Graeme Mitchison 1944 - April 13 2018

- 1960s Oxford – Mathematics BA and PhD
- 1970s MRC LMB – developmental patterning in plants
- 1980s MRC LMB with periods in San Diego, San Francisco, King's College – brain function and development
- 1990s MRC LMB – protein sequence analysis
- 2000s DAMTP – quantum computation
- 2010s SLCU – plant morphogenesis

Patterns in neural maps and genome sequences

(with illustrations from Graeme's garden)

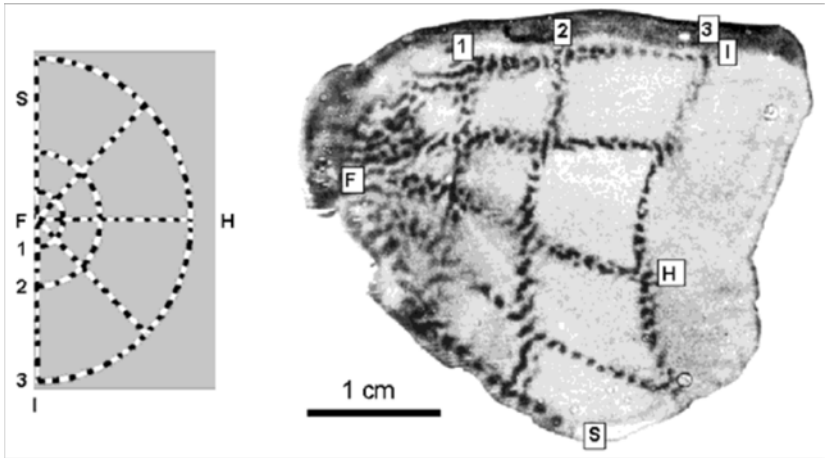
Richard Durbin

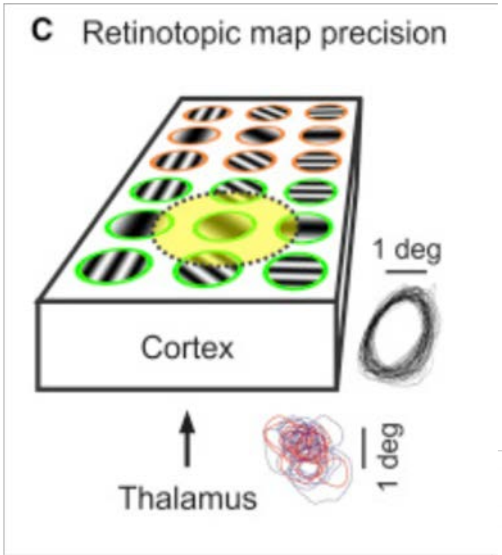
Department of Genetics, University of Cambridge

rd109@cam.ac.uk, @richard_durbin

Symposium in memory of Graeme Mitchison, April 13 2019

Introduction to neural maps





Proc. Natl. Acad. Sci. USA
Vol. 79, pp. 3661–3665, June 1982
Neurobiology

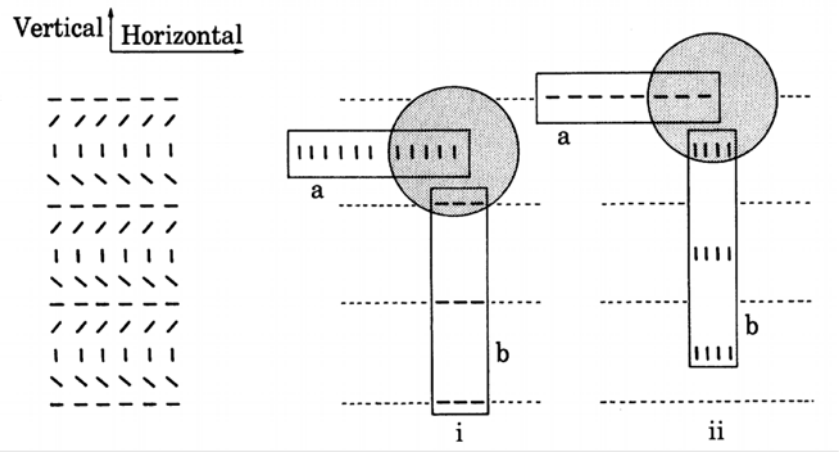
Long axons within the striate cortex: Their distribution, orientation, and patterns of connection

(horseradish peroxidase/stripes/orientation columns/tree shrew/cat)

GRAEME MITCHISON AND FRANCIS CRICK

The Salk Institute, Post Office Box 85800, San Diego, California 92138

Contributed by Francis Crick, March 8, 1982



The human neocortex is a sheet of neural tissue, organized in areas. Within an area there is a continuity of representation, with in primary visual cortex (V1), nearby cells responding to stimuli that are similar in position in visual space, in orientation, and in which eye the signal comes from (ocular dominance).

SIAM J. ALG. DISC. METH.
Vol. 7, No. 4, October 1986

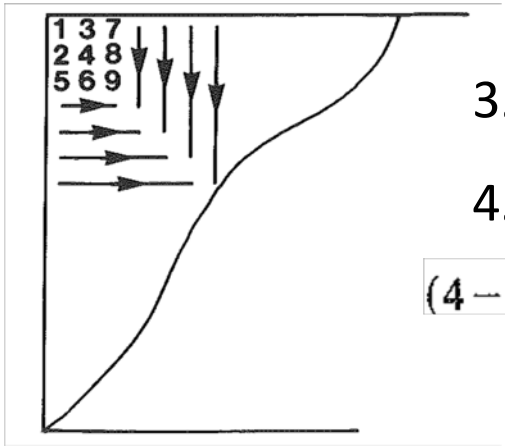
007

OPTIMAL NUMBERINGS OF AN $N \times N$ ARRAY*

GRAEME MITCHISON† AND RICHARD DURBIN†

1. Introduction. Suppose we number an $N \times N$ array with the integers $1 \cdots N^2$. What numbering minimizes the absolute values of differences between adjacent entries?

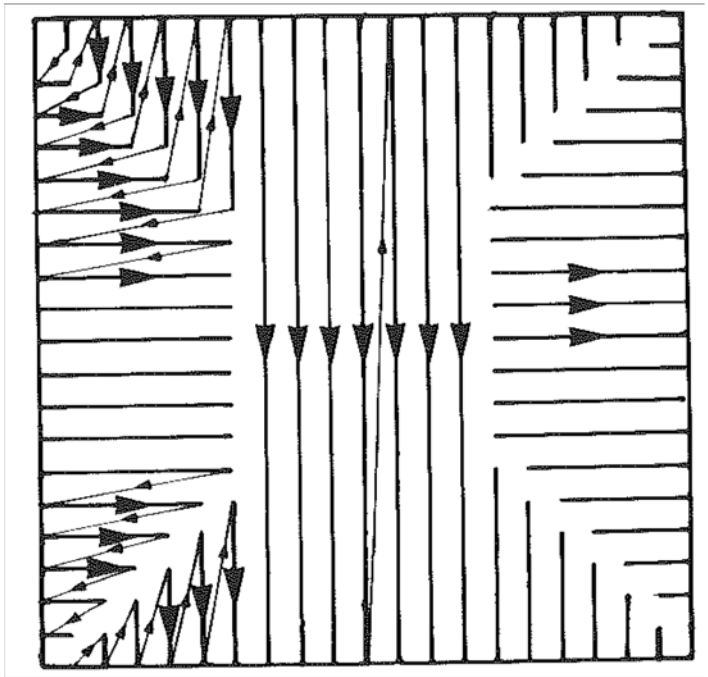
1. The numbering must be ordered, top left to bottom right
2. The top left is an alternating square of size *Nx*



3. Find x that minimizes cost C(x)
4. C_{min} =

$$(4-2^{1/2})N^3/3+O(N^2)=0.868N^3+O(N^2)$$

at $x=(1-2^{-1/2})N$



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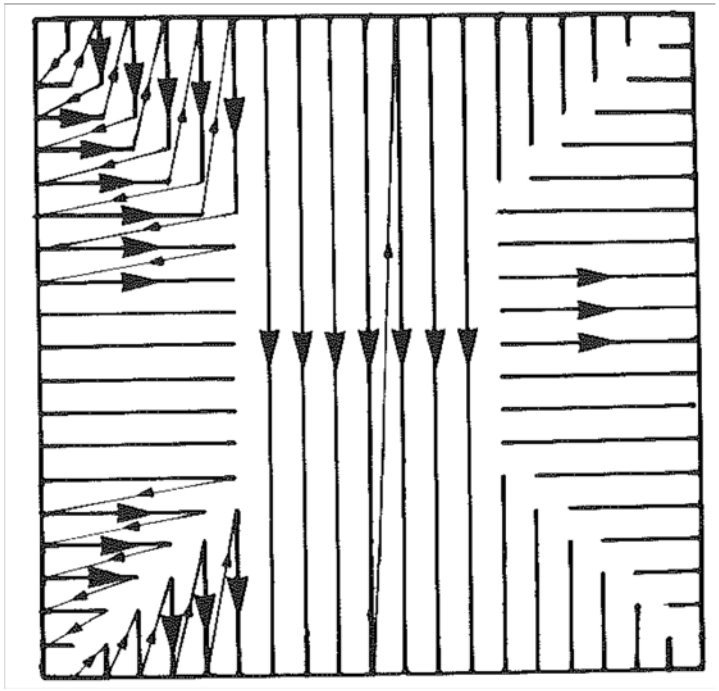
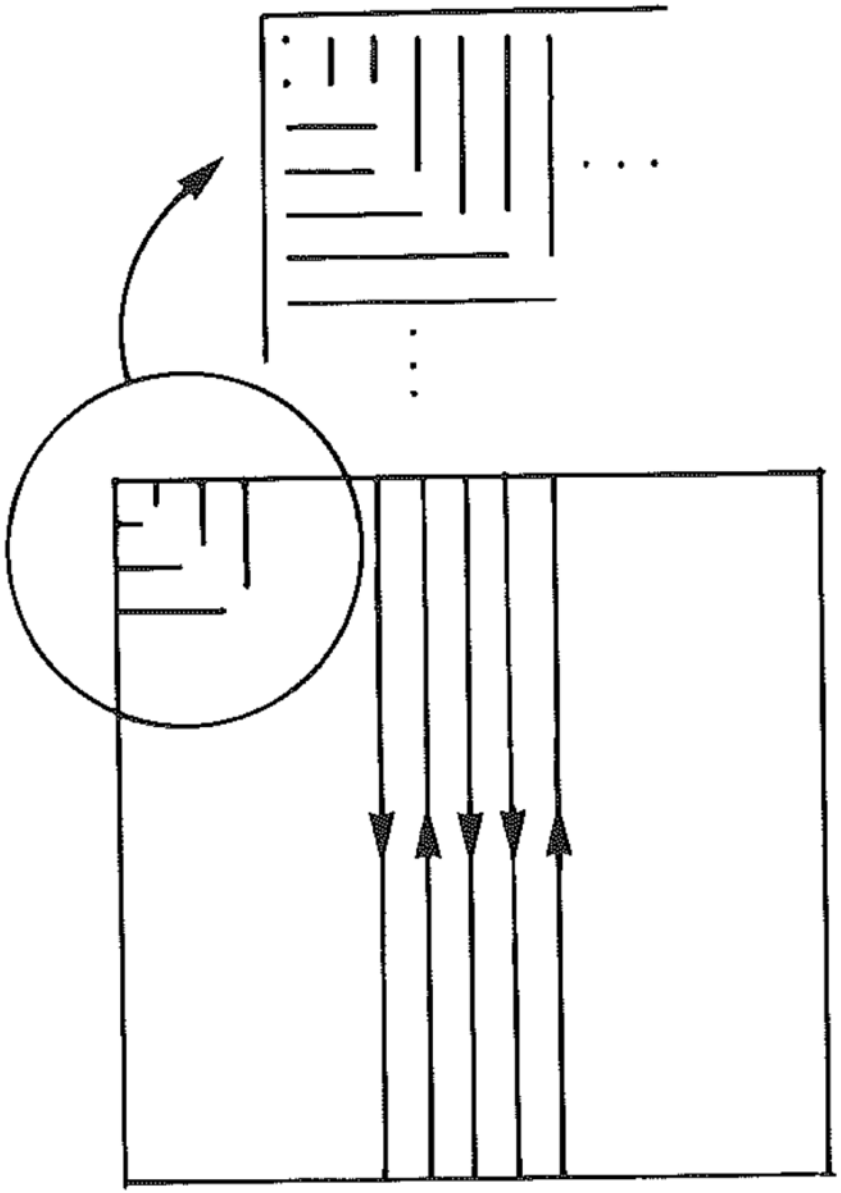
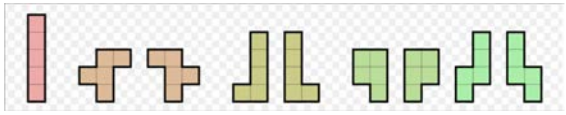
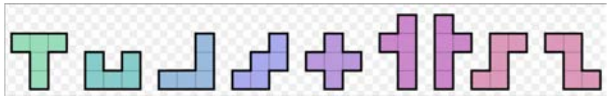




Boustrephedon variants

With Sol Golomb and Bo in Graeme’s garden in the 1980s

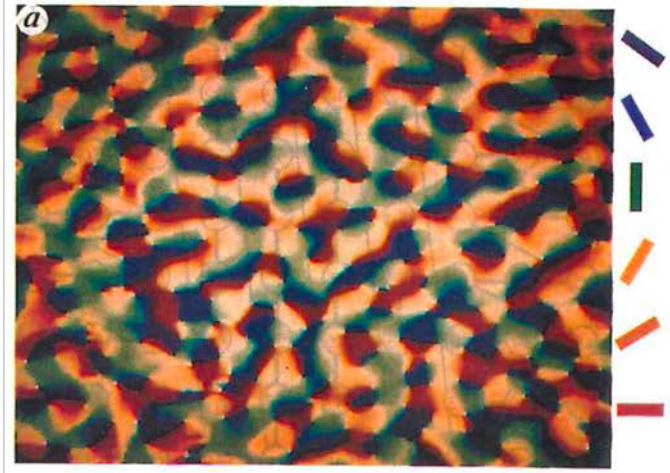




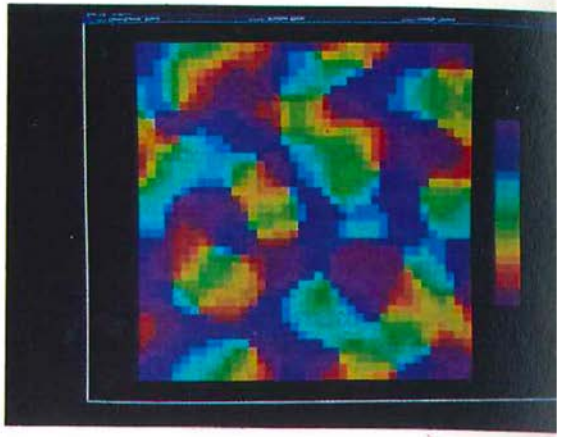
A dimension reduction framework for understanding cortical maps

Richard Durbin* & Graeme Mitchison†

We suggested that the neural map patterns seen in brain cortical areas arise from trying to fit multiple dimensions of information onto the 2-dimensional surface of the cortex.



The arrangement of regions responding to oriented stimuli in a real macaque monkey brain (activity-dependent dye data)



The corresponding pattern in a 4-D to 2-D dimension reduction model.
At right, the corresponding spatial map.

“Elastic net” model

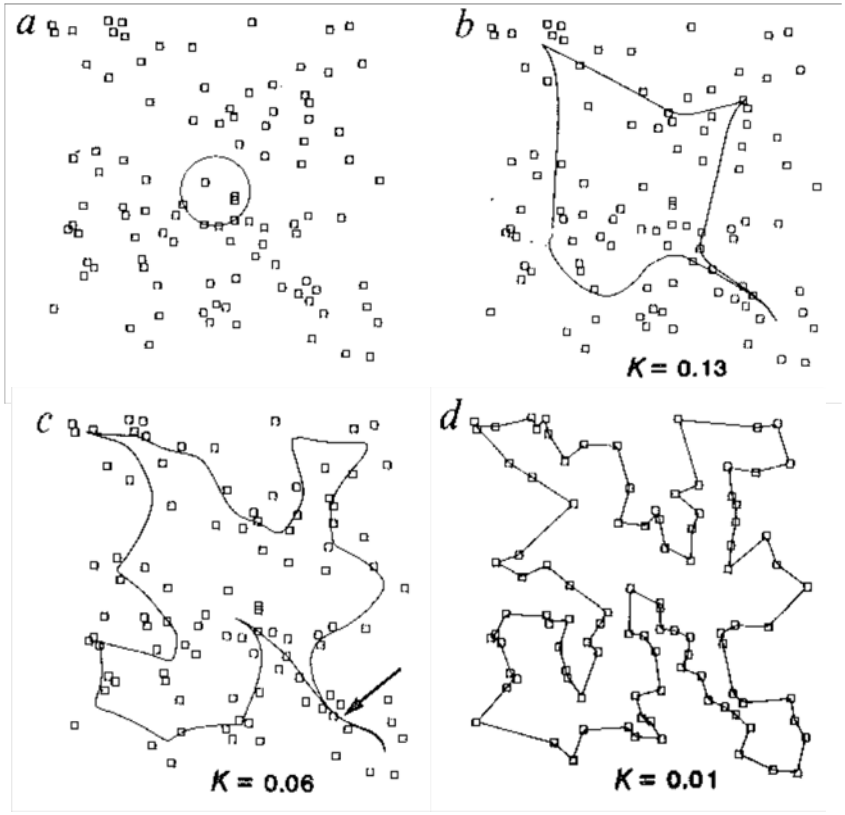
Given a set of points $\mathbf{X}_i$ in D_1-dimensional space

Minimise an “energy” for a representation in terms of points $\mathbf{Y}_j$ in D_2-dimensional space

$$E(\{\mathbf{Y}_j\}, K) =$$

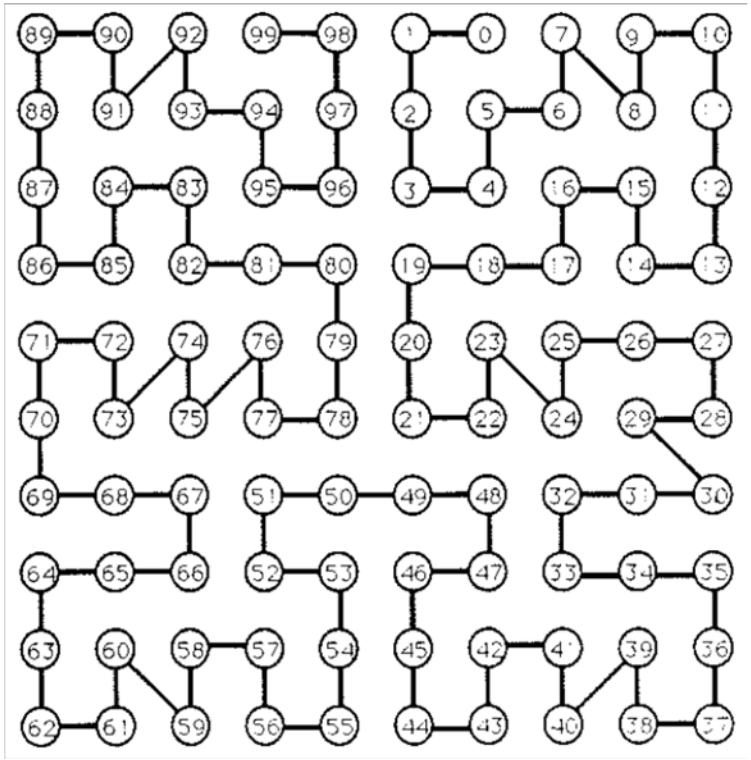
$$-\alpha K \sum_i \log \sum_j e^{-|\mathbf{X}_i - \mathbf{Y}_j|^2/2K^2}$$

$$+ \beta \sum_j \{\mathbf{Y}_j - \mathbf{Y}_{j+1}\}^2$$



Application to the Travelling Salesman Problem: 1D embedding in 2D

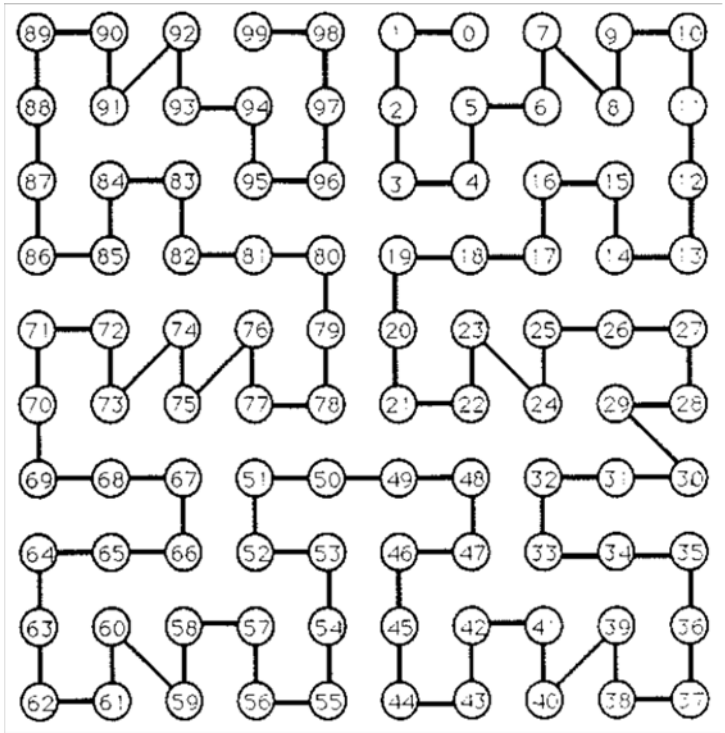
Durbin and Willshaw (1987)



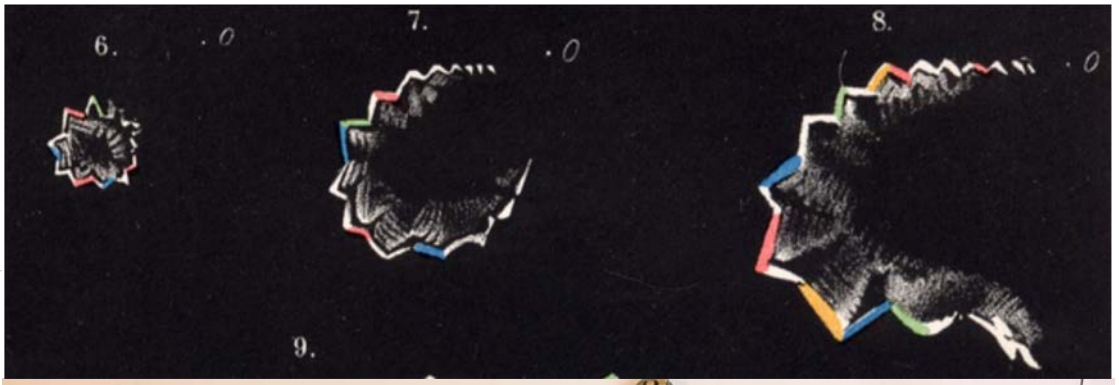
Application to NxN array numbering 2D dimension reduction to 1D

Mitchison and Durbin (1990)

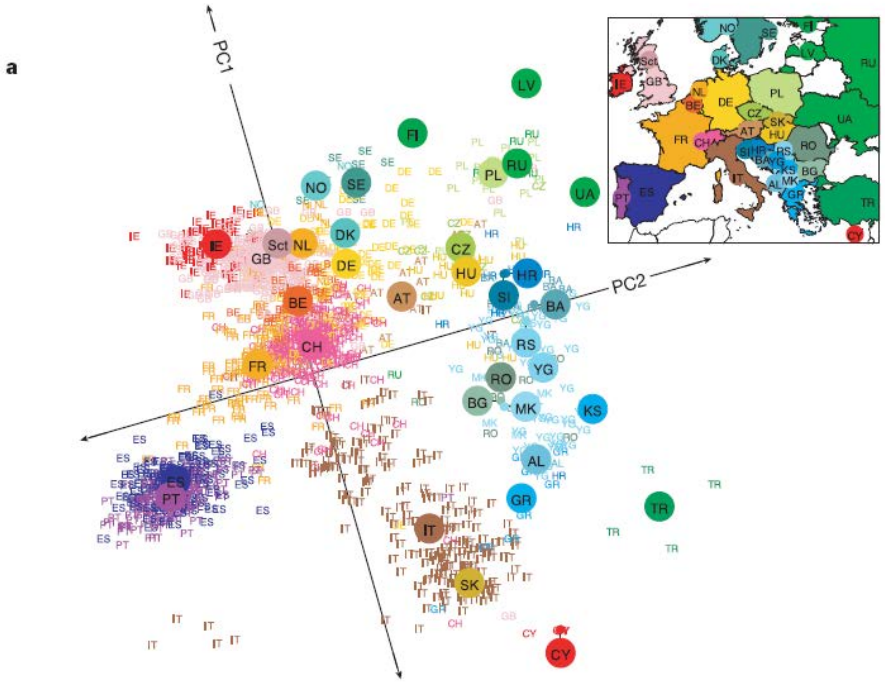
“Elastic net” model

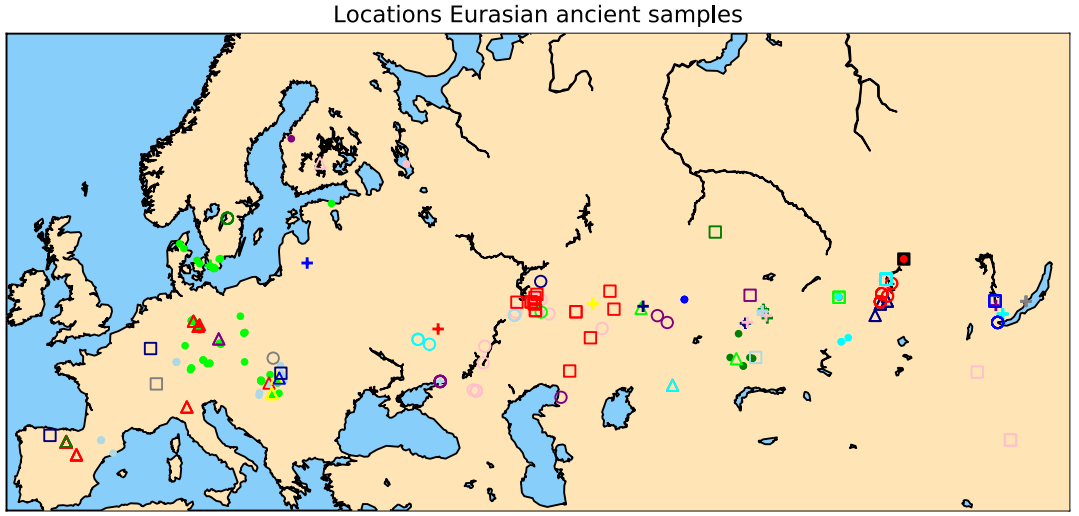


Other strange reflections of the mind



Ancient genomes across Europe and Asia





AG2
AG_LBA
Altai_Andronovo
Altai_IA
AncFinn
Andronovo
Botai
CentralSaka
EBA_Steppe
EHG
Europe_EN
Europe_LNBA
Europe_MNChL
GoldenHordeAsian
GoldenHordeEuro
HallstattBylany
HungarianScythian
Hungarian_Med
Iberia_BA
Karasuk
Karelians
Kimak
Kipchak
Kostenki14
Kurma
Lokomotiv
MA1
Mezhovskaya
NLithuania
Nomad_HP
Nomad_Hun-Sarmatian
Nomad_IA
Nomad_Med
Nordic_IA
Okunevo
Poprad
R_Andronovo
SHG
SaltovoMayaki
Sarmatian
ShamankaBA
ShamankaEN
Sidelkino
Steppe_EMBA
Steppe_Eneolithic
Steppe_IA
Steppe_MLBA
Switzerland_HG
Tagar
Turk
UstIdaBA
UstIdaLN
Ust_Ishim
WHG
XiongNu
Yamnaya

$$\Delta f_{jl} = \alpha\gamma \sum_{k:l\in L_k} w_{jk}(g_k - f_j) + \beta T \sum_{i\in\Gamma(j)} (f_i - f_j)$$

with Marilou Boddé