Evolution 9

- send answer to iClicker Question 6A now.
- Molecular Evolution
- Molecular Phylogeny
 - mutations
 - molecular clocks
 - examples (whales & HIV)
- iClicker Question 6B

Due in lab next week:

- ⇒ pre-lab for Molecular Phylogeny (lab manual p. 27 and on-line)
- ⇒ Skull lab report
- \Rightarrow Meet in W-2-030 & -032

DateTopicM 1/25Evolution 1: IntroductionW 1/27Evolution 2: DetailsF 1/29Evolution 3: Population Genetics IM 2/1Evolution 4: Population Genetics IIIW 2/3Evolution 5: Population Genetics IIIF 2/5Evolution 6: Natural SelectionM 2/8Evolution 7: Species & PhylogenyW 2/10SNOW F 2/12Evolution 9: Molecular PhylogenyM 2/15Presidents' DayW 2/17Fevolution 8: Taxonomy & Earth HistoryF 2/19Themes 1: Major Groups & NutritionM 2/22Themes 2: Size and ScaleW 2/24Themes 3: Size, Respiration, and CirculationF 2/26Themes 4: ReproductionM 3/1EXAM 1: Evolution & Themes	10: Field Trip: Museum of Natural History [report due week of 2/8] 02: Skulls & Evolution [report due week of 2/15] 03: Molecular Phylogeny [report due week of 2/22] 04: Aipotu IV
F 1/29 Evolution 3: Population Genetics I M 2/1 Evolution 4: Population Genetics II W 2/3 Evolution 5: Population Genetics III F 2/5 Evolution 6: Natural Selection M 2/8 Evolution 7: Species & Phylogeny W 2/10 SNOW F 2/12 Evolution 9: Molecular Phylogeny M 2/15 Presidents' Day W 2/17 Evolution 8: Taxonomy & Earth History F 2/19 Themes 1: Major Groups & Nutrition M 2/22 Themes 2: Size and Scale W 2/24 Themes 3: Size, Respiration, and Circulation F 2/26 Themes 4: Reproduction M 3/1 EXAM 1: Evolution & Themes	Museum of Natural History [report due week of 2/8] 02: Skulls & Evolution [report due week of 2/15] 03: Molecular Phylogeny [report due week of 2/22]
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F 2/26 Themes 4: Reproduction M 3/1 EXAM 1: Evolution & Themes	
M 3/1 EXAM 1: Evolution & Themes	[report due week of 3 / 1]
	[report due week of 3/1] 05: Eukaryotic Cells
W 3/3 Plants 1: Introduction	05. Edikaryotic Cens
F 3/5 Plants 2: Mosses & Ferns	[report due week of 3/8]
M 3/8 Plants 3: Gymnosperms & Angiosperms I	06: Plant Diversity I
W 3/10 Plants 4: Angiosperms II	
F 3/12 Plants 5: Monocots & Dicots	
M 3/15 SPRING BREAK	NONE
W 3/17 SPRING BREAK	
F 3/19 SPRING BREAK	
M 3/22 Animals 1: Introduction	06: Plant Diversity II
W 3/24 Animals 2: Invertebrates I	F
F 3/26 Animals 3: Invertebrates II	[report due week of 4/5]
M 3/29 Animals 4: Invertebrates III	06: Plant Diversity III
W 3/31 Animals 5: Vertebrates	Lab Practical Exam
F 4/2 Physiology 1: Nervous Systems Introduction M 4/5 EXAM 2: Themes & Plants	07 A : 1 D: :- 1 T :
	07: Animal Diversity I: Trout
W 4/7 Physiology 2: Resting Potential F 4/9 Physiology 3: Action Potential	
M 4/12 Physiology 5: Input & Output	07: Animal Diversity II: Squid
W 4/14 Physiology 6: Scent & Smell	[report due week of 4/26]
F 4/16 Physiology 7: Muscle	[report due week of 4/20]
M 4/19 Patriots' Day	07: Animal Diversity III:
W 4/21 Physiology 8: Neurotoxins & Excretion	Lab Practical Exam
F 4/23 Ecology 1: Introduction & Climate	
M 4/26 EXAM 3: Animals & Physiology	08: Animal Behavior
W 4/28 Ecology 2: Population Growth	
F 4/30 Ecology 3: Interactions I	[report due week of 5/3]
M 5/3 Ecology 4: Interactions II	09: Phylogenetic Collection
W 5/5 Ecology 5: Interactions III	
F 5/7 Ecology 6: Community Structure	[rpt. to TA mailbox wk of 5/10]
M 5/10 Ecology 7: Ecosystems	NONE
W 5/12 Ecology 8: Biogeochemical Cycles	_
Changes:	~ Be prepar
 Evolution 8 and 9 switched 	, Be prepai
 Physiology 4 cancelled 	
 Wednesday afternoon and night labs (sections 5, 6 	6, and 11) will do <u>both</u> Skulls &
Evolution and Molecular Phylogeny on 2/17. Their	HMNH reports will be due 2/17; the
Skulls and Mol Phyl reports will be due on 2/24.	

Molecular Evolution = changes in genes (ONA) over evolutionary time to due to mutation = changes in ONA sequence sometimes changes in amino acid sequence of proteins

Molecular Phylogeny - using differences in MAIA/protein scavences



Molecular Phylogeny - using differences in DNA/protein sequences to Infer evolutionary relationships

based on a random accumulation of mutations over time

: the more time has passed since last common uncestor (LCA) the more different the sequences will be

or the more distantly related two organisms are,
the more different the sequences will be
(i vice versa)

* mutations are random, but averaged over long terms accumulate at a constant rate

depending on 10 mutation rate

(3) "Flexibility" of sequences - how many mutations it can take & still function

=) "molecular clock"

molecular clock with real protein

Molecular Phylogeny Handout part of cellular respiration done by both

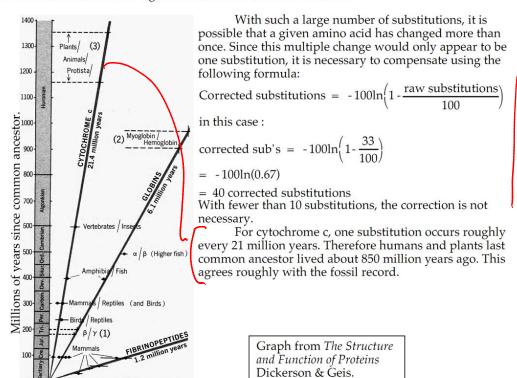
Comparision of amino acid sequences of cytochrome c proteins from Human and Cucumber.

The computer program first aligns the sequences to find the maximum number of matching amino acids; these are indicated by the vertical bars "|". It then counts the number of amino acids which are identical in both cytochrome c's.

To be identical

70% identical Human: GDVEKGKKIFIMKCSQCHTVEKGGKHKTGPNLHGLFGRKTGQAPGYSYTAANKNKGIIWG matches: GNSKAGEKIFKTKCAQCHTVDKGAGHKQGPNLNGLFGRQSGTTPGYSYSAANKNRAVIWE Cucumber: This uses the single-letter EDTLMEYLENPKKYIPGTKMIFVGIKKKEERADLIAYLKKAT 103 Human: amino acid code: matches: A = alanineCucumber: EKTLYDYLLNPKKYIPGTKMVFPGLKKPQDRADLIAYLKEAT 110 G= gycine, etc.

These two species come from different kingdoms (plantae and animalia) and their cytochrome c's only have 69 out of 102 amino acids that are identical. That is, 102-69 or 33 substitutions have occurred since the two organisms last had a common ancestor.



Evolution 9 - 3

o 20 40 60 80 100 120 140 160 Corrected # of amino acid substitutions

Bio 112 Molecular Phylogeny Handout

Question: What is the closest land relative of a whale, a Hippo, a Cow, or a Deer?

Data: DNA sequences from the same part of the same gene (the gene for casein, a protein found in milk) in all 4 organisms. Use "molecular clock" to find out - count that of differences

Whale: AATCCCCAAAGCTAAGGAGACTATCCTTCCTAAGCATAAAGAAATGCCCTTCCCTATATC
Hippo: AGTCCCCAAAGCAAAGGAGACTATCCTTCCTAAGCATAAAGAAATGCCCTTCTCTAAATC

8
AGTCCCCAAAGTGAAGGAGACTATGGTTCCTAAGCACAAGGAAATGCCCTTCCCTAAATA

Deer: AGTCTCCGAAGTGAAGGAGACTATGGTTCCTAAGCACGAAGAAATGCCCTTCCCTAAATA)

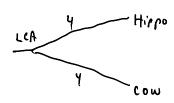
how to show differences? tree diagram where

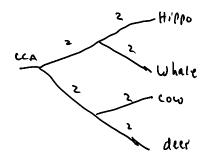
O distance proportional to # of differences (molecular clock)

© all branches same length from LCA (all current organisms have been evolving the same amount of time)

© path length matters
start with smallest distances
LCA 2 Whole

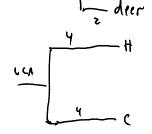
Lea 2 (ow

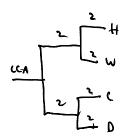




O only distance matters
this length doesn't matter

LCA whole





= map showing evolutionary relationships = phylogenetic tree

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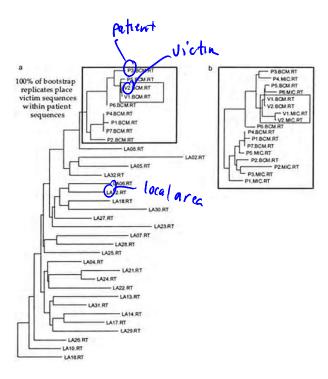
: hippo is closest land relative of whate (of these mammals)

(predict whate-cow = 8 - its really 9 = close enough)

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Molecular phylogeny & criminal justice

- 1994: Dr. Richard Schmidt accused of injecting his ex-girlfriend (the Victim) with HIV (AIDS virus) from one of his patients.
- HIV evolves very rapidly, even leading to multiple different sequences in the same patient!
- Police collected HIV samples from victim (V), Dr. Schmidt's patient (P), and many local HIV⁺ individuals from the community who were unrelated to the case (LA)
- They then used computer tools to construct the following phylogeny.



From: "Molecular evidence of HIV-1 transmission in a criminal case" by Michael L. Metzker, David P. Mindell, Xiao-Mei Liu, Roger G. Ptak, Richard A. Gibbs, and David M. Hillis. *Proceedings of the National Academy of Sciences* 99:22 14292-14297 (2002).

Evolution 9 - 4

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