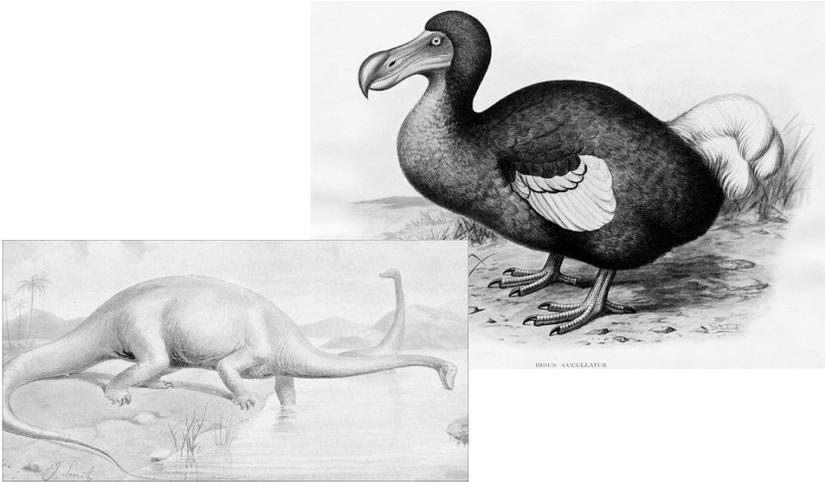


Flip side of tree creation: EXTINCTION



Quiz 2 1141

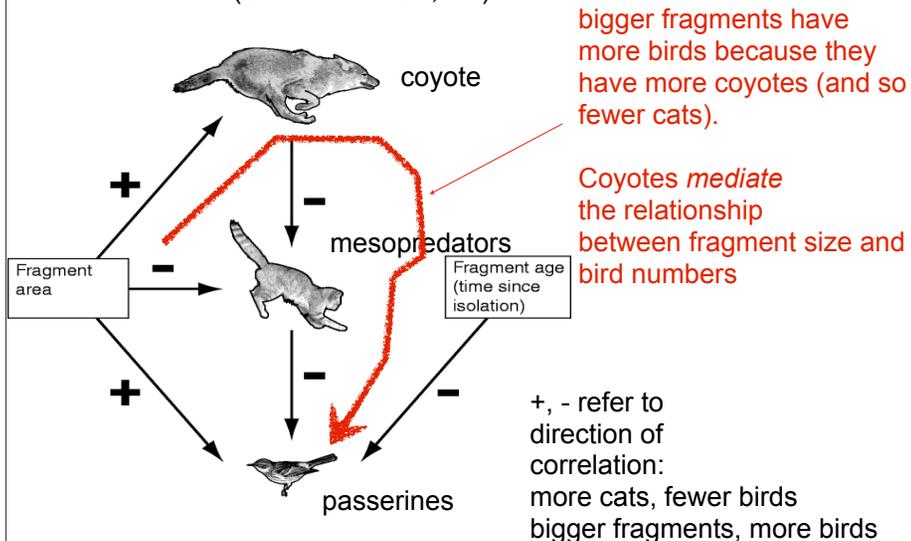
1. The Jukes-Cantor model is below. What does the term μt represent?

$$p = \frac{3}{4} \left(1 - e^{-\frac{4}{3}\mu t} \right)$$

2. How many ways can you root an unrooted tree with 5 edges? Include a drawing.
3. Why might Lineage-through-time plots show a **decreasing** slope nearer the present?
4. Draw a **fully balanced** tree with 8 species that would have a **increasing** LTT through time.
5. MtDNA and Nuclear genes may suggest different numbers of species? Why?

2

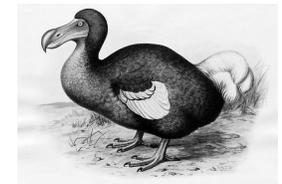
Knock-on effects (Crooks & Soule, '99)



'extinction' is not well-represented in textbook discussions on evolution

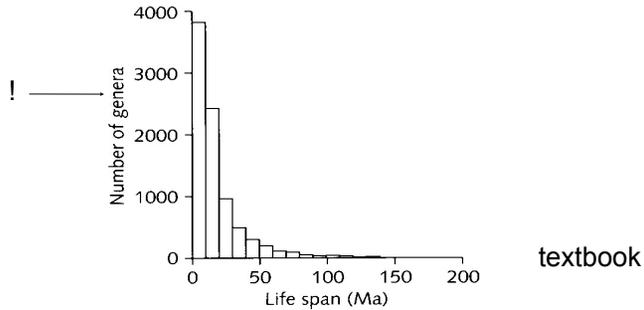
1. Phylogenetic patterns of extinction
2. Correlates of extinction (-risk)
3. The final blow - small population size

(will jump from extinction of species to extinction of entire clades - is this ok?)



Elusive diversification and extinction facts from fossils

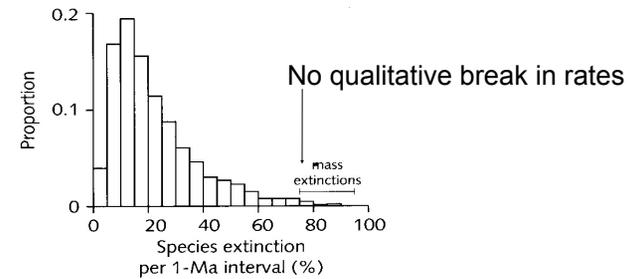
1. Between 90-99% of all species ever to have lived are extinct.
2. Most **taxa** are very short-lived, but strong skew in data.



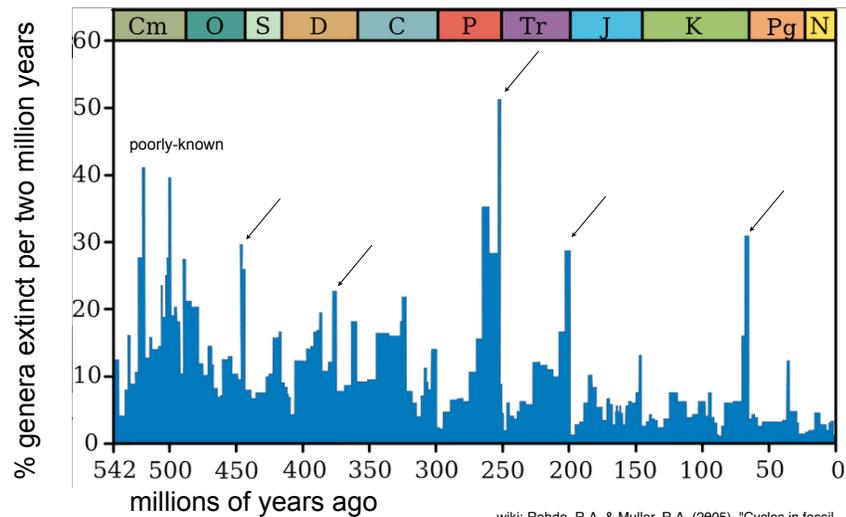
Why might fossil record overestimate average taxon duration?

Why might fossil record underestimate it ?

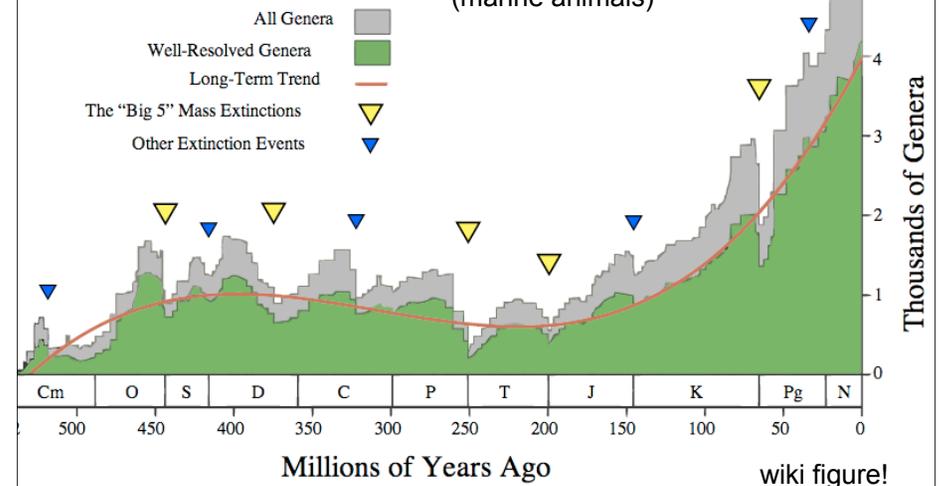
3. - Extinction rates through geological time seem to be drawn from another right-skewed distribution.
 -inconsistent with independent extinction rates among taxa over time, but consistent with general models for disasters (floods, etc.) (more intense events happen more rarely...)



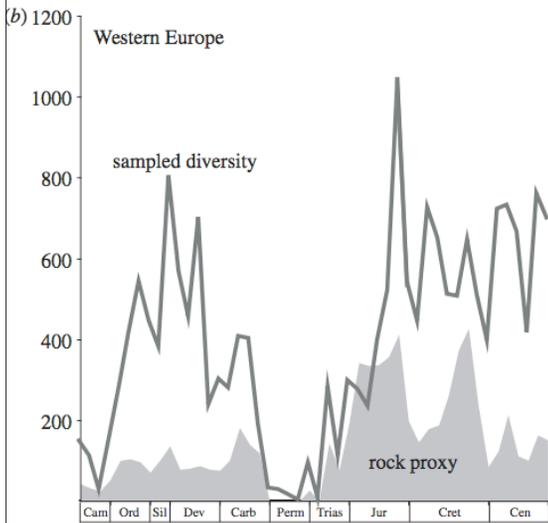
4. Sum of 5 mass extinctions <10% of all extinctions G&S fig. 2.10



Biodiversity during the Phanerozoic (marine animals)

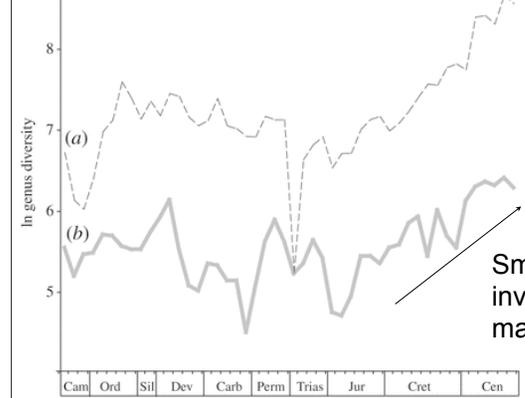


However, more genera where there are more rocks!



PRSLB doi:10.1098/rspb.2012.1793

Sampling depresses the curve

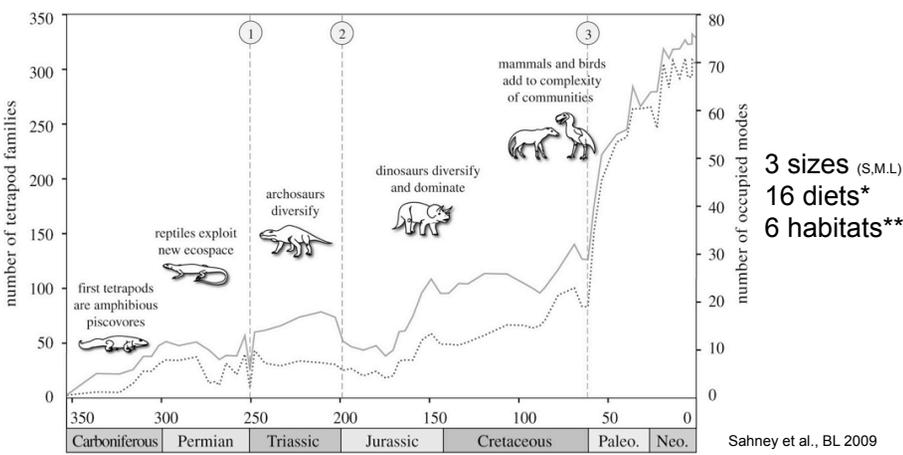


Smith et al., late 2012. Marine invertebrates only...still evidence for maximum in Cenozoic.

Figure 1. Comparative global marine biodiversity through time based on (a) raw counts of recorded taxa with range interpolation between first and last occurrences [27], and (b) sampled taxa recorded in the Paleobiology Database and corrected for variation in sampling using SQS (from [13]).

PRSLB doi:10.1098/rspb.2012.1793

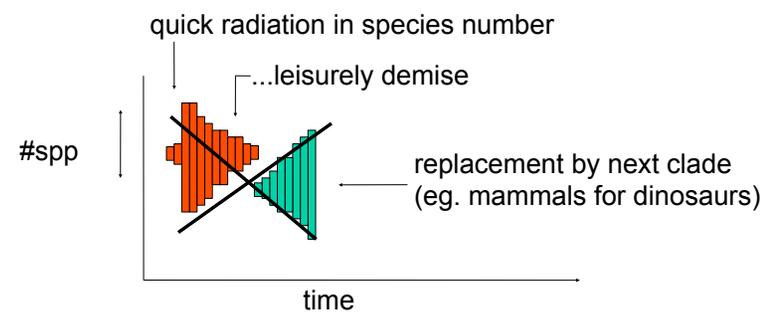
Why the Cenozoic increase in diversity?
No one knows...in tetrapods, associated with expansion in ecologies



Sahney et al., BL 2009

*browsers, grazers, gnawers, grain, roots, nectar, fruit, algae, molluscs, fish, terrestrial invertebrates, terrestrial vertebrates, eggs, carrion, blood, and omnivores
**marine, freshwater, subterranean, terrestrial, arboreal, and aerial

5. Little evidence that extinction of clades is particularly slow (contra Darwin).



6. Extinction of clades is **not often** driven by competition (contra Darwin): 13-26% of 840 tetrapod families: Benton, 1996
Though Sepkowski, 1996 argues that jury is still out...
Extinction of species by competition is possible, however.

And different clades are hit at different mass extinction events

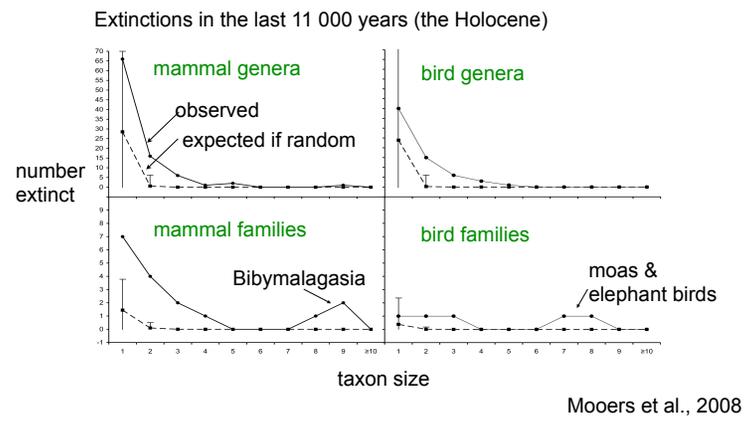
Table 1. Extinction patterns of nine different major marine invertebrate taxa after five mass extinction events

Mass extinction event (millions of years before present)	Mean extinction severity for event (no. families extinct/ no. extant)	Casualties	Survivors
Late Ordovician (455 M yr)	0.21 (65/310)	Crinzoans Cephalopods	Poriferans Foraminifera Gastropods
Late Devonian (370 M yr)	0.21 (68/322)	Cephalopods Poriferans	Bryozoans Foraminifera Gastropods Ostracodes
Late Permian (255 M yr)	0.63 (220/348)	Crinzoans Anthozoans Bryozoans	Foraminifera Poriferans Bivalves Gastropods Cnidzoans
Late Triassic (220 M yr)	0.10 (18/178)	Bryozoans Cephalopods	Ostracodes Bryozoans Cnidzoans
Late Cretaceous (75 M yr)	0.11 (46/425)	Cephalopods Poriferans	Poriferans Crinzoans Anthozoans

Extinction severity is measured as the number of families extinct/number extant in each taxon at the end of the extinction event. Only those groups whose severities were significantly different from the mean at each event are shown. Modified from ref. 24 and based on an analysis of Sepkoski's (1982) database of the stratigraphic ranges of marine invertebrate families.

(Purvis et al., 01)

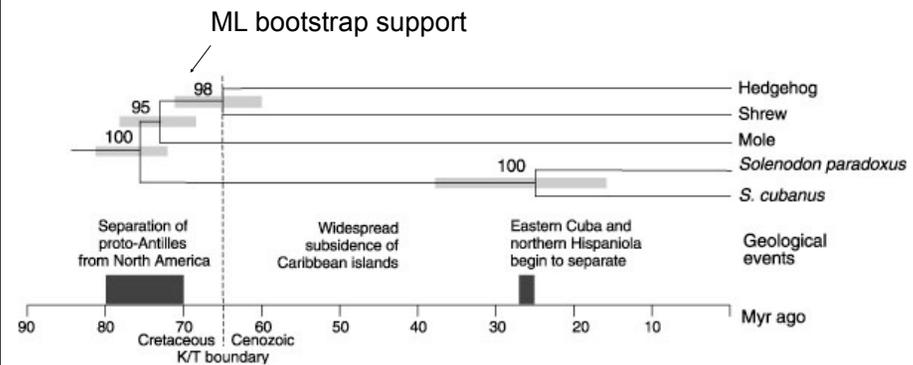
We saw before the break that recent extinction does not seem random (at least taxonomically) - in Holocene, an island effect



Is extinction risk *generally* "clumped" on the tree? (why might this matter?)

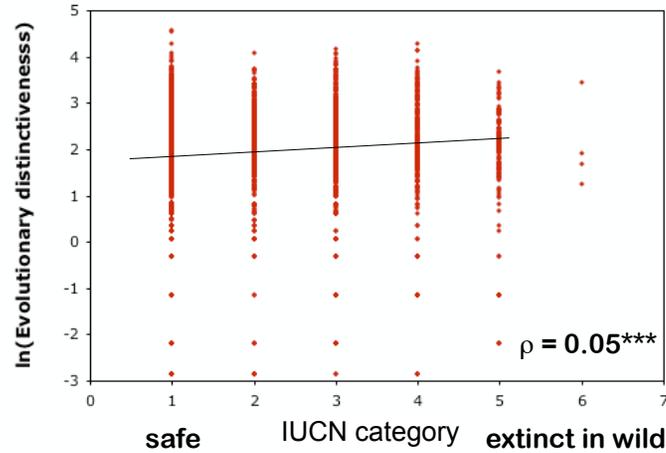
- Plants: Likely (Various papers)
- Mammals: No (Verde Arregoitia et al., 2013)
- Birds: No (Jetz et al., in review)
- Other groups: ?

Two solendons are both endangered and on long branches...



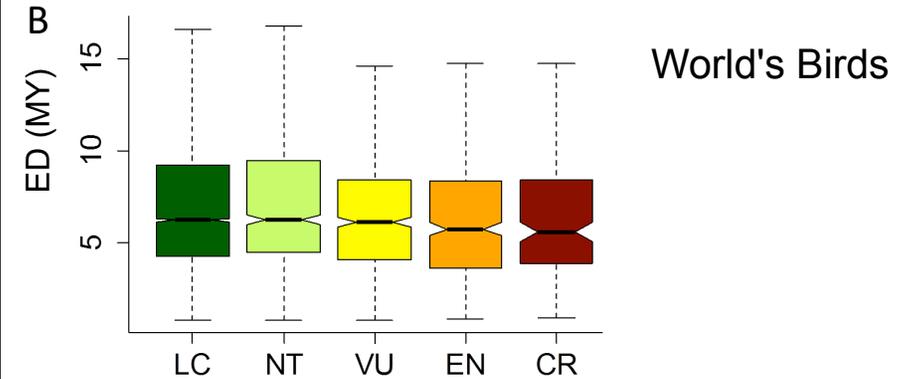
Roca et al., Nature (2004)

Distinctiveness and extinction risk in Mammals (N=4507)



Also Jono and Pavoine, 2012

The effect is tiny!



Jetz et al., in review

Can we identify clades of birds with higher than expected numbers of species at risk?

HOW?



ORDER	#SPP	#ENDANGERED	Prop(endangered)	
EURYPYGIFORMES	2	1	0.50	Sunbittern, kagu
*SPHENISCIFORMES	18	5	0.28	Penguins
APTERYGIFORMES	4	1	0.25	Kiwis
PROCELLARIIFORMES	128	30	0.23	Albatrosses
*CICONIIFORMES	19	3	0.16	Storks, herons, etc.
OTIDIFORMES	25	4	0.16	Bustards
PODICIPEDIFORMES	19	3	0.16	Grebes
PSITTACIFORMES	354	50	0.14	Parrots
GRUIFORMES	156	20	0.13	Cranes and allies
*PELECANIFORMES	106	13	0.12	Pelicans + Shoebill
GALLIFORMES	288	29	0.10	Chicken, grouse
*SULIFORMES	52	5	0.10	Cormorants, boobies
ACCIPITRIFORMES	251	22	0.09	Many Birds of Prey

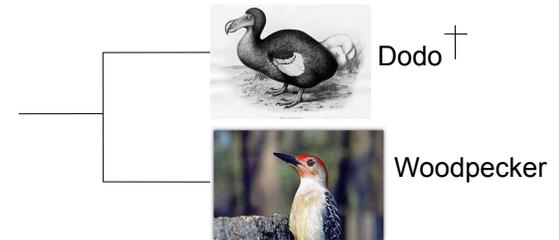
But even **non-random** extinction would not make it **predictable**...

1. Patterns of extinction
2. **Correlates of extinction (-risk)**
3. The final blow - small population size

non-random vs. **predictable**

(sometimes sponges won, sometimes they lost; both chinchillas and chimps are in small genera; what do albatrosses and kiwis have in common?)

So, how to investigate the correlates of extinction (risk)?



Just looking at threatened birds, more threatened ones do tend to be larger in size. (old data...)

IUCN category	Average mass (g)	N
Extinct/endangered	118	160
Vulnerable	99.3	217
Rare	90.4	211
Data deficient	64.1	240

p<0.03

Gaston & Blackburn, 95

...Include historically extinct species, trend is stronger

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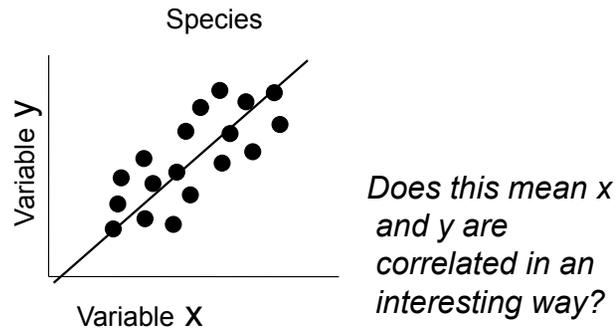
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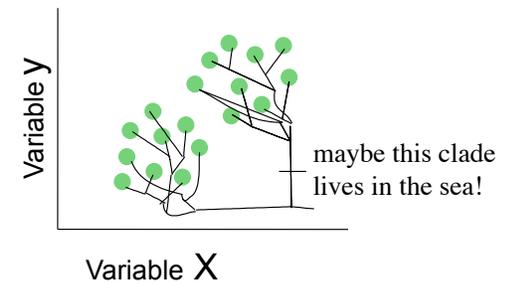
Why consider phylogeny??

Correlations across species



Maddison, 2001

But, what if the species were related by the phylogeny shown?

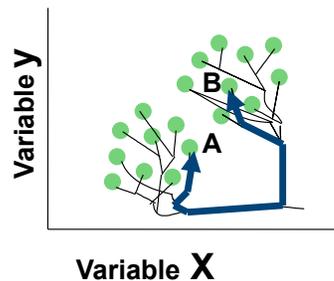


Could there be merely a **single** change in X and a **coincidental** change in Y?

Maddison, 2001

26

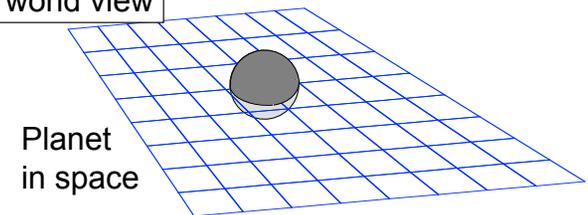
It isn't appropriate to compare or measure horizontally across the character space. Explanations must be constrained to follow the tree's branches, just as evolutionary processes are constrained to follow the tree's branches.



Maddison, 2001

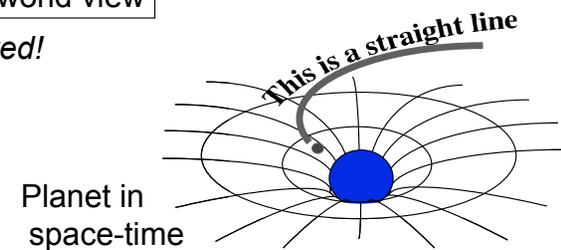
27

"Newtonian" world view



"Einsteinian" world view

Space is curved!



Maddison, 2001

28

