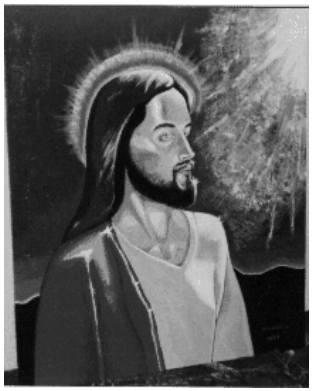
Some Evidence of Evolution

Pre-Darwin western Christian thought



- Life arose by special creation
- Organisms were formed as we find them today
  - That is species do not change
- Believed to be recent
  - In 1664 Archbishop James Ushher calculated that the earth was 5668 years old
  - 26th of October, 4004 B.C., 9 AM

Facts and Inferences

- Facts are observable things
- Inferences are extensions to what is not directly observed

Claims of special creation

- Species created independently
- Species do not change through time
- Created recently

- Process inferred from those claims is that some God did it

Claims of Darwin

- Species change through time
- Species related to each other as ancestor-descendant
- Life on earth is ancient

- Process inferred: ‘descent with modification’
- Process of adaptation: ‘natural selection’

Any evidence?

- Are species independent?
- Are they unchanging?
- Is life recent?

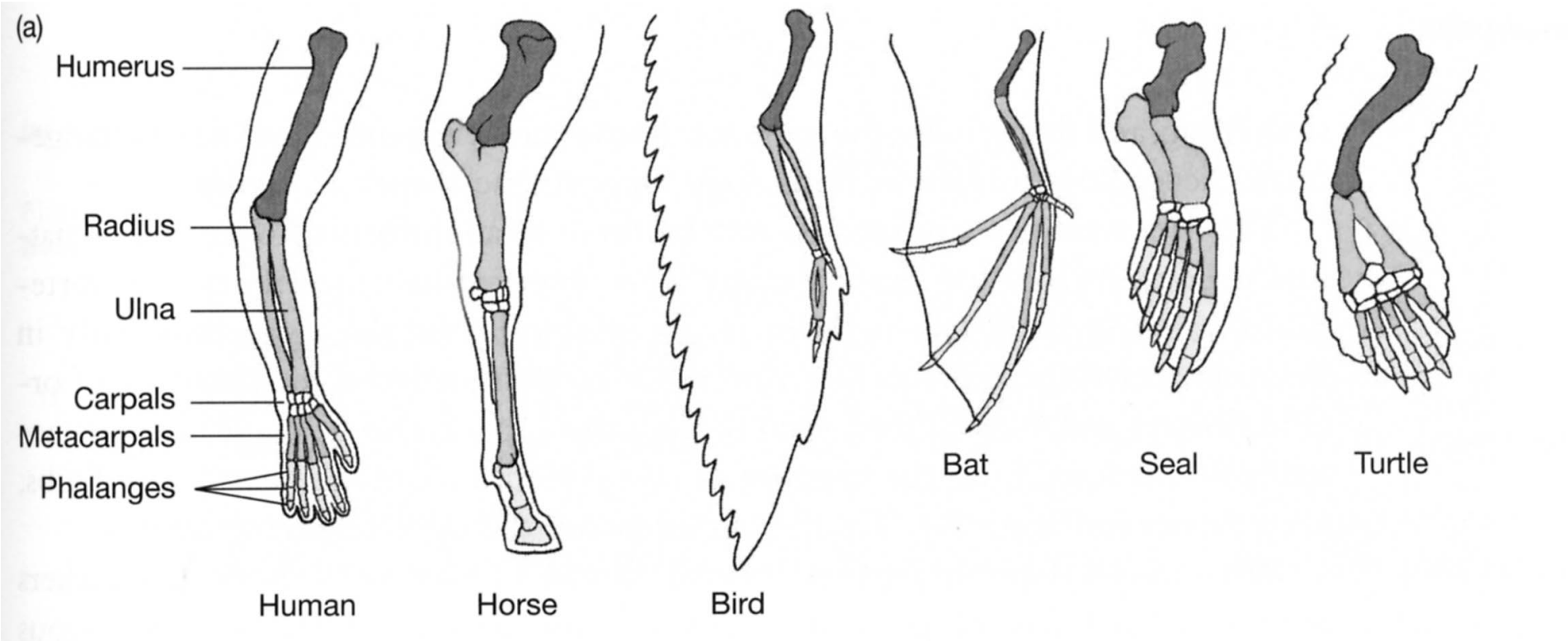
Are species independent, or do they show shared ancestry?

- Shared ancestry proposed before Darwin
  - Comte de Buffon, Erasmus Darwin, Jean-Baptiste Lamarck
  - What Darwin provided was the mechanism of adaptive evolutionary change
    - Natural selection
- Comparative anatomy was basis

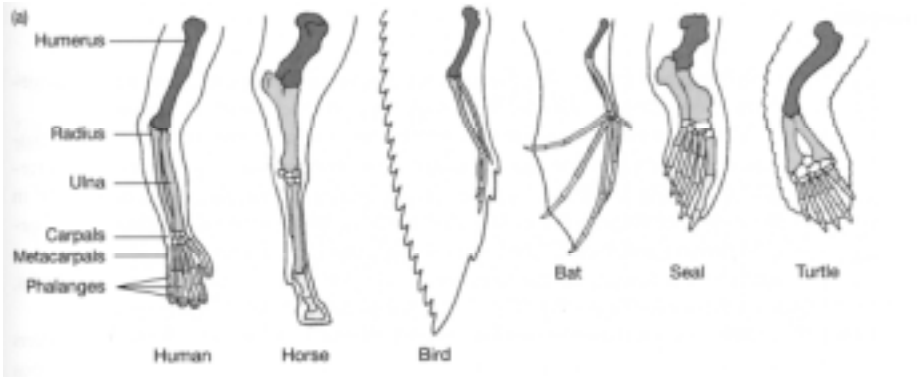
Homology and Analogy

- Homology (modern sense): similar by descent or ancestry
- Analogy: similar not by descent
  - In conversation: *'let me compare thee to a summers day'*
  - In biology: similar selection pressures produce similar adaptations
    - E.g. desert plants in N. America share many water saving features with other desert plants

Vertebrate forelimbs



Making sense of similarity



- If you built a flying limb from scratch, you would design it *differently* than you would design a swimming or grasping or running limb
- The similarity of structure *despite* very different function suggests similarity of origin
- Called structural homology

Other homology examples

- Embryology
  - Louis Agassiz (among others) showed that vertebrate embryos in early development are very similar
  - Early human embryos have structures like gills; also have a tail
- Called Developmental Homology

Human embryo with tail

Genetic Homology

- Structural homologies are similar because they share developmental homology
- Developmental homology is the result of genetic homology

‘Universal’ genetic code

(a)

First base	Second base: U			Second base: C			Second base: A			Second base: G			Third base
U	UUU	Phenylalanine	F	UCU	Serine	S	UAU	Tyrosine	Y	UGU	Cysteine	C	U
	UUC	Phenylalanine	F	UCC	Serine	S	UAC	Tyrosine	Y	UGC	Cysteine	C	C
	UUA	Leucine	L	UCA	Serine	S	UAA	Stop		UGA	Stop		A
	UUG	Leucine	L	UCG	Serine	S	UAG	Stop		UGG	Tryptophan	W	G
C	CUU	Leucine	L	CCU	Proline	P	CAU	Histidine	H	CGU	Arginine	R	U
	CUC	Leucine	L	CCC	Proline	P	CAC	Histidine	H	CGC	Arginine	R	C
	CUA	Leucine	L	CCA	Proline	P	CAA	Glutamine	Q	CGA	Arginine	R	A
	CUG	Leucine	L	CCG	Proline	P	CAG	Glutamine	Q	CGG	Arginine	R	G
A	AUU	Isoleucine	I	ACU	Threonine	T	AAU	Asparagine	N	AGU	Serine	S	U
	AUC	Isoleucine	I	ACC	Threonine	T	AAC	Asparagine	N	AGC	Serine	S	C
	AUA	Isoleucine	I	ACA	Threonine	T	AAA	Lysine	K	AGA	Arginine	R	A
	AUG	Start (Methionine	M)	ACG	Threonine	T	AAG	Lysine	K	AGG	Arginine	R	G
G	GUU	Valine	V	GCU	Alanine	A	GAU	Aspartic Acid	D	GGU	Glycine	G	U
	GUC	Valine	V	GCC	Alanine	A	GAC	Aspartic Acid	D	GGC	Glycine	G	C
	GUA	Valine	V	GCA	Alanine	A	GAA	Glutamic Acid	E	GGA	Glycine	G	A
	GUG	Valine	V	GCG	Alanine	A	GAG	Glutamic Acid	E	GGG	Glycine	G	G

Codon Amino acid Abbreviation

Genetic homology in homeodomain eye genes

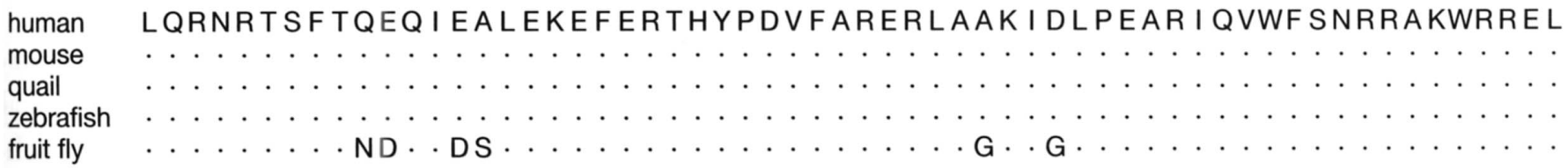


Figure 2.2 Genetic homologies (a) In almost every organism studied, the same nucleotide triplets, or codons, specify the same amino-acid bearing transfer RNAs. (b) This chart shows the amino acid sequences of a section called the homeodomain in a protein involved in the development of the eye (Quiring et al. 1994). Dots indicate the same amino acid as the one above.

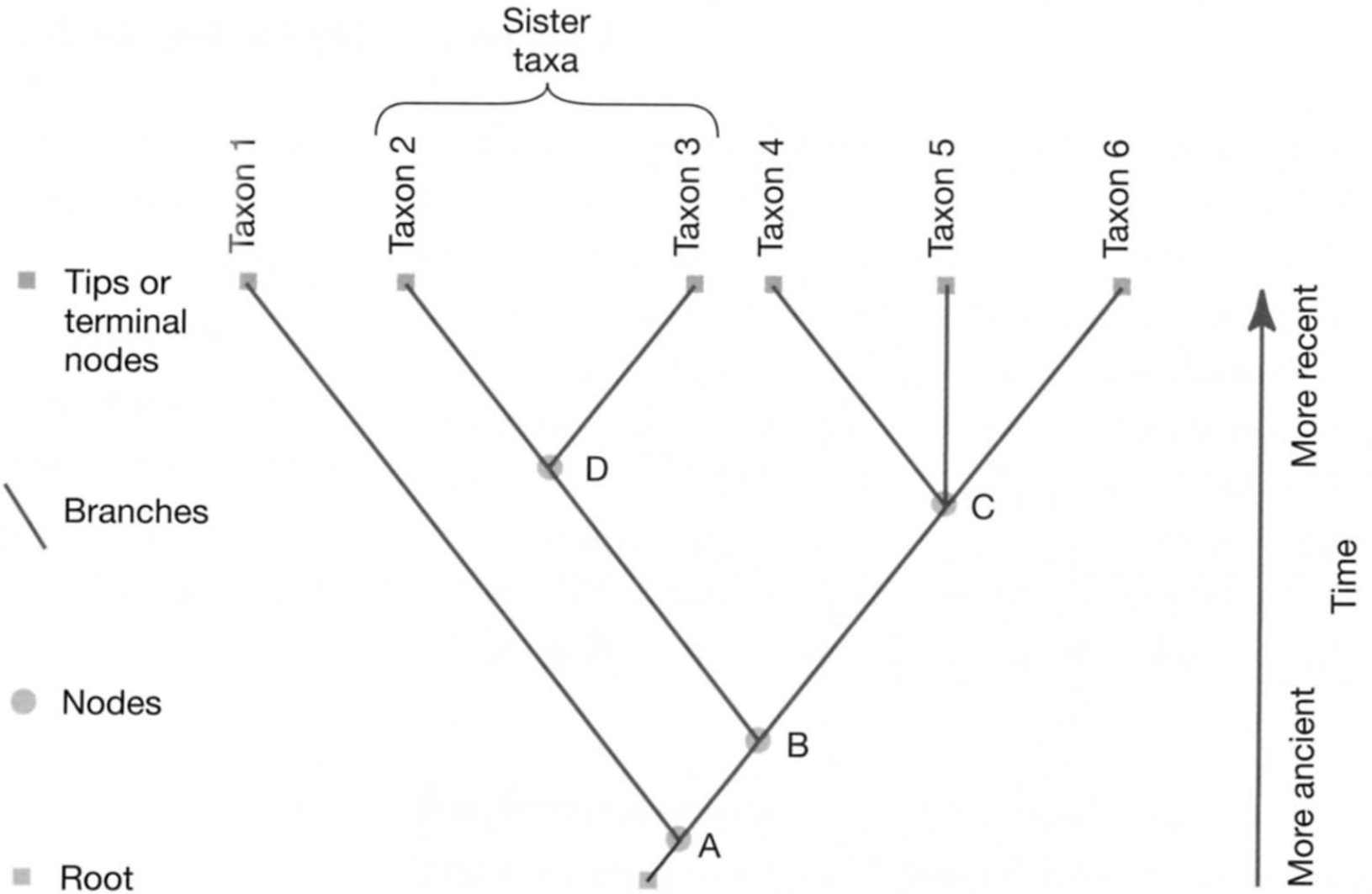
Thought question

- Biomedical researchers often seek treatments for human disease by doing experiment in other species (e.g. mice)
- How successful would they be if mice and humans did not share numerous homologies?

All this homology suggests shared ancestry

- Shared ancestry….what does that mean?
- Often said that “humans evolved from apes”
- People think that means that modern humans descended from modern apes
- Thoughts?

Phylogenetic tree: tips, branches, nodes



Parsimony

- Important principle of science
- Simply explanations are favored over complicated ones (Ockham's razor)
- In general English usage: less, or sparing
- In biology usage: requiring less evolutionary change

So a horse, a zebra and a chicken go into a bar……..

- Which is more parsimonious?
- The horse and the zebra are more closely related than either is to the chicken, or
- The chicken and the horse are more closely related than either is to the zebra

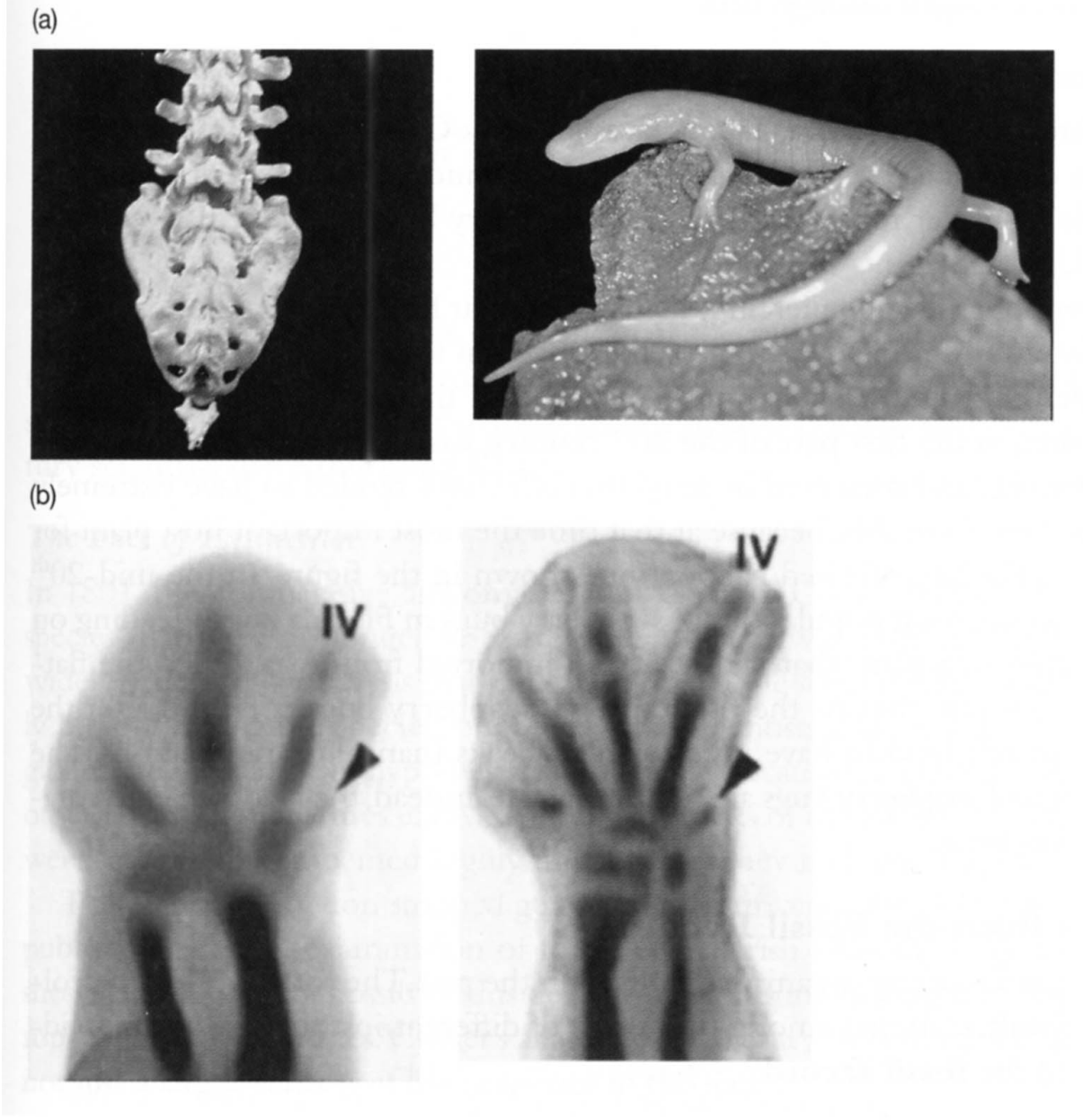
Do species change over time?

- Evidence from living species
  - Vestigial traits
  - Direct observation
  - Fossil record
- Evidence from fossils
  - Extinction
  - Transitional forms
  - Environmental change

Vestigial structures

- Vestigial structure: functionless or rudimentary ***homolog*** of a structure that has an important function in closely related species

Examples of vestigial traits



Also:

Your appendix

Wisdom teeth

Goose bumps

Vestigial traits can be:

- Structural
  - Tail bone in adult humans
- Developmental
  - Embryonic tail

Does it make sense to have a tail bone and an embryonic tail UNLESS your ancestors had tails?

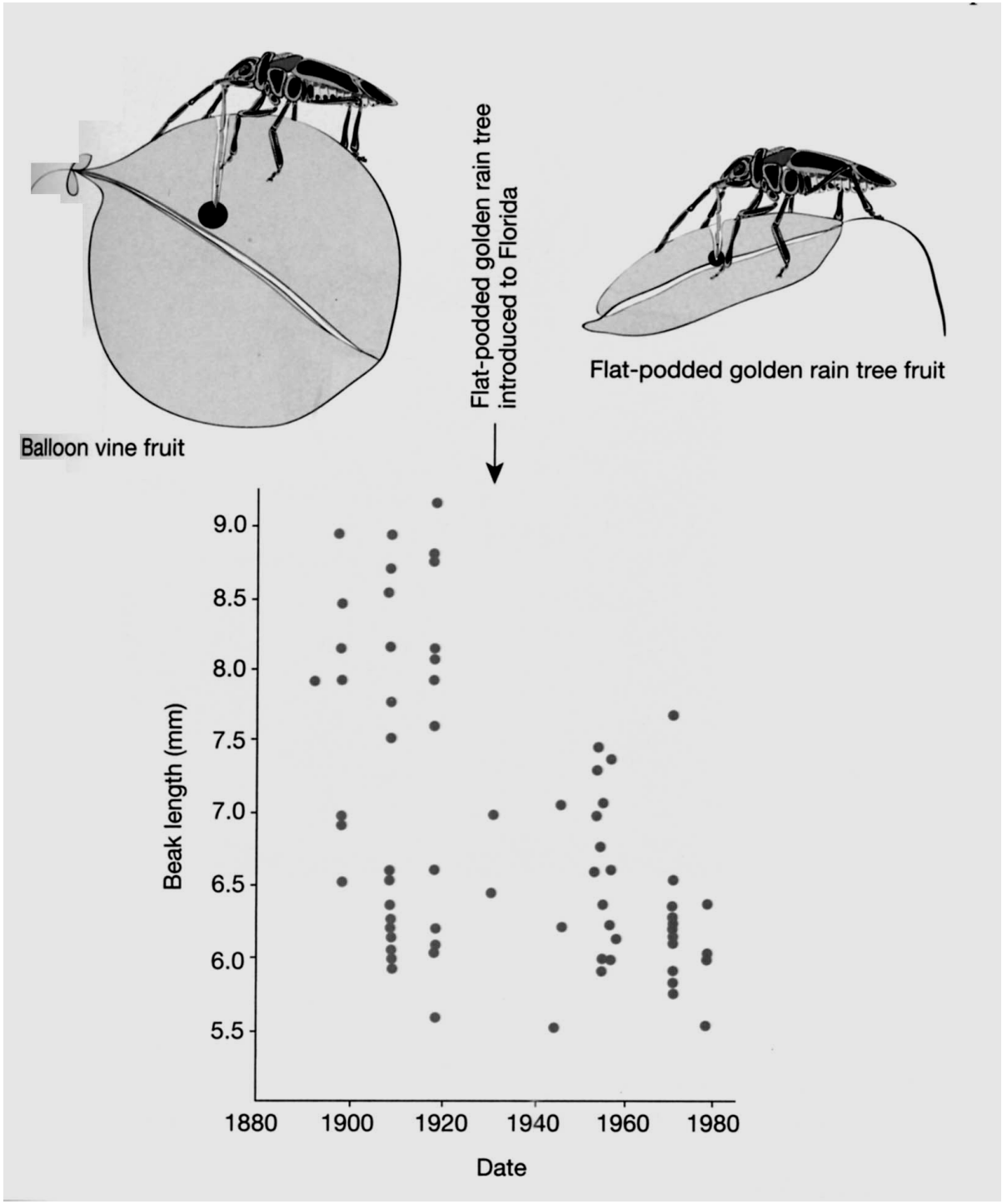
Vestigial Genes

- Genetic
  - Pseudogenes: nearly normal genes that are not transcribed to protein
  - E.g., psi-alpha locus of hemoglobin
  - Resembles that alpha locus but has a mutation that stops transcription

Direct observation of change over time

- Change from AZT susceptible to AZT resistant HIV strains repeatedly found within patients?
- 100’s of other examples, finch beaks being the most famous
- Soapberry bugs another good one

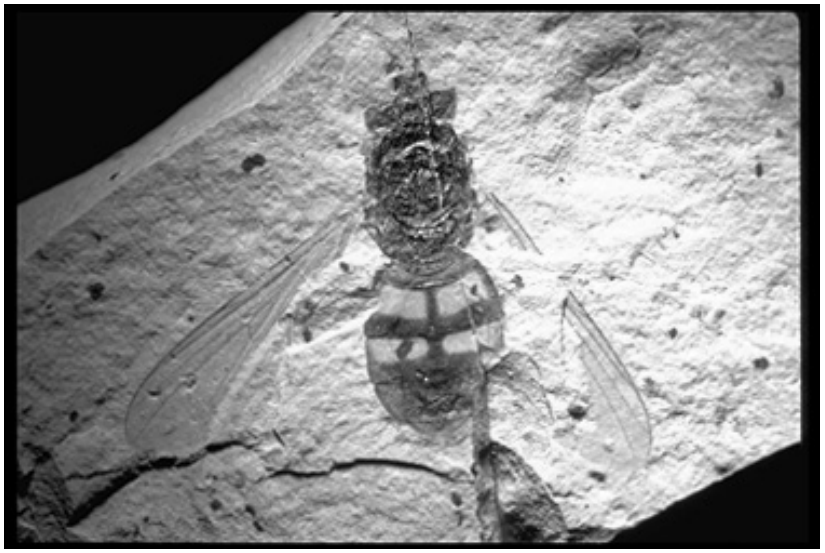
Soapberry bug beak length evolution



What about fossils?

Fossils provide three types of evidence for evolution

- Evidence of extinction
- Evidence of change of species through time
- Evidence of age of life



Extinction

- Was actually controversial in early 1800's
- By 1812 Cuvier published Irish Elk analysis

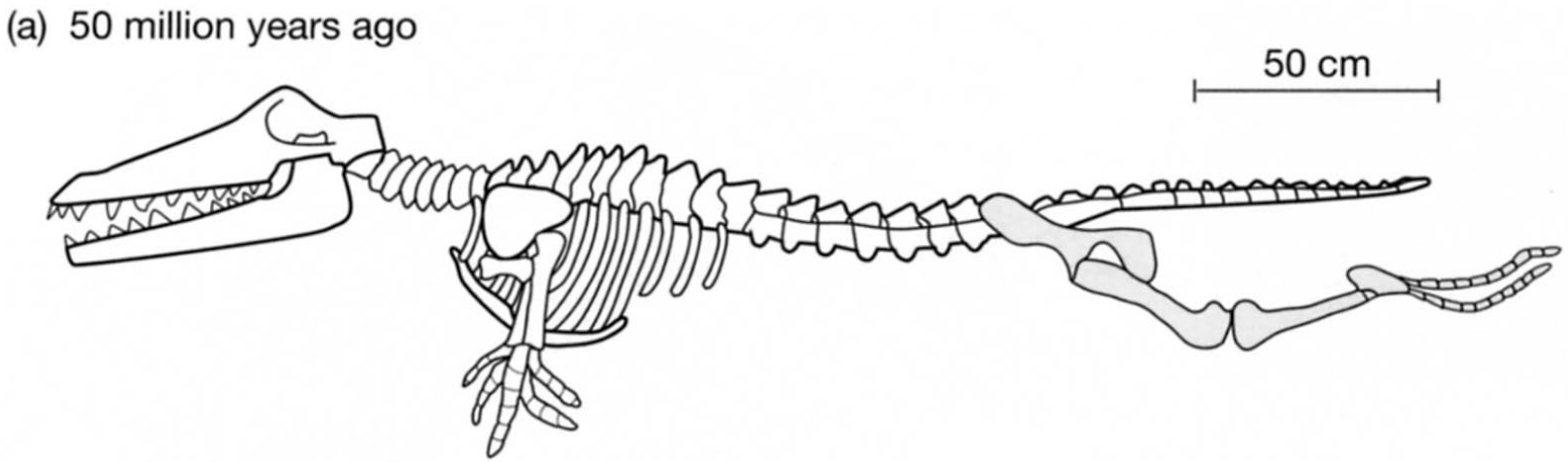
But how does the fact of extinction help the case for evolution?

- **Species do not persist indefinitely; that suggests life on earth changes**

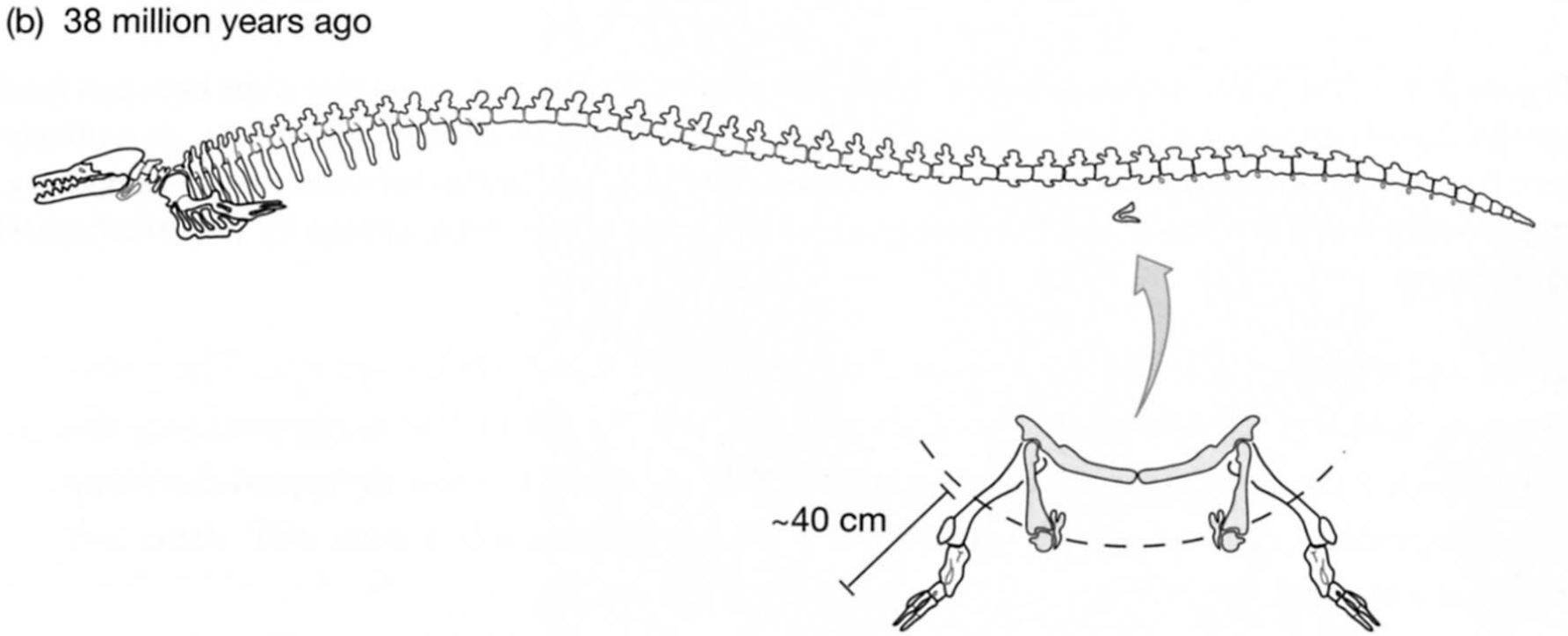
- **Fossils prove that life isn't set in stone**

Change through time: Transitional fossils

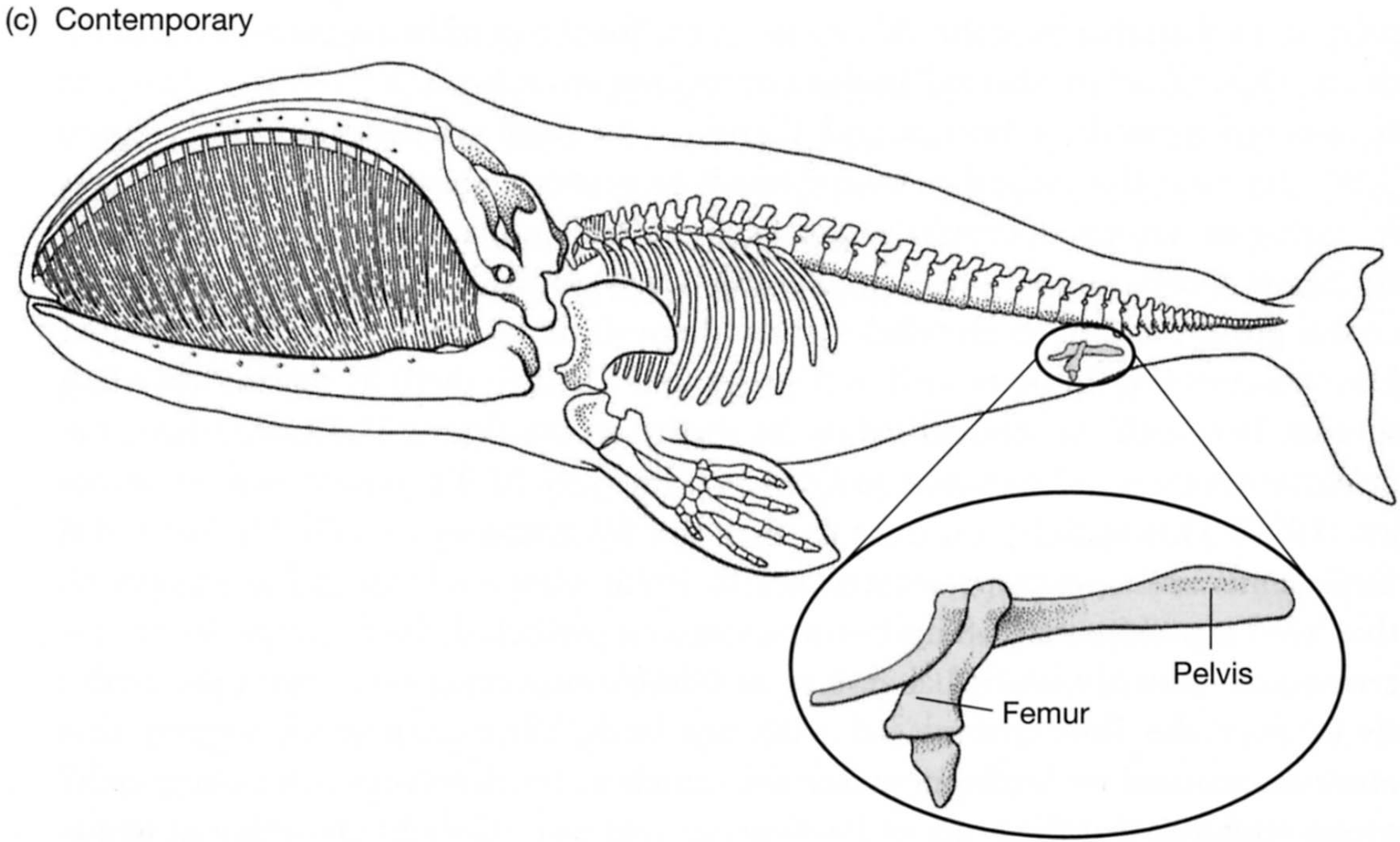
- Fossils species intermediate between modern living forms
- Fossil species intermediate between older and younger fossils, or older fossils and modern forms



Ambulocetus natans, ca. 50 mya, described 1994, from Pakistan



Basilosaurus isis, ca. 38 mya, described 1990, from Egypt



Modern baleen whale

Whale fossils from Egypt and Pakistan?

- Marine fossils found high and dry
  - Clearly, the earth changes
  - But does it change fast or slow?

- Before the late 1700's, change thought to be rapid, e.g. Biblical floods, other 'catastrophies'
  - Catastrophism: hypothesis of catastrophic rapid change

Geological Evidence

- James Hutton and Charles Lyell
- British geologists, actually set out to ***measure*** rates of geologic change (wow, science!)
- Determined that the rates of geologic change are very very slow

Why is that important?

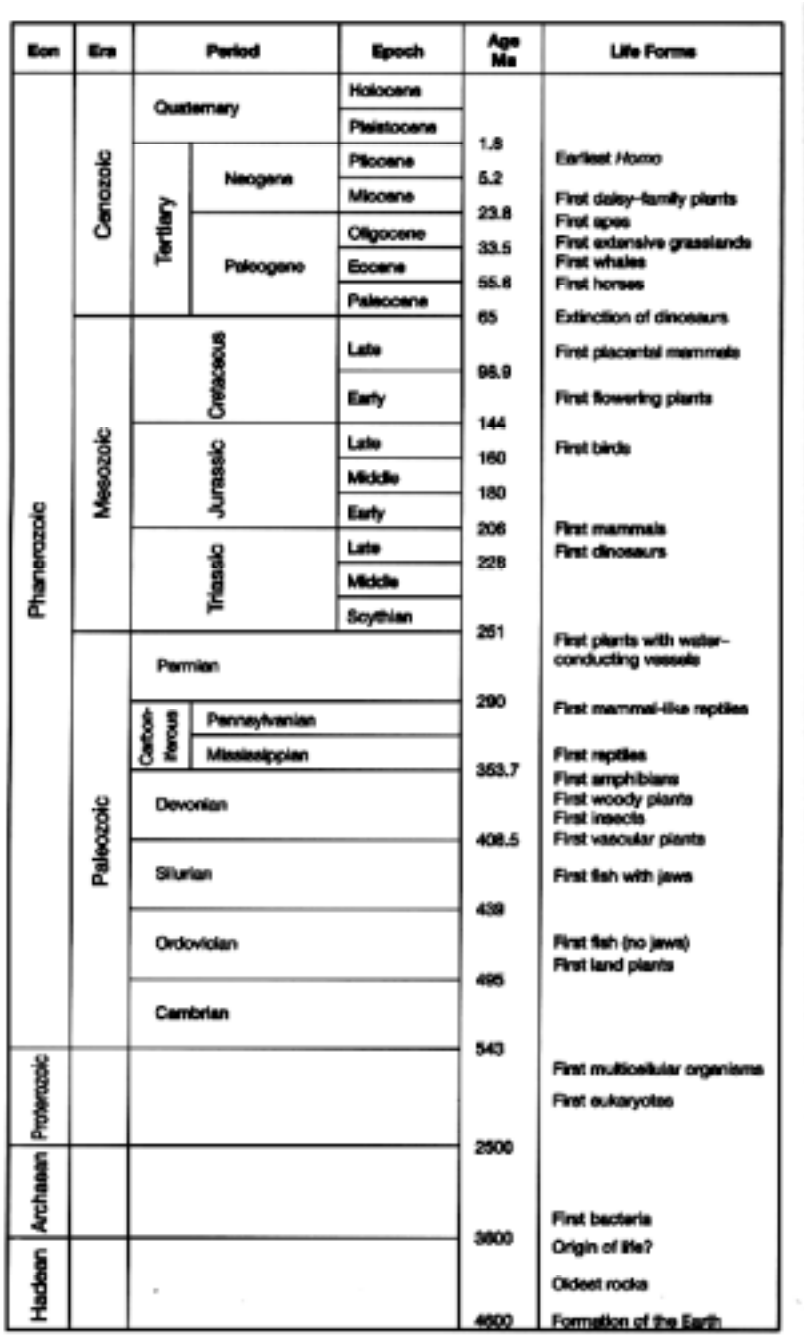
- If rates of change are very very slow (which mostly they are)
- AND
- If the rates of change in the past were similar to the rates observed today
  - Why would they be different?
- Then the earth must be very old, much much older than Archbishop James Ussher's 6000 years.

How Old?

Current estimate's

Earth ~4.6 bya

Life ~3.7 bya



How do you know that?

- Relative age dating techniques
  - Deeper layers are older
  - Layers are originally flat
  - Rocks within other rocks are older
  - But rocks that fill cracks in other rocks are younger
- Those are good, but you'd like actual ages

Actual ages: Radiometric dating

- Isotopes decay at characteristic rates, called half-lives
- A half-life is the amount of time it takes for 1/2 of the isotope to decay

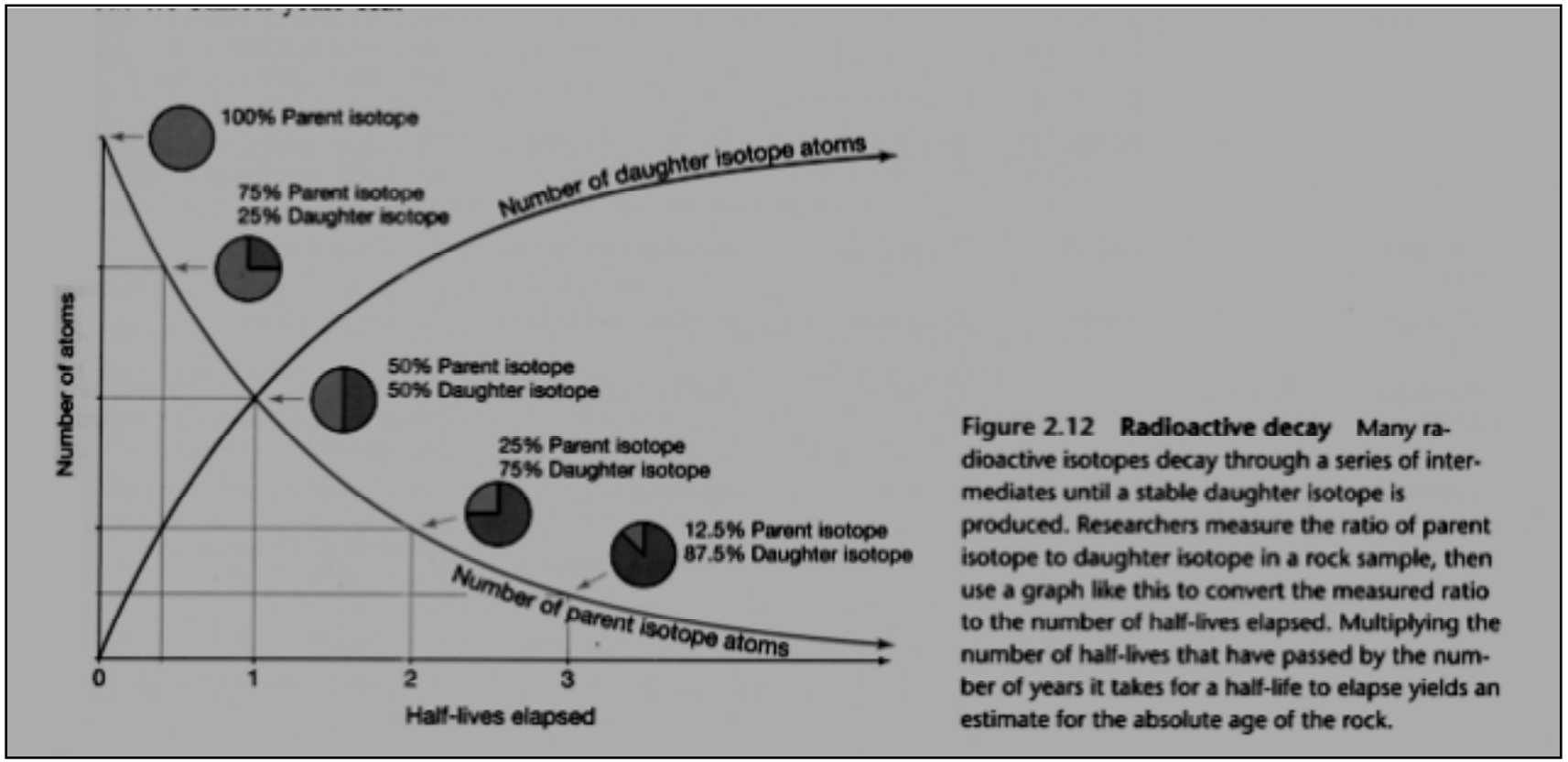


Figure 2.12 Radioactive decay Many radioactive isotopes decay through a series of intermediates until a stable daughter isotope is produced. Researchers measure the ratio of parent isotope to daughter isotope in a rock sample, then use a graph like this to convert the measured ratio to the number of half-lives elapsed. Multiplying the number of half-lives that have passed by the number of years it takes for a half-life to elapse yields an estimate for the absolute age of the rock.

Summary of Facts

- Species are not independent
  - Homology: structural, developmental, genetic
- Species change
  - Observable in populations today
  - Observable through time in fossils
- Life on earth is ancient
  - Earth 4.6 Billion years; Life 3.7 Billion years

So not special creation, then how?

- Process inferred:
  - ‘descent with modification’
- Process of adaptation:
  - ‘natural selection’

- Natural selection next lecture