# MODELS, PROBABILITY, AND THE DEEP PAST

MS6, 5/10/2014

Charles H. Pence

Department of Philosophy
and Religious Studies

LSU
LOUISIANA STATE UNIVERSITY

# PROBABILISTIC MODELS: WHY?

# Genuine metaphysical indeterminism

# Genuine metaphysical

## Quantum Indeterminism and Evolutionary Biology*

David N. Stamos†‡
Department of Philosophy, York University

In "The Indeterministic Character of Evolutionary Theory: No 'Hidden Variables Proof' But No Room for Determinism Either," Brandon and Carson (1996) argue that evolutionary theory is statistical because the processes it describes are fundamentally statistical. In "Is Indeterminism the Source of the Statistical Character of Evolutionary

PRL 106, 040503 (2011) PHYSICAL REVIEW LETTERS week ending 28 JANUARY 2011

# Sustained Quantum Coherence and Entanglement in the Avian Compass

Erik M. Gauger,[1] Elisabeth Rieper,[2] John J. L. Morton,[1,3] Simon C. Benjamin,[2,1,*] and Vlatko Vedral[2,3,4]

[1]*Department of Materials, University of Oxford, Parks Road, Oxford OX1 3PH, United Kingdom*
[2]*Centre for Quantum Technologies, National University of Singapore, Singapore*
[3]*Clarendon Laboratory, University of Oxford, Parks Road, OX1 3PU, United Kingdom*
[4]*Department of Physics, National University of Singapore, Singapore*

(Received 24 May 2010; revised manuscript received 23 November 2010; published 25 January 2011)

In artificial systems, quantum superposition and entanglement typically decay rapidly unless cryogenic temperatures are used. Could life have evolved to exploit such delicate phenomena? Certain migratory birds have the ability to sense very subtle variations in Earth's magnetic field. Here we apply quantum information theory and the widely accepted "radical pair" model to analyze recent experimental observations of the avian compass. We find that superposition and entanglement are sustained in this living system for at least tens of microseconds, exceeding the durations achieved in the best comparable man-made molecular systems. This conclusion is starkly at variance with the view that life is too "warm and wet" for such quantum phenomena to endure.

DOI: 10.1103/PhysRevLett.106.040503 PACS numbers: 03.67.−a, 03.65.Yz, 82.30.−b

David N. Stamos†‡

Department of Philosophy, York University

In "The Indeterministic Character of Evolutionary Theory: No 'Hidden Variables Proof' But No Room for Determinism Either," Brandon and Carson (1996) argue that evolutionary theory is statistical because the processes it describes are fundamentally statistical. In "Is Indeterminism the Source of the Statistical Character of Evolutionary

# Probabilistic causation (in fitness, selection, drift)

# The Trials of Life:
# Natural Selection and Random Drift*

Denis M. Walsh†‡
University of Edinburgh

Tim Lewens

Natur

THE JOURNAL OF PHILOSOPHY

VOLUME XCIX, NO. 2, FEBRUARY 2002

# TWO WAYS OF THINKING ABOUT FITNESS AND NATURAL SELECTION*

The concept of fitness is, Philip Kitcher[1] says, "important both to informal presentations of evolutionary theory and to the mathematical formulations of [population genetics]" (*ibid.*, p. 50)

THE JOURNAL OF PHILOSOPHY

VOLUME XCIX, NO. 2, FEBRUARY 2002

*Biology and Philosophy* **17:** 33–53, 2002.


# Are Random Drift and Natural Selection Conceptually Distinct?

ROBERTA L. MILLSTEIN
*Department of Philosophy*
*California State University, Hayward*
*25800 Carlos Bee Blvd.*
*Hayward, CA 94542-3056*
*U.S.A.*

THE JOURNAL OF PHILOSOPHY

VOLUME XCIX, NO. 2, FEBRUARY 2002

*Biology and Philosophy* **17:** 33–53, 2002.



# Fit and Diversity: Explaining Adaptive Evolution*

Denis M. Walsh†‡

THE JOURNAL OF PHILOSOPHY

VOLUME XCIX, NO. 2, FEBRUARY 2002

*Biology and Philosophy* **17:** 33–53, 2002.

# Fitness, Probability and the Principles of Natural Selection

Frédéric Bouchard and Alex Rosenberg

ABSTRACT

We argue that a fashionable interpretation of the theory of natural selection as a

THE JOURNAL OF PHILOSOPHY

VOLUME XCIX, NO. 2, FEBRUARY 2002

*Biology and Philosophy* **17:** 33–53, 2002.

# Natural Selection as a Population-Level Causal Process

Roberta L. Millstein

ABSTRACT

Recent discussions in the philosophy of biology have brought into question some

THE JOURNAL OF PHILOSOPHY

VOLUME XCIX, NO. 2, FEBRUARY 2002

*Biology and Philosophy* **17:** 33–53, 2002.

13

# Epiphenomenalism

## The Dos and the Don'ts

**Larry Shapiro and Elliott Sober**

THE JOURNAL OF PHILOSOPHY

VOLUME XCIX, NO. 2, FEBRUARY 2002

*Biology and Philosophy* **17:** 33–53, 2002.



# Selection and Causation*

Mohan Matthen and André Ariew†

We have argued elsewhere that natural selection is not a cause of evolution, and that a resolution-of-forces (or vector addition) model does not provide us with a proper understanding of how natural selection combines with other evolutionary influences. These propositions have come in for criticism recently, and here we clarify and defend

THE JOURNAL OF PHILOSOPHY

VOLUME XCIX, NO. 2, FEBRUARY 2002

*Biology and Philosophy* **17:** 33–53, 2002.

# An Explication of the Causal Dimension of Drift

Peter Gildenhuys

ABSTRACT

THE JOURNAL OF PHILOSOPHY

VOLUME XCIX, NO. 2, FEBRUARY 2002

*Biology and Philosophy* **17:** 33–53, 2002.

# A New Foundation for the Propensity Interpretation of Fitness

Charles H. Pence and Grant Ramsey

Biological systems have dependencies on the external environment best modeled probabilistically

# Biological systems have dependencies on the external e

Review

Cell PRESS

## Stochasticity in evolution

**Thomas Lenormand[1], Denis Roze[2] and François Rousset[3]**

[1] Centre d'Ecologie Fonctionnelle et Evolutive, UMR 5175, 1919 Route de Mende, F-34293 Montpellier cedex 5, France
[2] Station Biologique de Roscoff, CNRS, Adaptation et Diversité en Milieu Marin, 29682 Roscoff, France
[3] Université Montpellier 2, CNRS, Institut des Sciences de l'Evolution, 34095 Montpellier, France

**The debate over the role of stochasticity is central in evolutionary biology, often summarised by whether or not evolution is predictable or repeatable. Here we distinguish three types of stochasticity: stochasticity of mutation and variation, of individual life histories and**

the genetic basis of adaptation and the rate of adaptation). In fact, the importance of 'history' in evolution has been stressed repeatedly [6,7], based on the idea that because it accumulates over time, evolutionary change is necessarily path dependent and nonrepetitive in all details. A similar

We can’t get enough data about the biological world to produce a deterministic model

Evolutionary theory refers to events in the deep past

# THE GOALS

Divergence time estimation is an example of probability due to historical inaccessibility

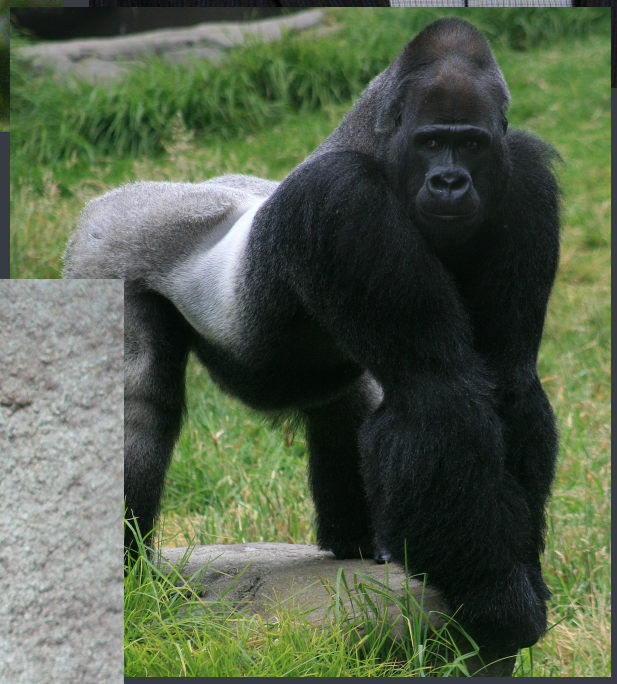
It's *ineliminable:* no amount of contemporary data can render the models deterministic

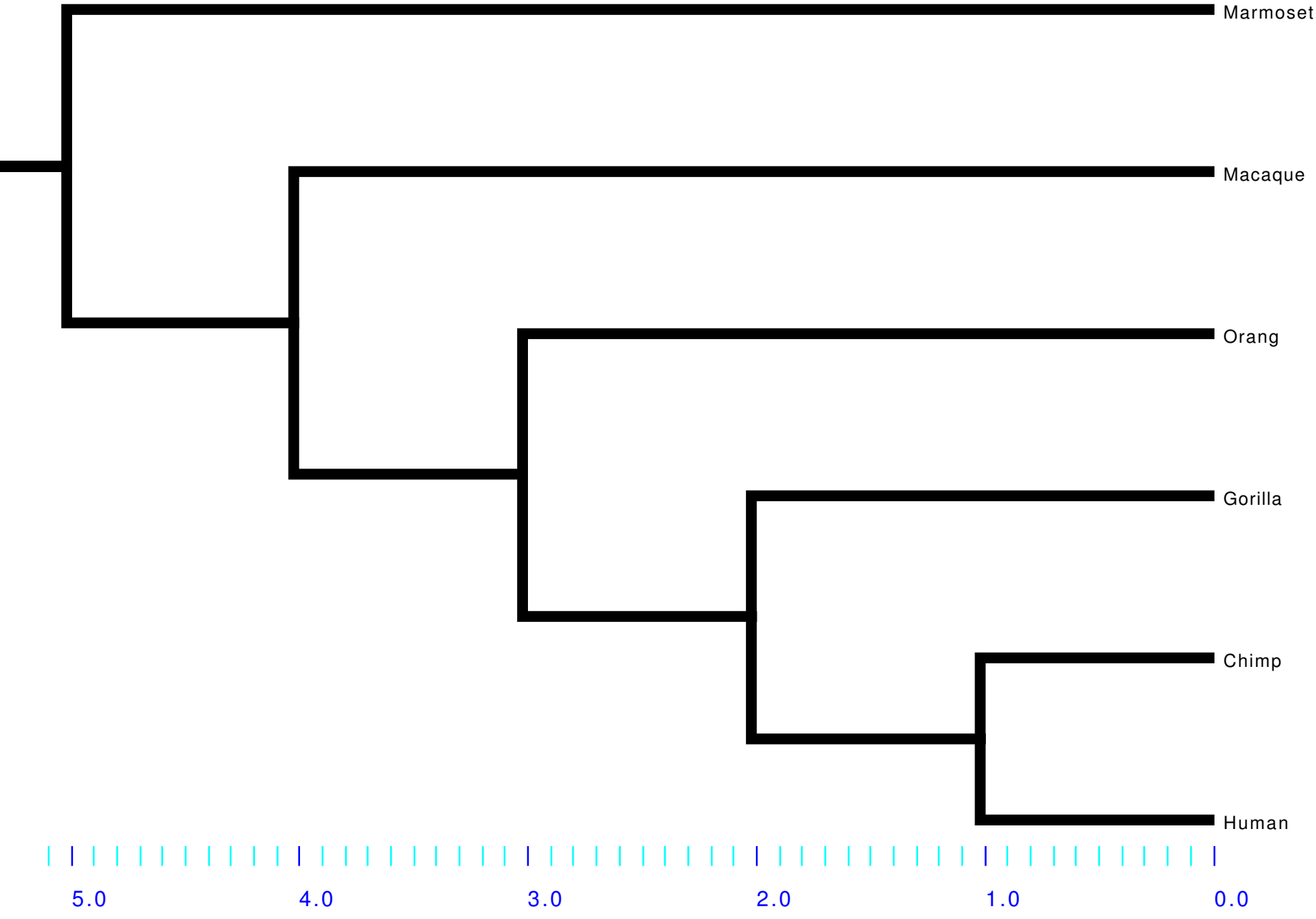
# An example of a biological model where we can *quantify* the source of probabilities

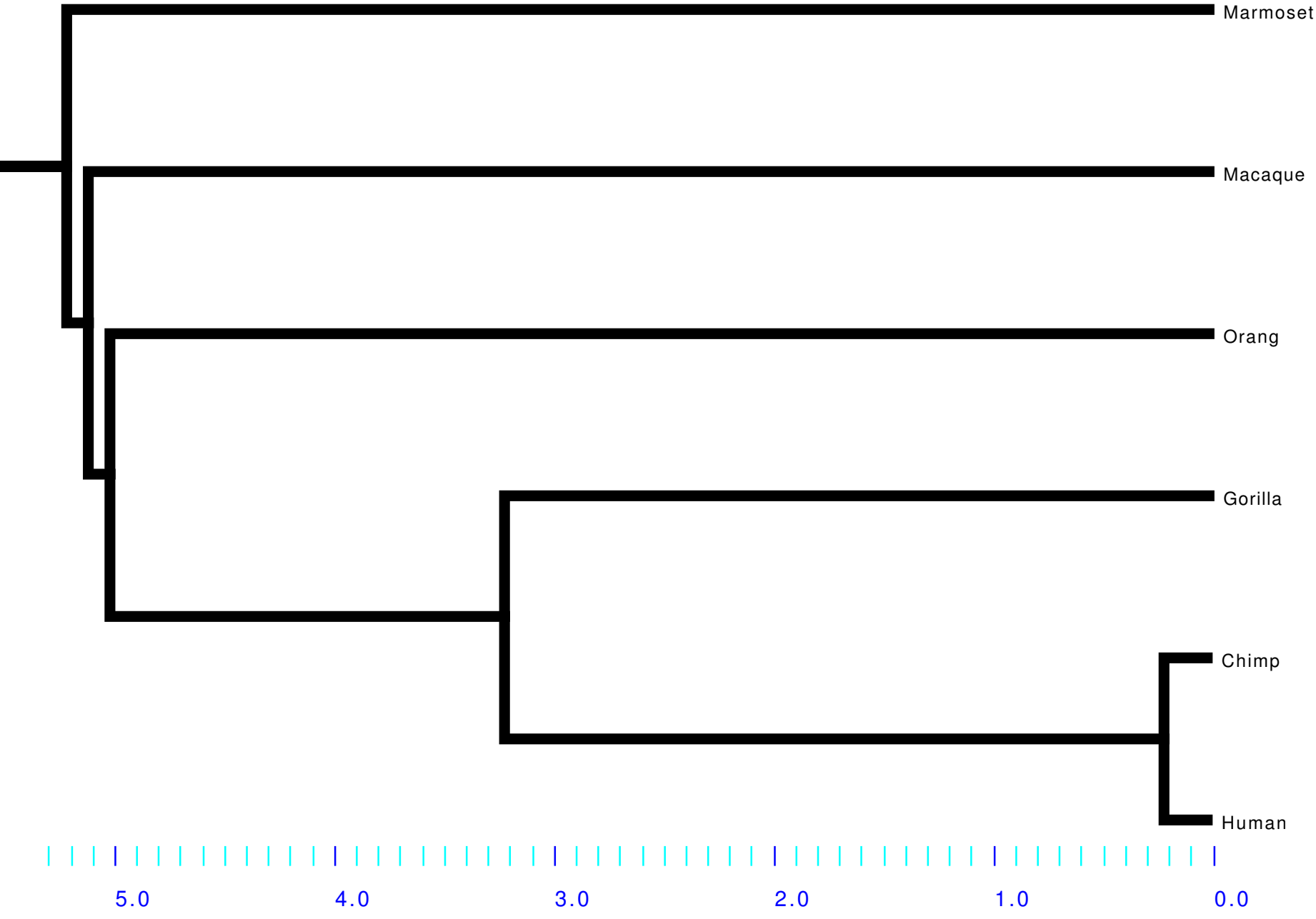
# DIVERGENCE TIME ESTIMATION

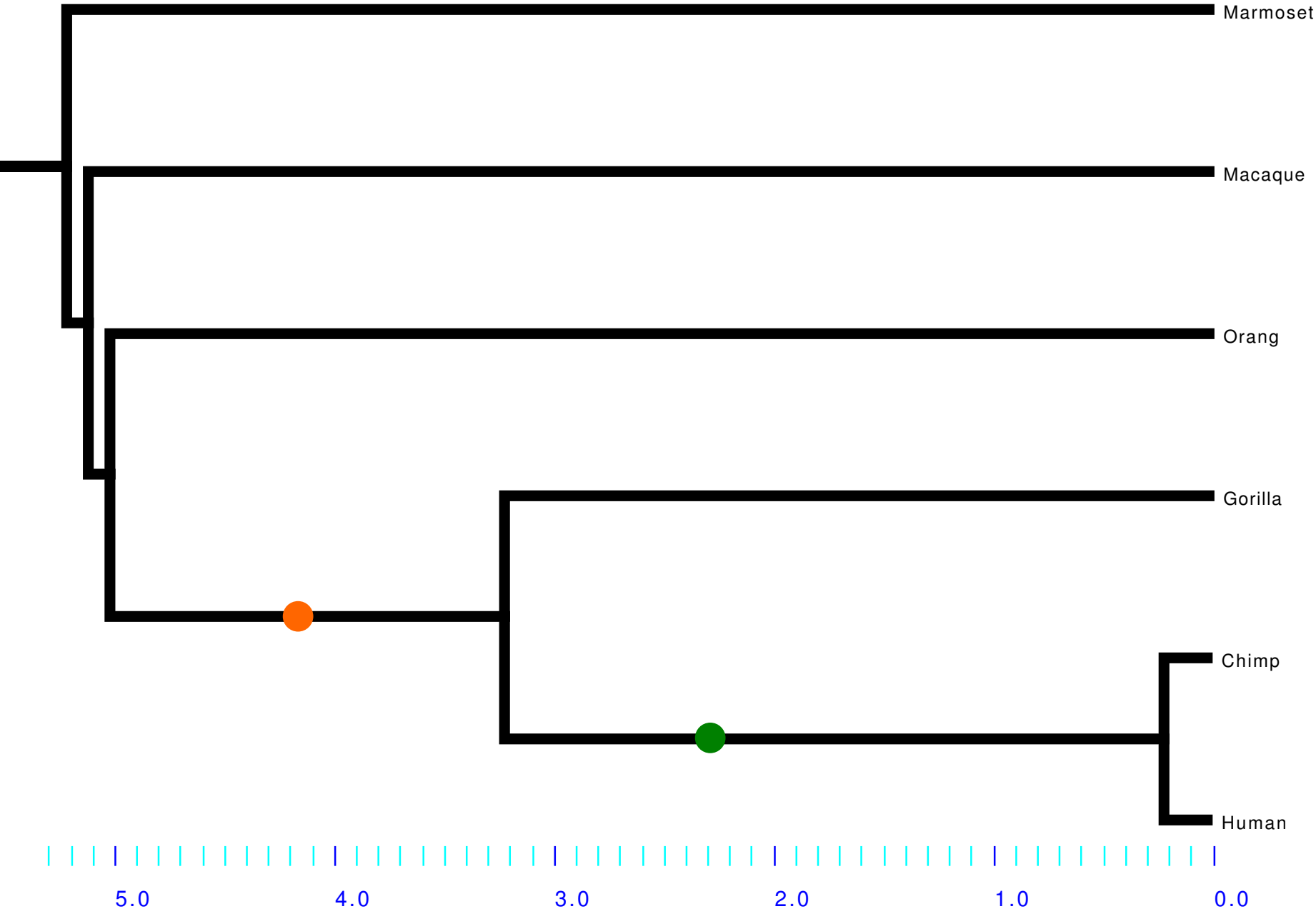


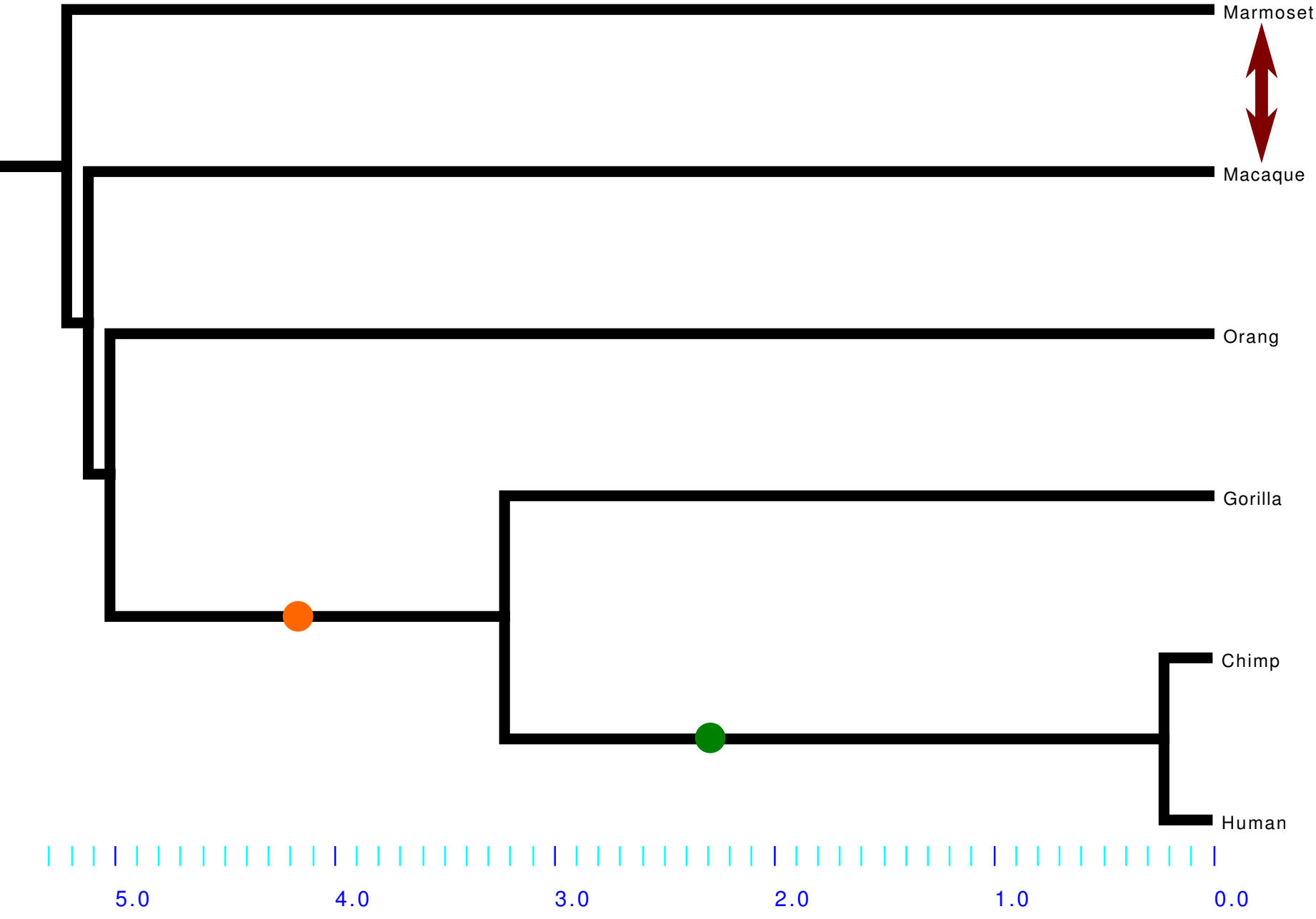


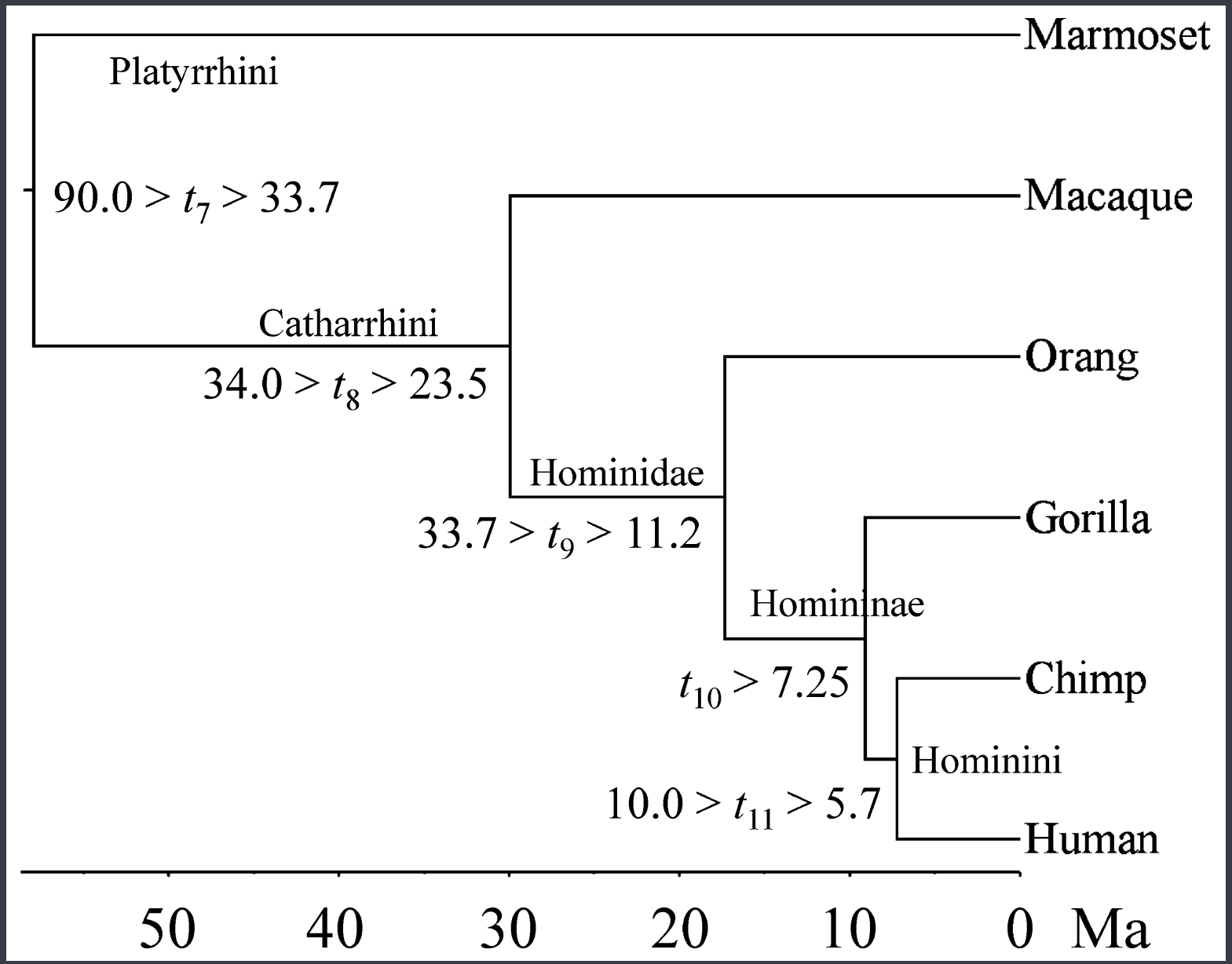




Marmoset
Macaque
Orang
Gorilla
Chimp
Human
5.0
4.0
3.0
2.0
1.0
0.0


Marmoset
Macaque
Orang
Gorilla
Chimp
Human
5.0
4.0
3.0
2.0
1.0
0.0

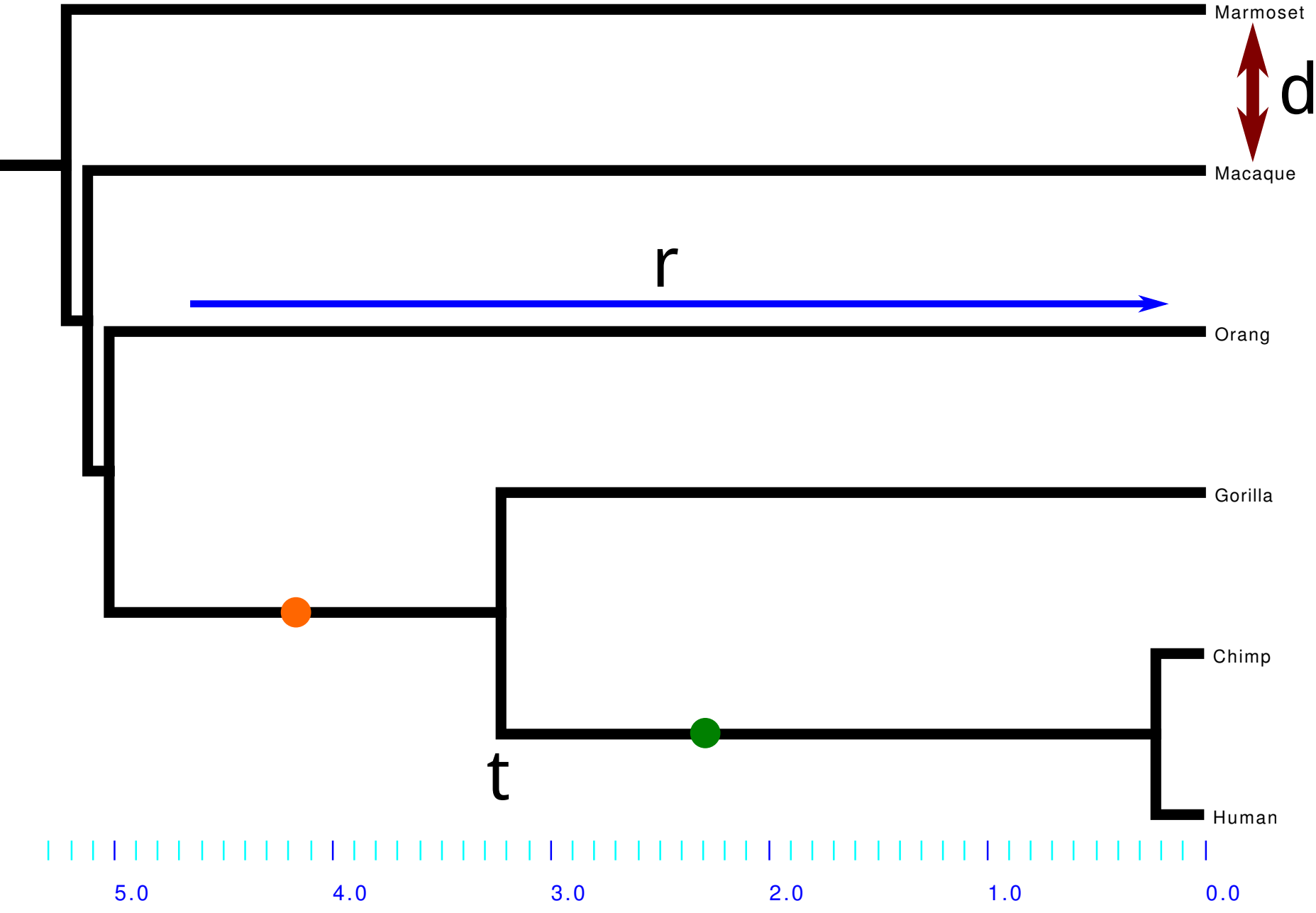

Marmoset
Macaque
Orang
Gorilla
Chimp
Human
5.0
4.0
3.0
2.0
1.0
0.0


Marmoset
Macaque
Orang
Gorilla
Chimp
Human
5.0
4.0
3.0
2.0
1.0
0.0




dos Reis and Yang (2013), *J. Syst. Evol.* 51:37

# THE MODELS


Marmoset
d
Macaque
r
Orang
Gorilla
Chimp
t
Human
5.0
4.0
3.0
2.0
1.0
0.0

$d$: set by contemporary data

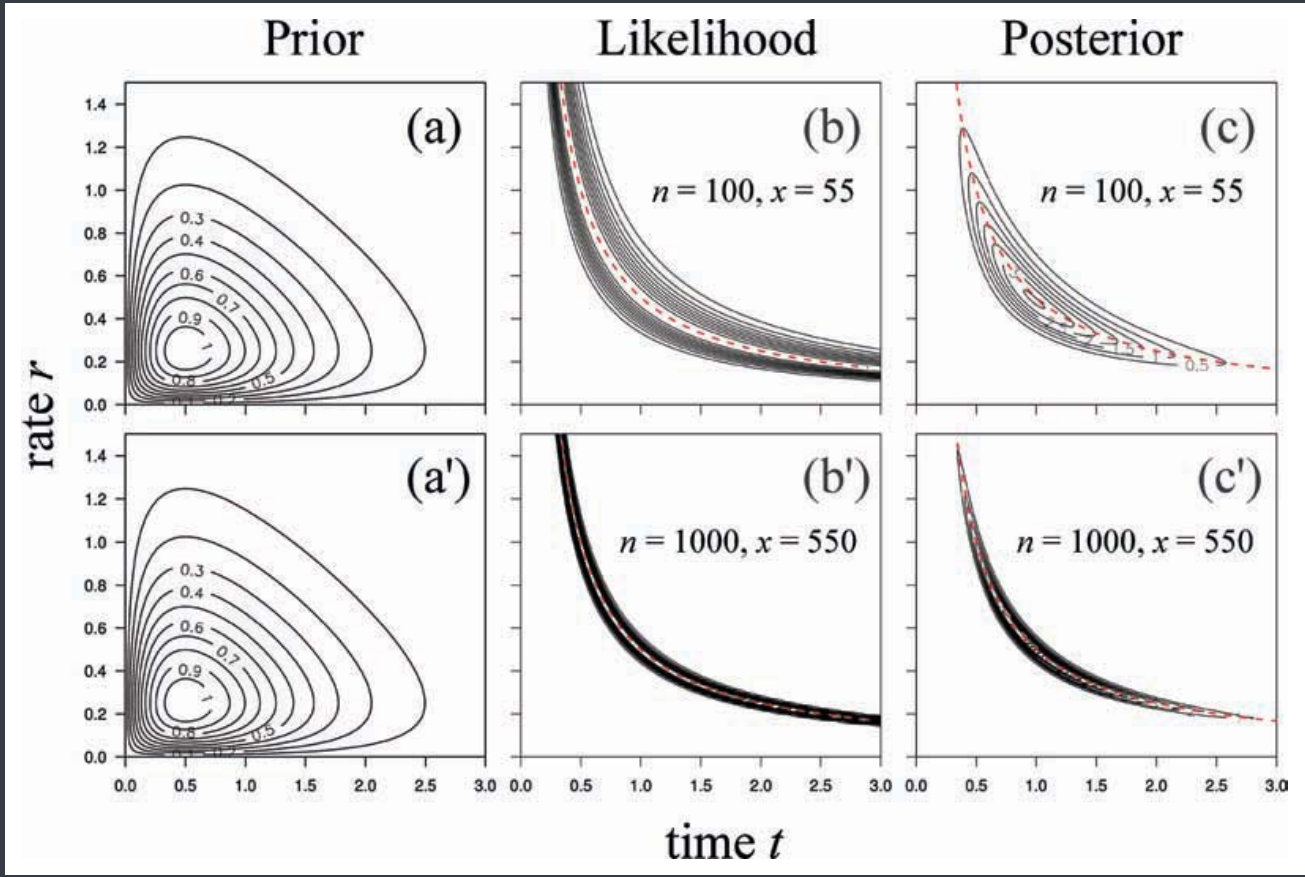
$t$: set by fossil observations

$r$: set by models of mutation

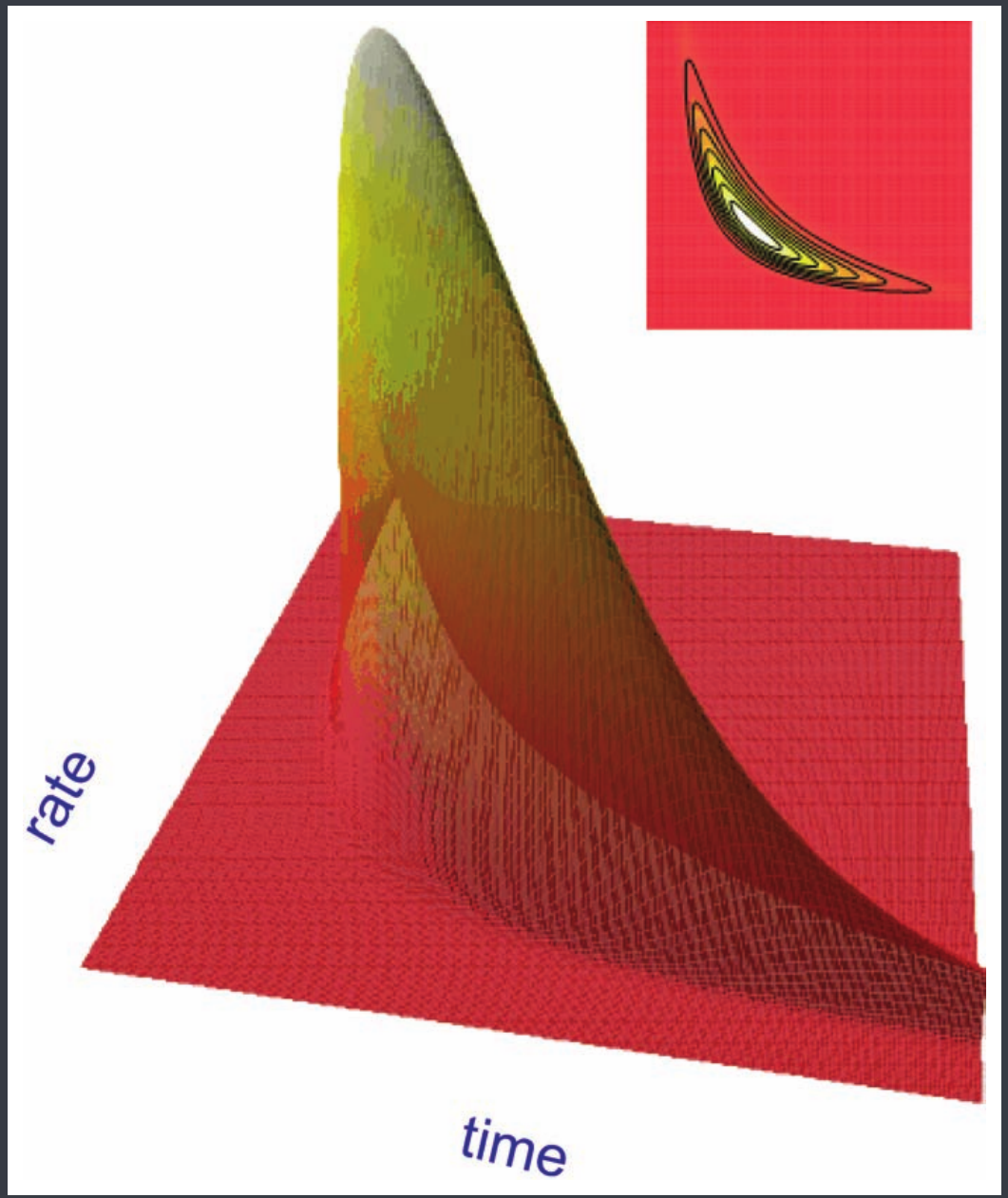
# Two species, an alignment of $n$ sites with $x$ differences

$$\hat{d} = -\frac{3}{4} \cdot \log\left(1 - \frac{4x}{3n}\right)$$

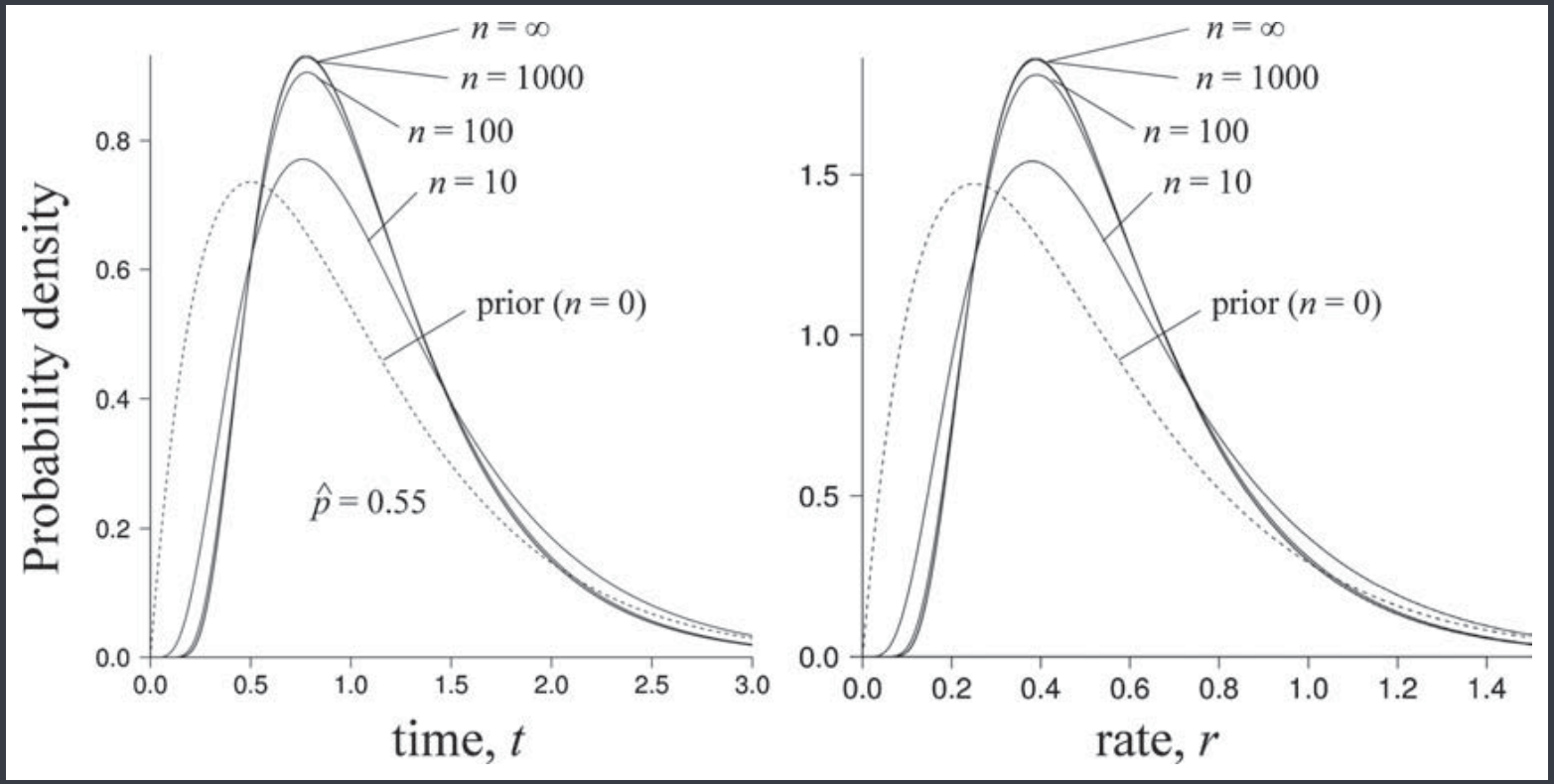
# What about r and t?




dos Reis and Yang (2013), *J. Syst. Evol.* 51:33

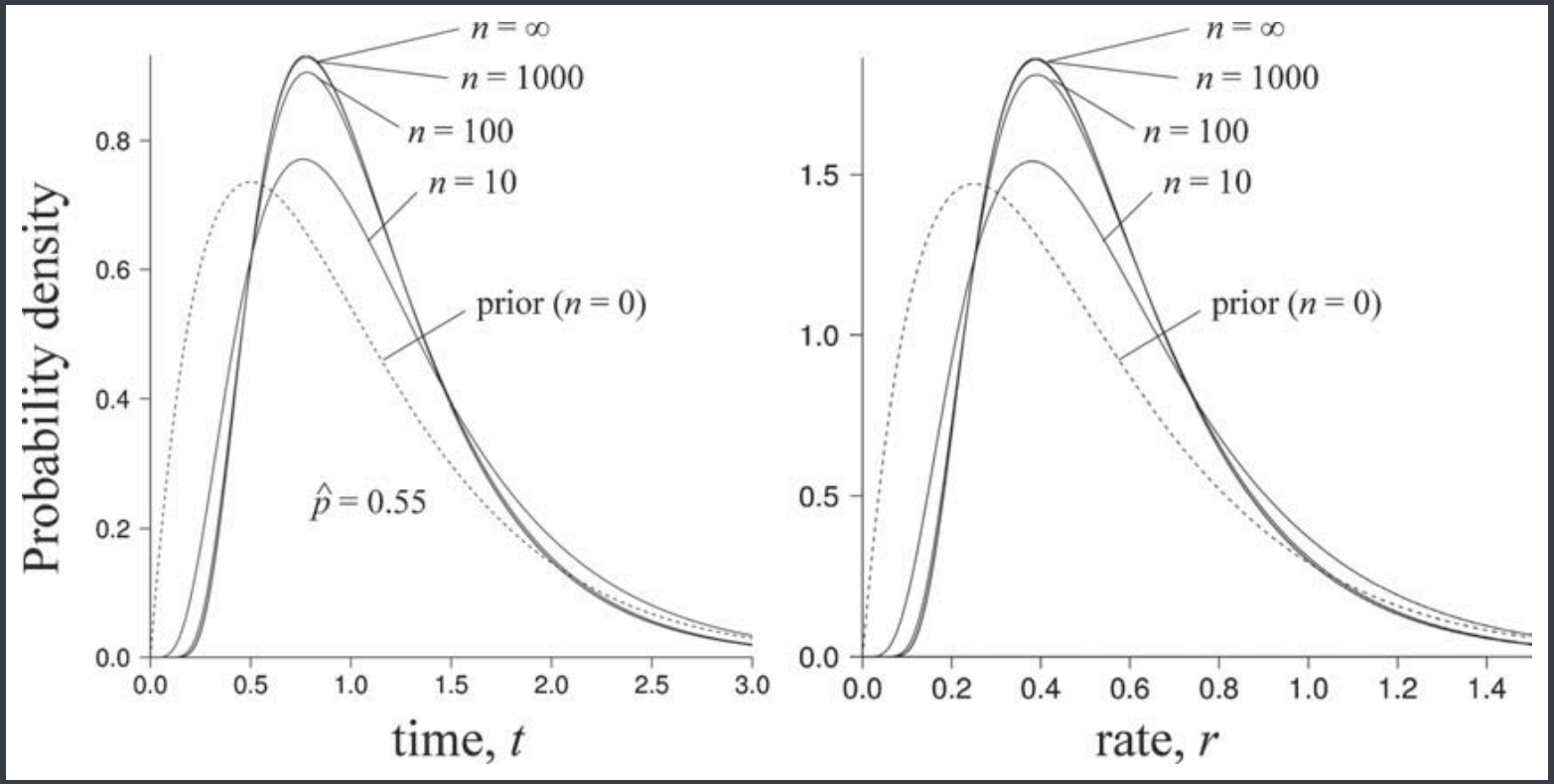



dos Reis and Yang (2013), *J. Syst. Evol.* 51:cover image




dos Reis and Yang (2013), *J. Syst. Evol.* 51:34

rate and time are *non-identifiable:* they only appear multiplied together in the expression for distance




dos Reis and Yang (2013), *J. Syst. Evol.* 51:34

# CONCLUSIONS

“The biological world is messy.”

“More data yields deterministic models.”

~~"The biological world is messy."~~

~~"More data yields deterministic models."~~

**We can do better!**

1. Actual observations
2. Currently possible observations
3. Observations possible in principle (with limits)
4. Observations possible in principle (no limits)

Werndl (2013), *Synthese* 190:2243

1. Actual observations
2. Currently possible observations
3. Observations possible in principle (with limits)
4. Observations possible in principle (no limits)

Werndl (2013), *Synthese* 190:2243

# QUESTIONS?

charles@charlespence.net
http://www.charlespence.net
@pencechp