.com/home-garden/crepe-myrtles-bloom-32839ef4fec915fa

Lantana, non-native

https://www.business.qld.gov.au/_data/assets/image/0013/226300/Red-and-yellow-lantana-flowers.JPG

http://2.bp.blogspot.com/-wR4vh1mLac4/UiVXA0P7K2I/AAAAAAAAMdk/a2S9HXDW5ZQ/s1600/IMG_0194+blog.jpg

Zinnia, horticulture

http://i.parkseed.com/images/xxl/04708-pk-p1.jpg

http://imgsplanet.com/pics/main/58/412413-zinnia.jpg

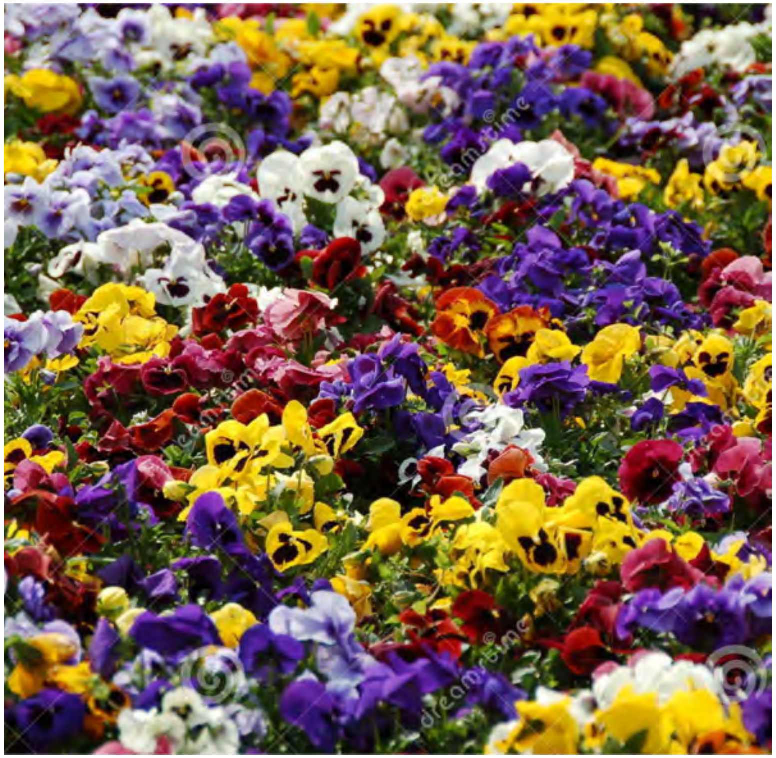
Rose, horticulture
(also in other colors)

http://images.rapgenius.com/1xacr30miprrfynxkl8adsf13.600x432x1.jpg

https://upload.wikimedia.org/wikipedia/commons/5/51/Small_Red_Rose.JPG

Pansy, horticulture (also in other colors)

https://thumbs.dreamstime.com/z/pansy-field-3100861.jpg



http://www.weathercharts.org/lucypaintbox/Photo-gallery-plants-pansy/pansy-0607-4567-lucy-paintbox.jpg

Turk's Cap, lower 48 native

http://texassuperstar.com/plants/malvaviscus/
Malvaviscus-Big-Momma.JPG

http://farm5.static.flickr.com/4149/5004017567_
1a09055442.jpg

Flame Acanthus, lower 48 native

http://maasnursery.com/wp-content/uploads/2014/08/flame-acanthus.jpg

http://aggie-horticulture.tamu.edu/ornamentals/natives/shrubs/anisq-v-wr9834.jpg

Salvia greggi (Autumn sage), lower 48 native

http://www.dallasplanttrials.org/_ccLib/image/articles/DETA1-66.jpg

http://www.wildflower.org/gallery/result.php?id_image=8874

Hot lips *Salvia*, lower 48 native

https://www.anniesannuals.com/signs/s
/images/salvia_hot_lips_02.jpg

https://en.wikipedia.org/wiki/Salvia_microphyll
a#/media/File:Salvia_microphylla_neurepia.jpg

Cypress vine, *Ipomoea quamoclit*, non-native

http://i.parkseed.com/images/xxl/03307-pk-p1.jpg

https://heartlandgardening.files.wordpress.com/2012/10/ipomoea-quamoclit-sept-12-crop.jpg