Nature vs Nurture

- Basic biological constraints on developing brain
- Environment can alter biology; before and after birth

- Reality is that genes influence development in relation to the environment

Nature v Nurture: Phenylketonuria (PKU)

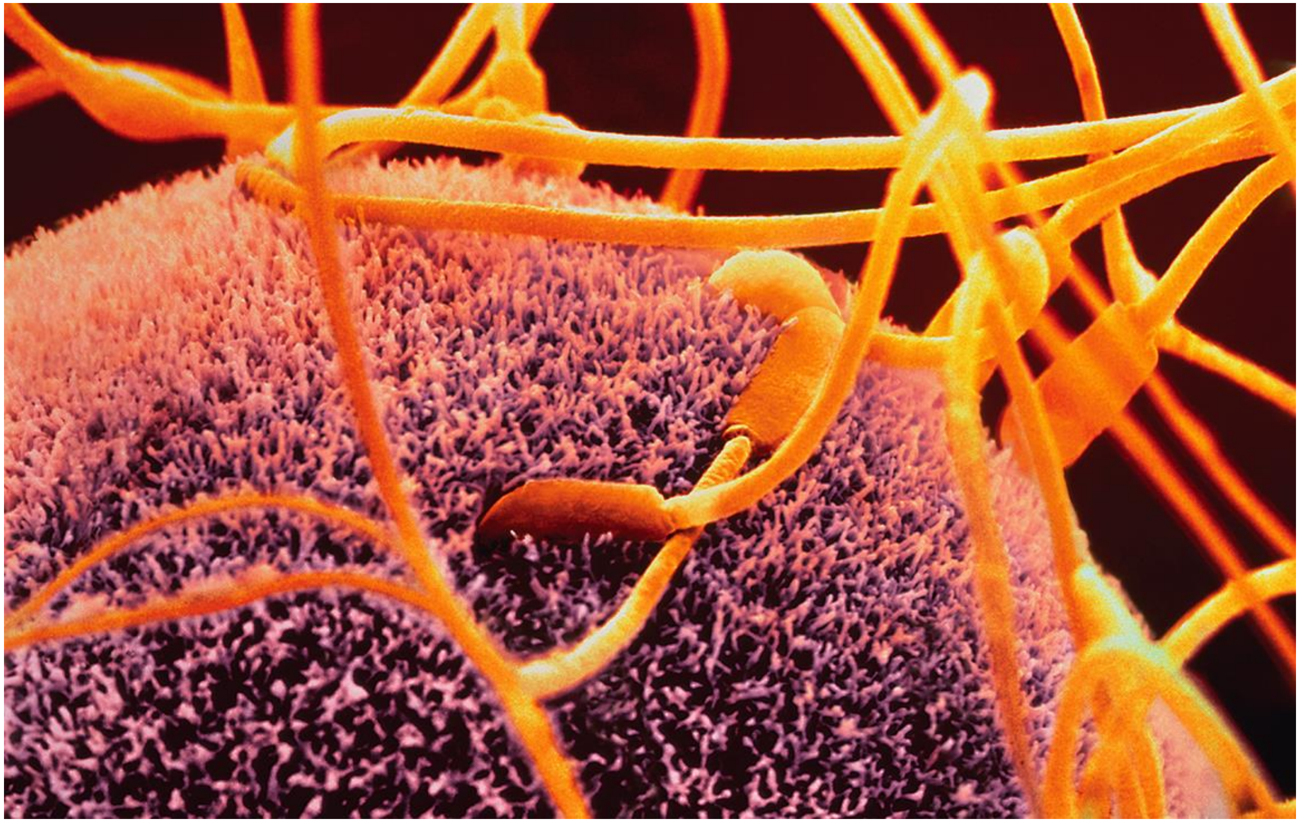
- Genetic disorder of chromosome 12 which fails to produce the enzyme that breaks down the amino acid phenylalanine (Phe) which is present in many foods e.g artificial sweeteners.

- High levels of Phe are neurotoxic, producing brain damage

- Solution: Avoid foods with Phe

- But where is the disorder? In the genes or in the environment

The Moment of Conception



Electron Micrograph Image (false colours)

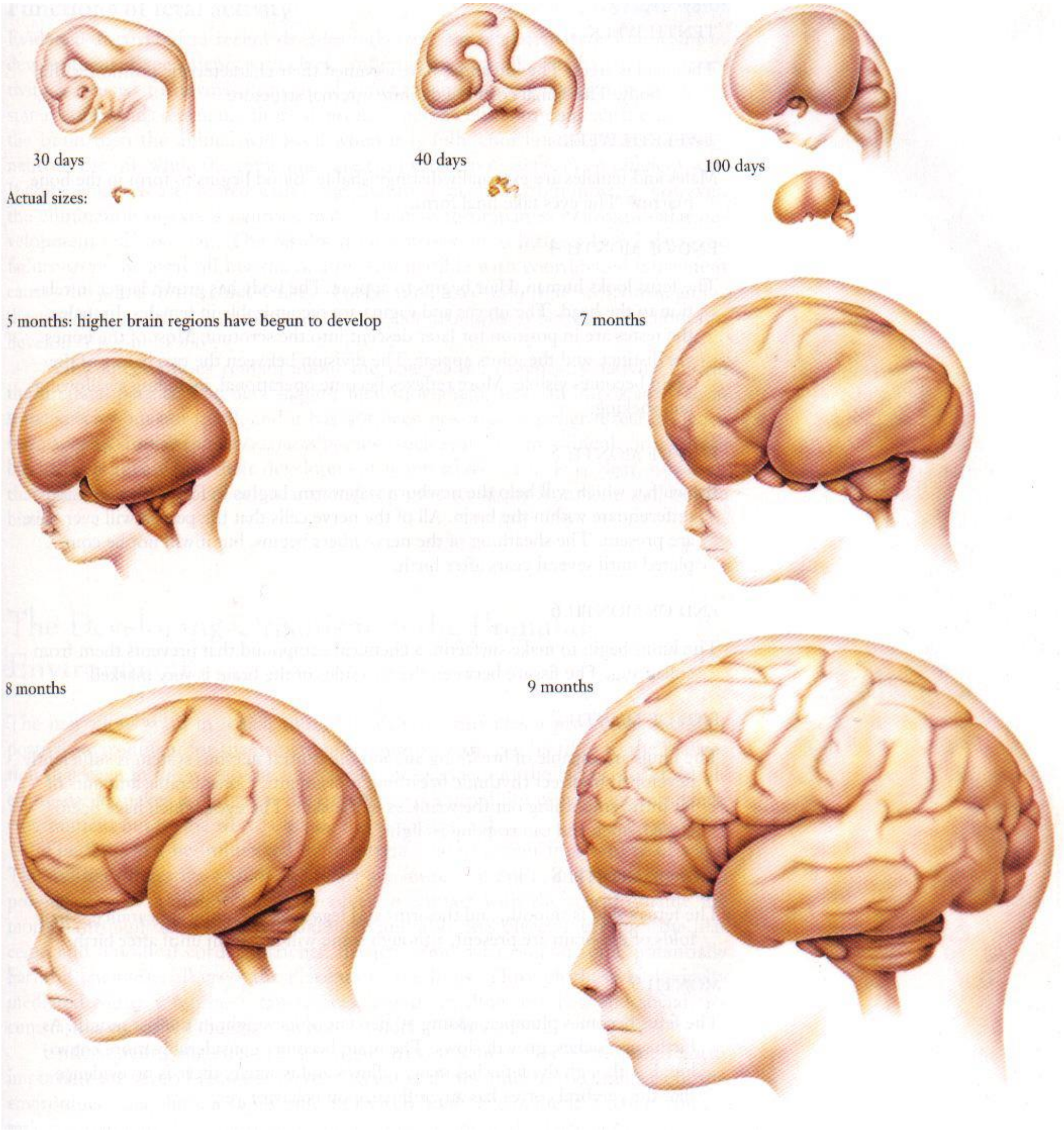
prenatal development

- Zygote: fertilized egg containing 23 *pairs* of chromosomes (22 plus sex chromosomes XX / XY)
- Germinal stage: implantation & cell division
- Embryonic stage: formation of 3-layered disc into the endoderm (organs), mesoderm (skeleton) & ectoderm (skin/nerves)
- Building a Brain: neurogenesis within the neural tube formed

Embryonic disk folds to become the neural tube.

This elongates to form the structures that will become the forebrain, midbrain & hindbrain

Cortical cells are born in the inner tube & migrate outwards. (Cortex is last to develop!)



fetal development

30 days

8-9 weeks

5 months

prenatal environment

- Teratogens: toxins & environments that affect fetal development
- Fetal alcohol syndrome
- Unlike most things which require building before they start working, the human brain functions as it is being built (see lecture 9 for transnatal learning)

teratogens

Normal 6-week

FAS 6-week

Child with FAS

Fetal Alcohol Syndrome

neurons

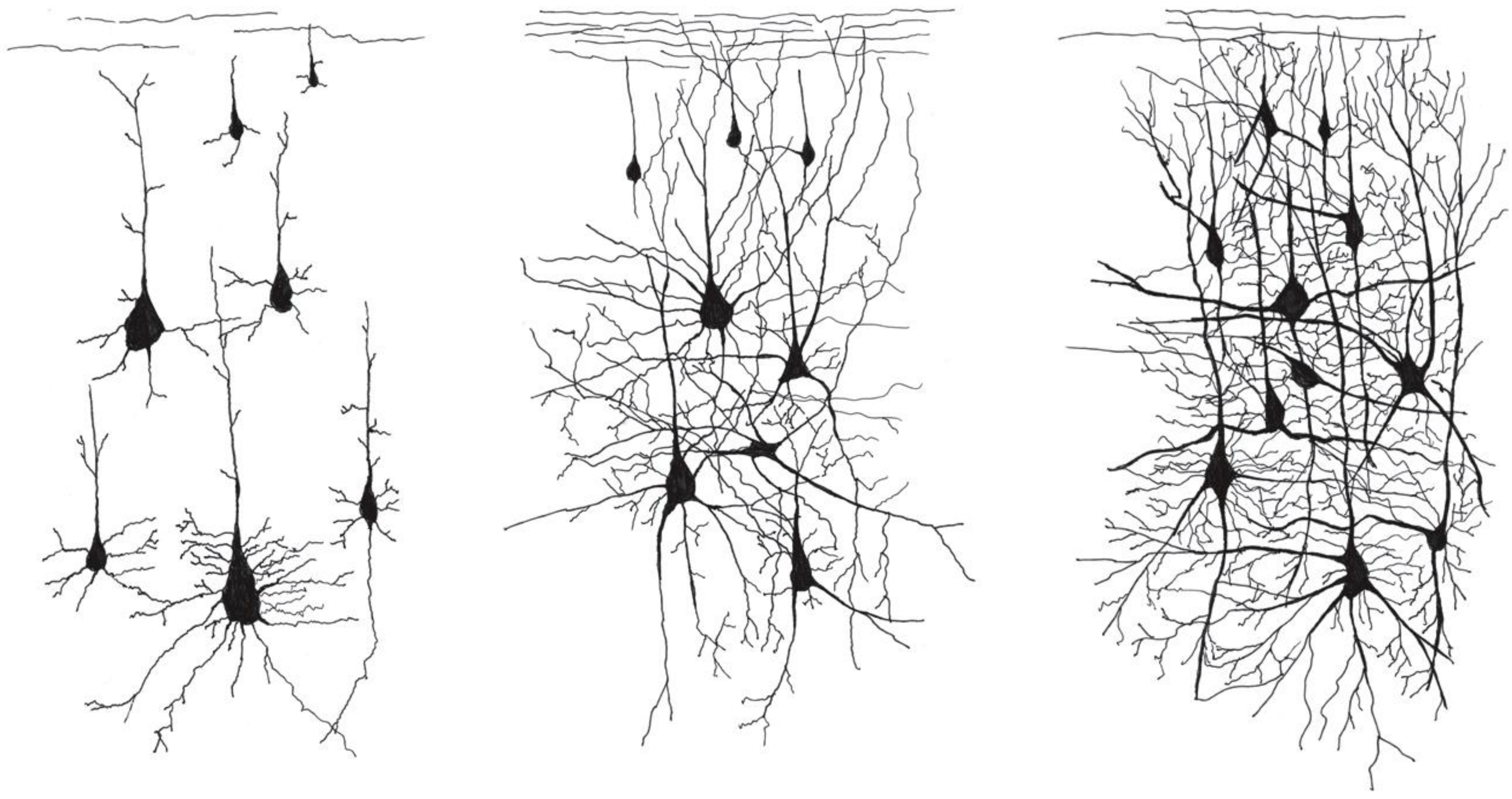
Brain cells responsible for higher order functions

1) Cell body
2) Axons
3) Dendrites

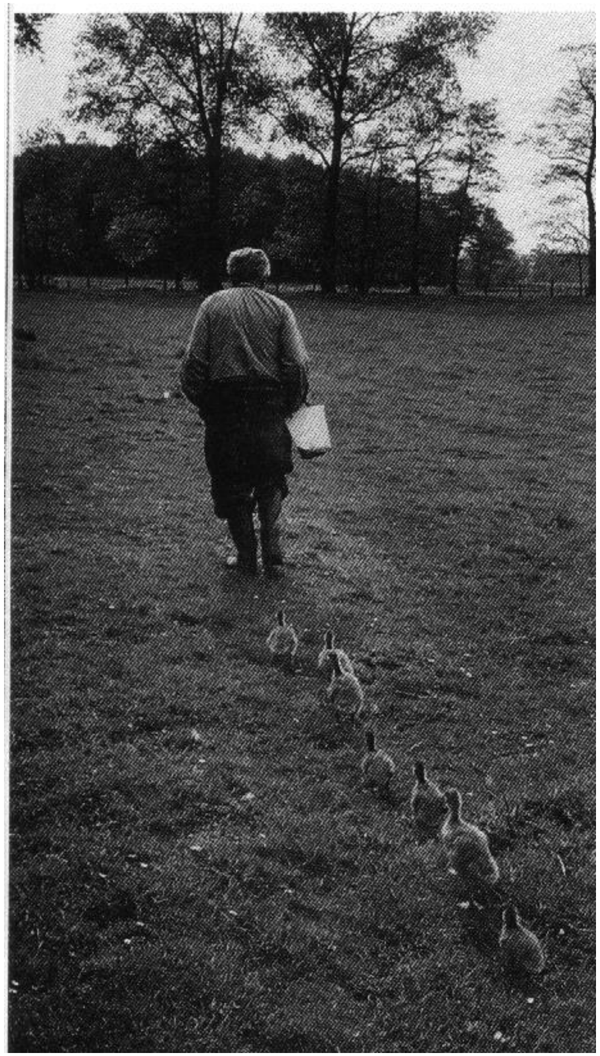
postnatal life: wiring and firing

- Cortical brain development after birth
  - Arborization (branching)
  - Synaptogenesis (connections)
  - Myelination (insulation)
  - Synaptic pruning (cutting back)

postnatal cortical development



newborn 3-month-old 6-month-old



brain plasticity

Experience-expectant (evolution)

Experience-dependent (within a lifetime)

Sensitive periods (time-limited when changes can occur)

e.g. Imprinting in birds; Lorenz
e.g. Vision in cats; Hubert & Weisel

individual differences

What could be the cause of individual differences?

Biological factors

Environmental factors

> "Professors are inclined to attribute the intelligence of their children to nature, and the intelligence of their students to nurture"
>
> (*Masters, in Ridley, 2003*)

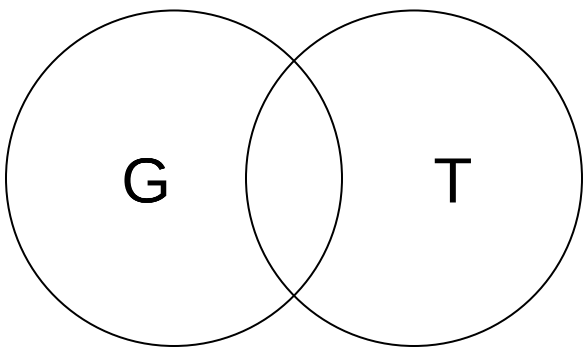
the general method

Genotype (G - genetic) to Phenotype (T - trait)

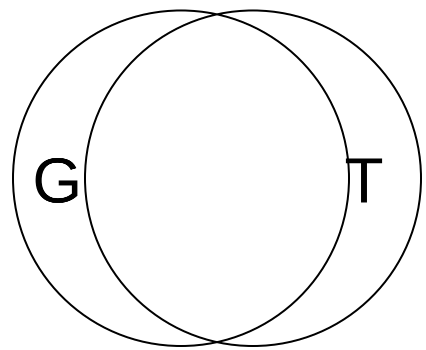
‘Linking’ – so a correlational method

Correlations: the extent to which 2 measures co-relate (range from 0 – 1)

More formally: shared variance (the variation in one measure that ‘overlaps’ with variation in the other)



r = .2?



r = .8?

the general method

So, want to explain behaviour – or more accurately, shared *variation* in behaviour

Seen already that there are two (and really only 2) possible causes of this variation

Genetic (nature)	vs.	environmental (nurture)

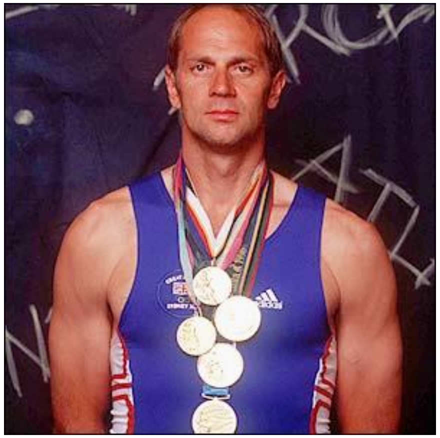
Heritability – is the proportion of variation in a trait explained by genetic factors

Environmentality – is the proportion of variation in a trait explained by environmental factors (and so, = 1-heritability)

heritability is quirky…

If we look at population statistics, we can estimate that the heritability of number of fingers is – considerably less than 1

Hard to see boundaries between genes and environment: if musicality in children is genetic, then musical children (of musical parents) grow up in a musical household

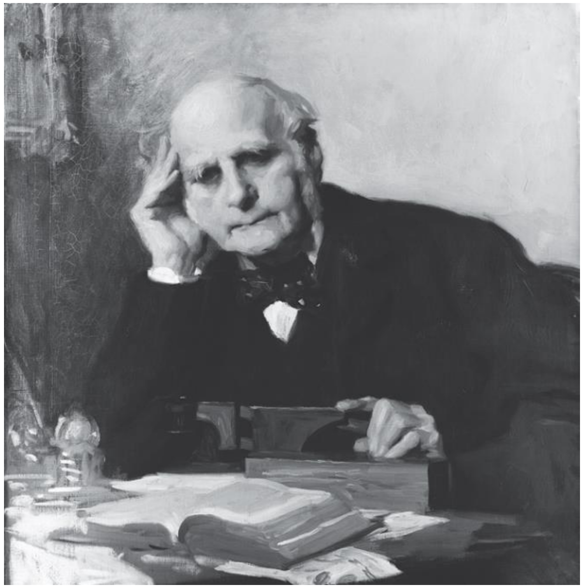


Heritability will necessarily increase with decreased environmental variation

Twin studies

Francis Galton (1822-1911)

Identical (monozygotic, MZ) and non-identical (dizygotic, DZ) twins



Why is a comparison of the two relevant?

Arguably they have the same degree of **shared environment**

If MZ twins share all their genes, & their IQs correlate .86

If DZ twins share half their genes, & their IQs correlate .60 (say)

Then we estimate the heritability (h_g^2) of IQ to be .52 (double the difference in correlations)

example: reading

Surely, reading is taught - environmentality?

yet large individual differences (despite same classroom, same instruction)

- moderate h_g^2 estimates of word reading ~.56-.73

    Olson et al. ('91) Kovas et al. ('07) Wilcutt et al. ('10)
- moderate h_g^2 estimates for reading deficits ~.56

    De Fries et al. (1991; 1993)
- even high in Chinese (Chow et al. 2011)

reading as influenced by genetic variation?

Colorado twin study

- Sample of twins with dyslexia; 667 MZ also 779 DZ (same-sex) 361 DZ(opp-sex)
- Control group of typical twins
- Word reading, spelling, comprehension
- Reading-related skills
  - Rapid word-reading
  - Phonological decoding “gight”
  - Orthographic coding “rain vs rane”

Colorado twin study

Shared (c) and Non-shared (e) influences?

- biological risk; accident or illness
- exposure in school; reading practice
- test error

Word reading $h_g^2 = .55$ $c_g^2 = .39$

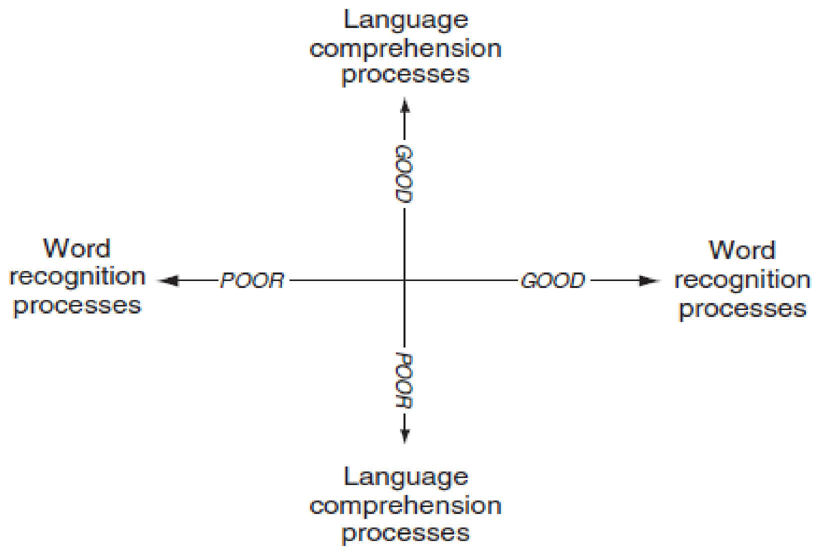
Phonological decoding $h_g^2 = .70$ $c_g^2 = .18$

Orthographic coding $h_g^2 = .67$ $c_g^2 = .17$

Data from Gayan & Olson, 1991

reading is multi-faceted

phonological abilities, decoding, spelling etc



Keenan (2006)

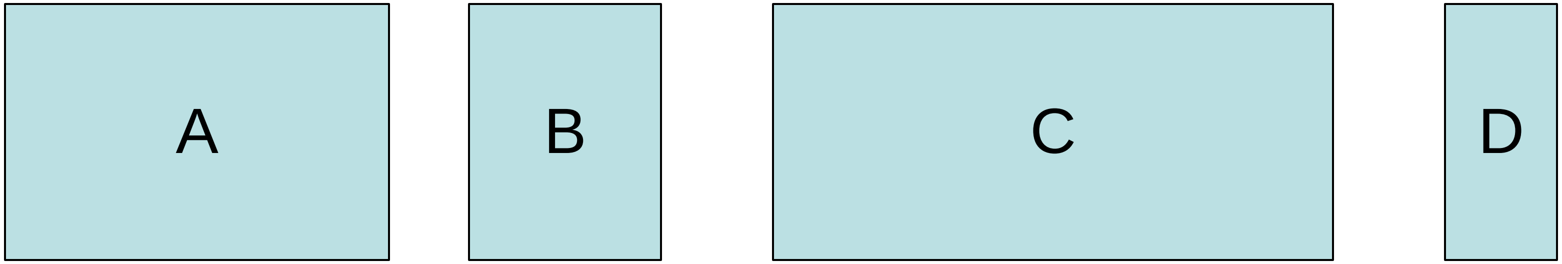
genetic correlations
also mirror ‘simple model’

independent contributions
to reading comprehension

*‘Simple’ model of **reading comprehension***
(Hoover & Gough, 1990)

understanding heritability

What does it mean to say the heritability of reading is ~52%
Does that mean that half of your reading skills are due to your genes and half is due to your environment?



What percentage in difference in size is due to width & height?

How much is the size of A due to width & height?

Heritability explains the variation **within a group**

Gene x Environment interaction

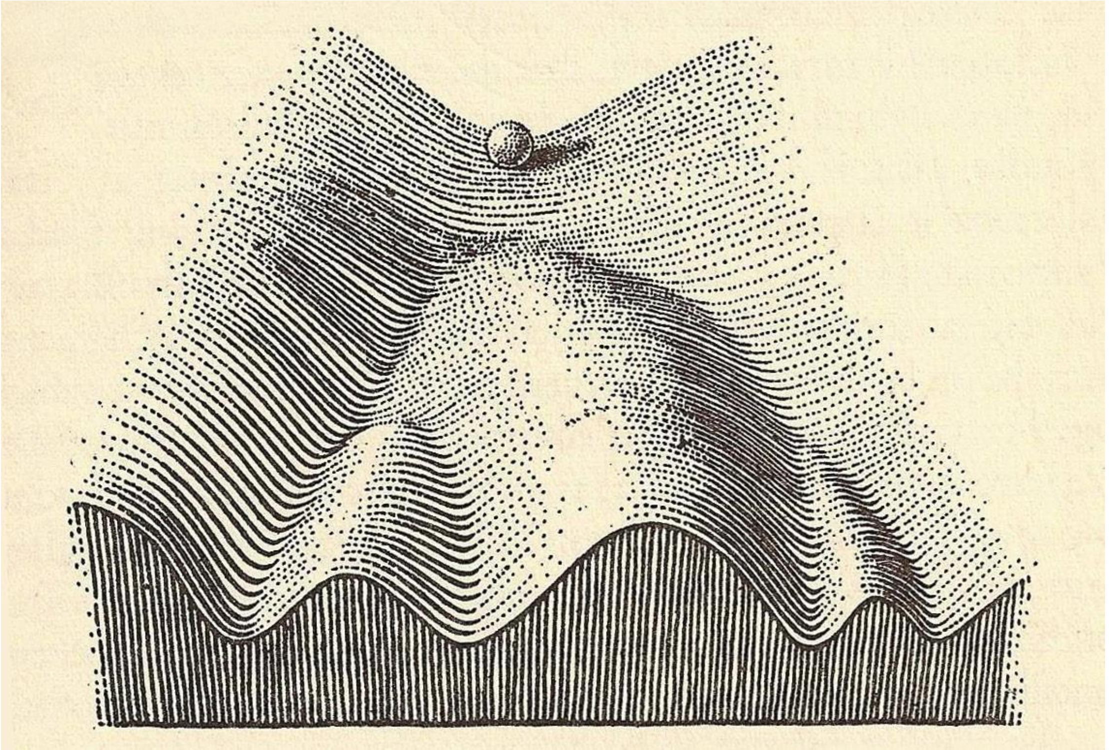
Cross-continent studies of reading?
Australia (from 5 years)
USA (from 5 years)
Europe (from 7 years)

Should heritability h_g^2 vary across countries?

Australia $h_g^2 \sim .80$; most schooling = most genetic effect?
USA $h_g^2 \sim .65$
Europe $h_g^2 \sim .30$
after 1 yr instruction; all similar ~ .80

schools influence ability to learn to read;
genes influence why some readers are strong, some weak
(variation within group is captured by heritability estimates)

Waddington's Epigenetic Landscape



Epigenesis: the interaction between genes & environment

Canalization: extent to which development is constrained by epigenesis

Conclusions

The nature-nurture issue is about the balance of genetic vs. environmental constraints on cognition and behaviour.

And is examined, typically, in terms of the factors that cause variability in a trait.

Almost all would accept that there are both genetic and environmental influences on almost all traits.

The question is one of balance; even if the exact figure for heritability isn't that obvious, identifying heritability will allow better targeting of genetic research and better targeting of school-based intervention