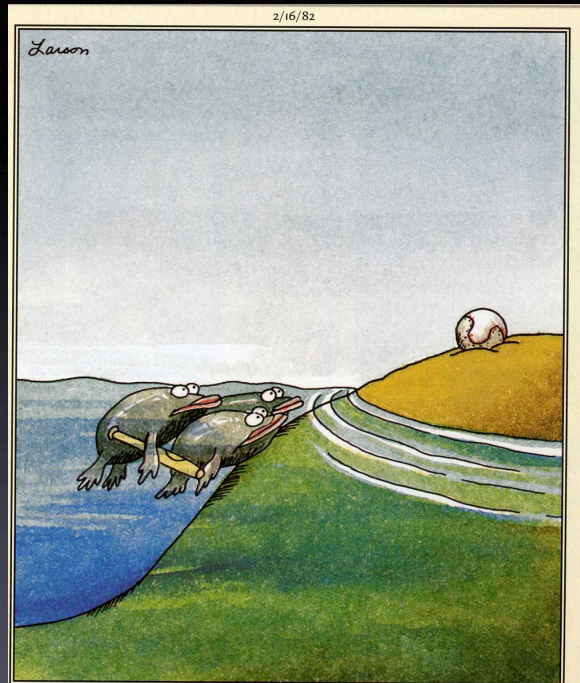
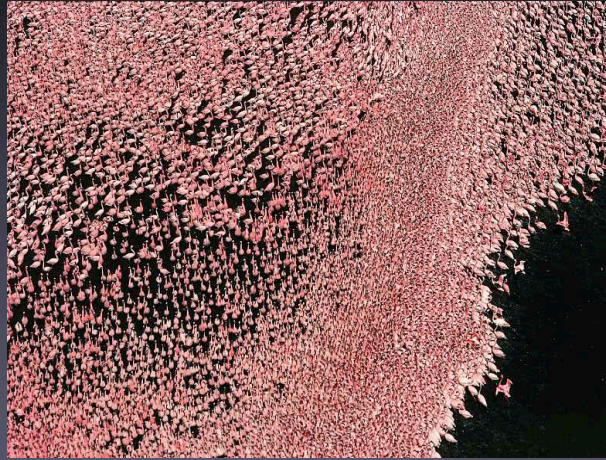


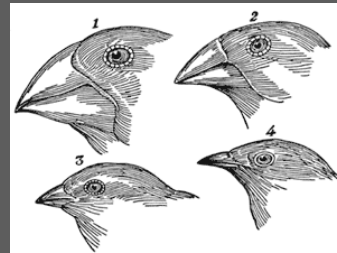
# 6.89 I: Computational Evolutionary Biology

R.C. Berwick & a cast of thousands



Great moments in evolution

*When on board H.M.S. 'Beagle' as naturalist, I was much struck with certain facts...*



## Darwin's finches

Darwin's finches. The finches numbered 1–7 are ground finches. They seek their food on the ground or in low shrubs. Those numbered 8–13 are tree finches. They live primarily on insects.

1. Large cactus finch (*Geospiza conirostris*)
2. Large ground finch (*G. magnirostris*)
3. Medium ground finch (*Geospiza fortis*)
4. Cactus finch (*G. scandens*)
5. Sharp-beaked ground finch (*G. difficilis*)
6. Small ground finch (*G. fuliginosa*)
7. Woodpecker finch (*Cactospiza pallida*)
8. Vegetarian tree finch (*Platypiza crassirostris*)
9. Medium tree finch (*Camarhynchus pauper*)
10. Large tree finch (*Camarhynchus psittacula*)
11. Small tree finch (*C. parvulus*)
12. Warbler finch (*Certhidia olivacea*)
13. Mangrove finch (*Cactospiza heliobates*)

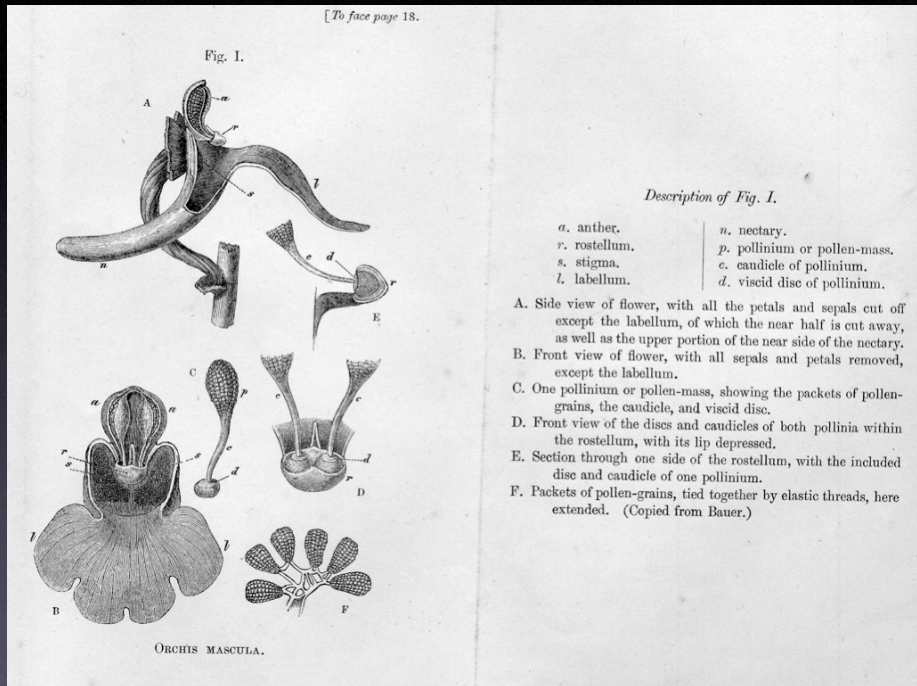
(From BSCS, Biological Science: Molecules to Man, Houghton Mifflin Co., 1963)





# “On the various contrivances...” - 1862

[To face page 18.]



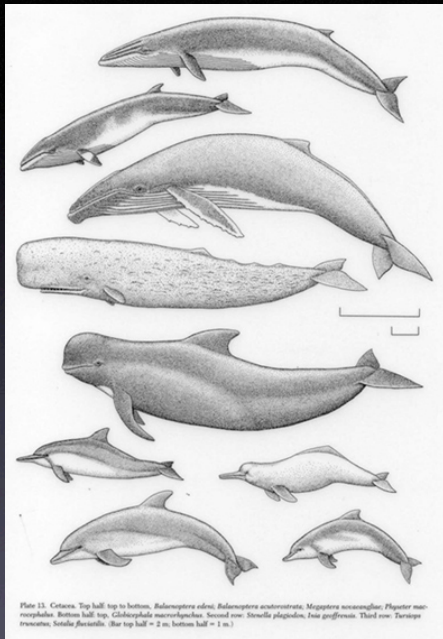
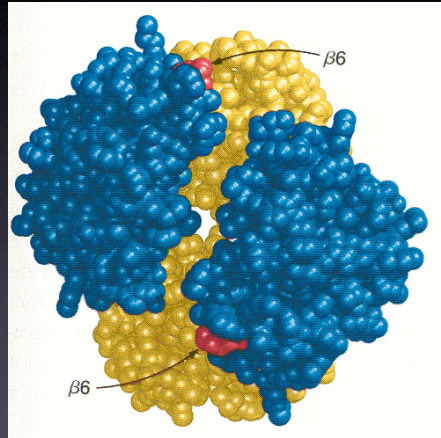


Plate 13. Cetacea. Top half, top to bottom, *Balaenoptera edeni*, *Balaenoptera acronotata*, *Megaptera americana*, *Physeter macrocephalus*. Bottom half top, *Gladioscapula australopacifica*, *Stenella platyptera*, *Stenella plegadis*, *For. griffithsi*. Third row, *Tursiops truncatus*, *Stella flascicola*. (Bar top half = 2 m, bottom half = 1 m.)





## Variation: within species - Human hemoglobin



## Human variation at genetic code level (genotype) to variation in protein to variation in...

*Hemoglobin A*:  $\beta$ -chain, Val-His-Leu-Thr-Pro-Glu-Glu-Lys-Ser-...

*Hemoglobin S*:  $\beta$ -chain, Val-His-Leu-Thr-Pro-Val-Glu-Lys-Ser-...

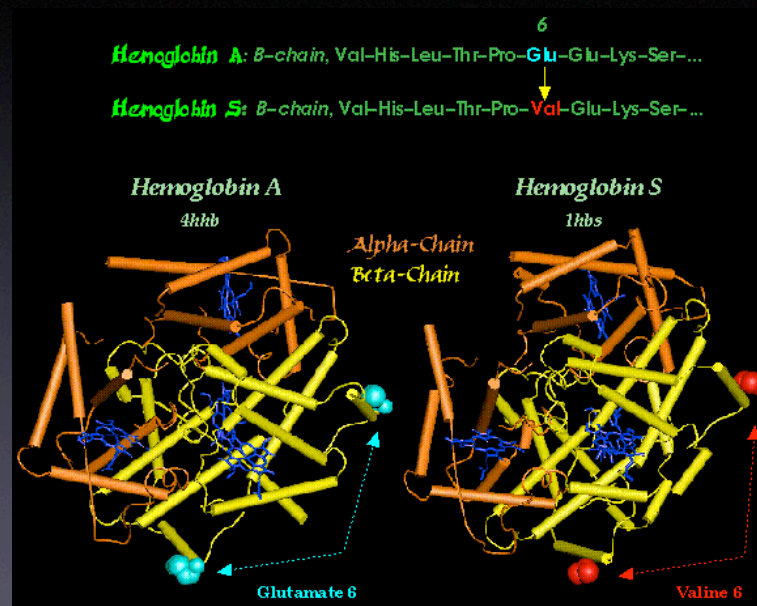
ATG GTG CAC CTG ACT CCT **GAG** GAG AAG TCT GCC GTT ACT  
 ATG GTG CAC CTG ACT CCT **GTT** GAG AAG TCT GCC GTT ACT

MVHLTP**E**EKSAVT (E is the single letter abbreviation for glutamic acid)

MVHLTP**V**EKSAVT (V is the single letter abbreviation for valine)

Glutamic acid is a hydrophilic amino acid. Valine is a hydrophobic amino acid.

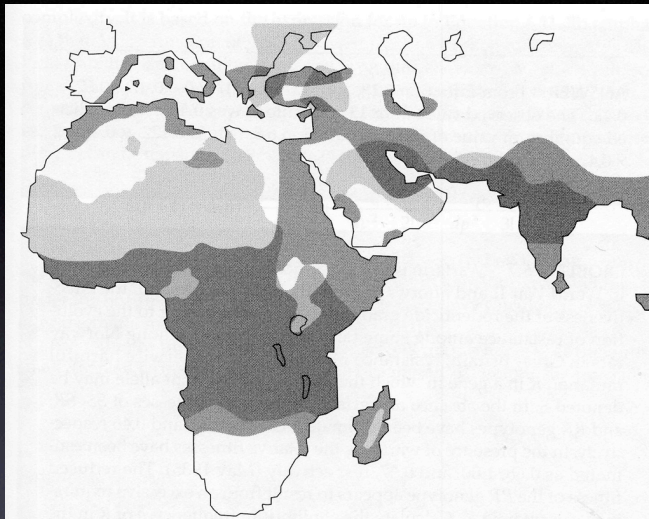
Variation: different “allelomorphs” or “alleles”  
(Bateson, 1908)



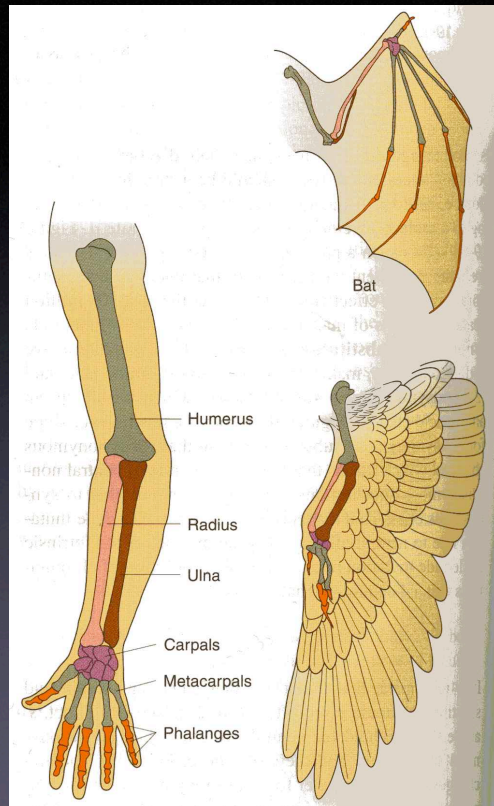
Variation in “phenotype” = ‘form that shows’





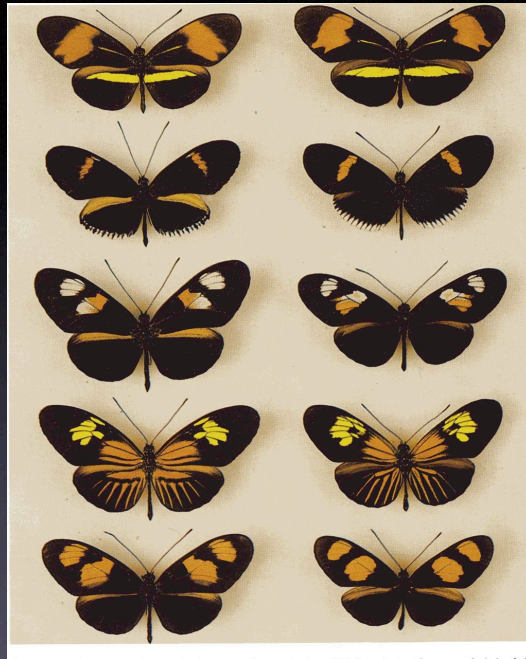


**Figure 6.5** The medium gray areas show the incidence of falciparum malaria in Africa, the Middle East, and southern Europe in the 1920s before mosquito control programs were implemented. The light gray areas are regions with a high incidence of sickle-cell anemia. The extensive overlap in the distributions (darkest shade) was an early indication that there might be some causal connection. (After Cavalli-Sforza 1974.)





**Plate 1.** Batesian mimicry in *Papilio dardanus* in east Africa. Three distasteful model species: *Aumaris albimaculata* (7), *Danaus chrysippus* (3), and *Amauris niavius* (5). Three female forms of *Papilio dardanus* (2)(4) and (6). Male *P. dardanus* (1). In Madagascar, female *P. dardanus* are non-mimetic, and resemble the males (1). (Produced from Weismann, A. (1904). *The evolution theory*. Arnold, London.)

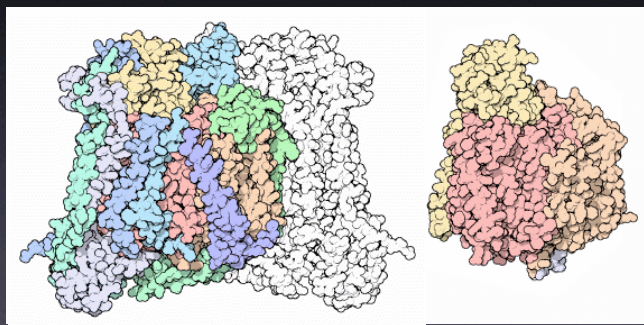


**Plate 2.** Müllerian mimicry in *Heliconius*. Five varieties of *Heliconius melpomene* (on the left) and *H. erato* (on the right). The two members of each pair come from the same geographical region. Birds find both species distasteful. (Reproduced from the *Report of the British Museum, Natural History, 1984-1986.*)

## Cytochrome c oxidase: cow vs. bacterium

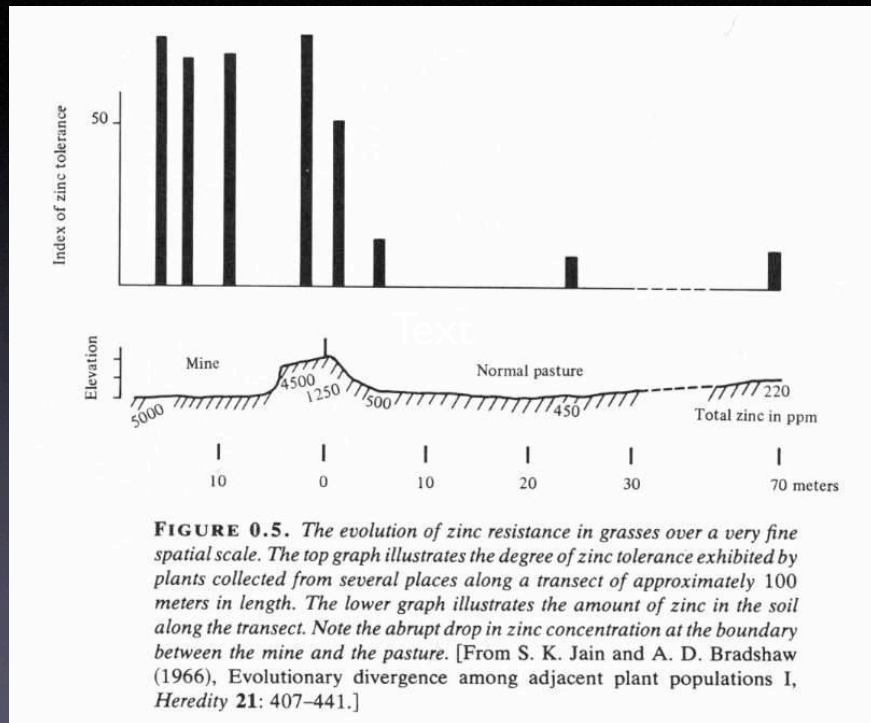
*Bos taurus*

*Paracoccus Denitrificans*



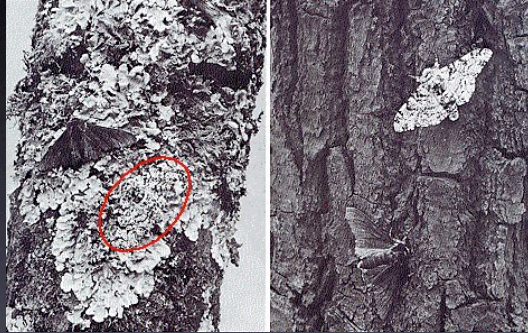


# Heavy Metal: zinc resistance in grasses

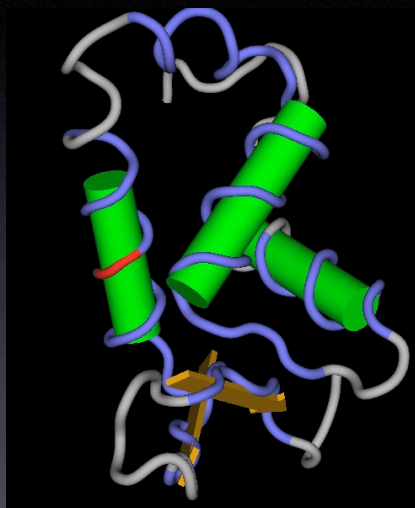


**FIGURE 0.5.** The evolution of zinc resistance in grasses over a very fine spatial scale. The top graph illustrates the degree of zinc tolerance exhibited by plants collected from several places along a transect of approximately 100 meters in length. The lower graph illustrates the amount of zinc in the soil along the transect. Note the abrupt drop in zinc concentration at the boundary between the mine and the pasture. [From S. K. Jain and A. D. Bradshaw (1966), Evolutionary divergence among adjacent plant populations I, *Heredity* **21**: 407-441.]

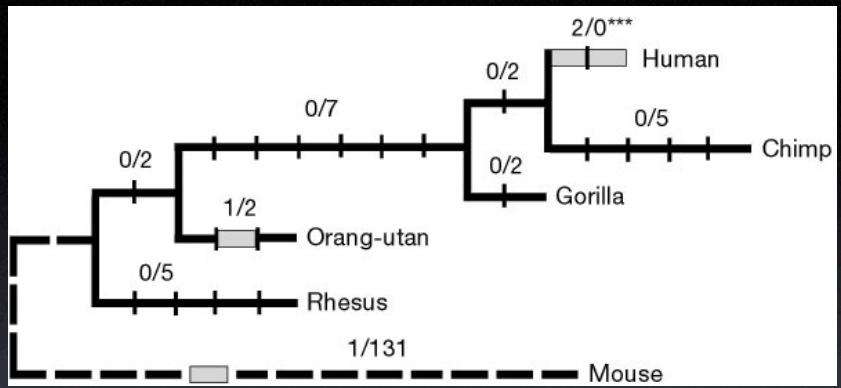
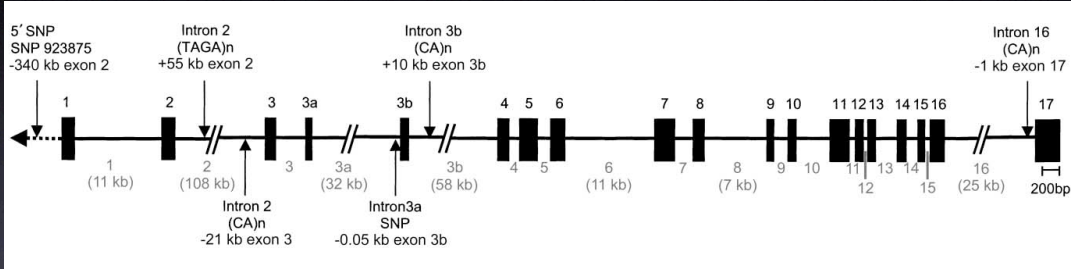




Between species variation: chimpanzee vs. human



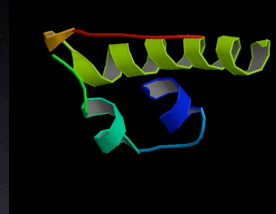
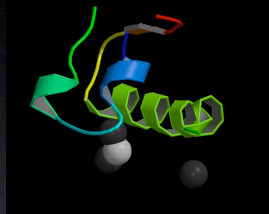




## Between-species variation that matters?

human	Human	TS	SKASP	PITHHSIVNG	QSSVL	RRD	SSSHEETGAS	HTLYGHGVCK	WPGCESICED	FGQLRHLN	EHALDRSTA	QCRVQMQVVO
chimp	Chimp	--	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....
gorilla	Gorilla	--	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....
orang	Orang	--	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....
rhesus	Rhesus	--	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....
mouse	Mouse	--	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....

## Between-species variation that matters?



```

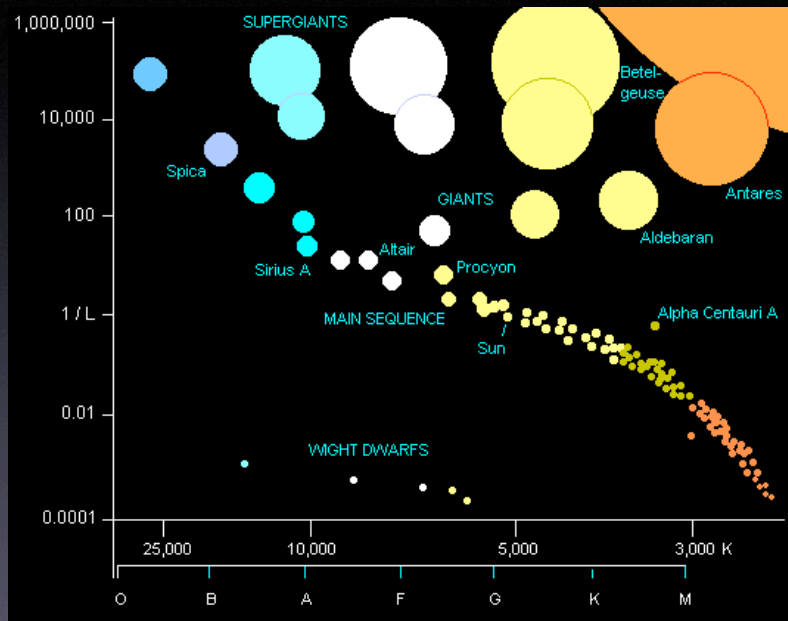
sp|P01315|INS_PIG PROINSULIN.
      Length = 84

Score = 229 (107.9 bits), Expect = 1.1e-52, Sum P(2) = 1.1e-52
Identities = 43/49 (87%), Positives = 44/49 (89%)

Query:   25 FVNQHLGSHLVEALYLVCGERGFFYTPKTRREAEDLQVQVELGGGPG 73 Human
         1 FVNQHLGSHLVEALYLVCGERGFFYTPK RREEA+ Q G VELGGG G
Sbjct:   1 FVNQHLGSHLVEALYLVCGERGFFYTPKARREAENPQAGAVELGGGLG 49 Pig
    
```

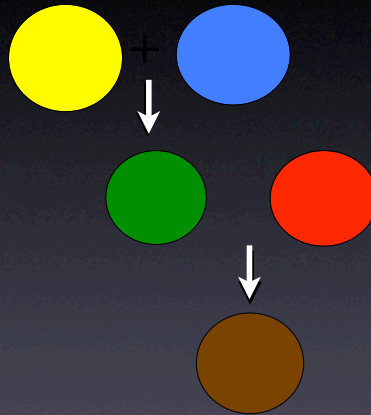


# Transformational Evolution - the main sequence



	Mortal	Immortal
Variational		
Transformational		

## Mud slide: Blending inheritance washes out variation



## Fisher's proof of mud slides

$x$  = 1st parent's deviation from mean

$y$  = 2nd parent's deviation from mean

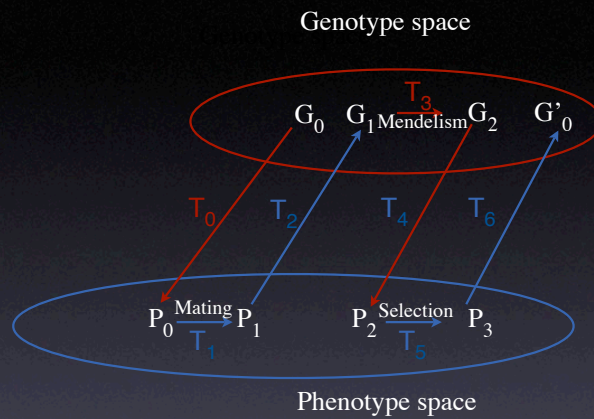
variance =  $E(x^2)$

$$\text{var}\left(\frac{1}{2}(x+y)\right) = E\left[\left[\frac{1}{2}(x^2 + y^2)\right]^2\right] = E\left[\frac{1}{4}(x^2 + 2xy + y^2)\right] =$$

$$E\left[\frac{1}{4}(2x^2)\right] = \frac{1}{2}E(x^2)$$



# Gregor Mendel saves Darwin?




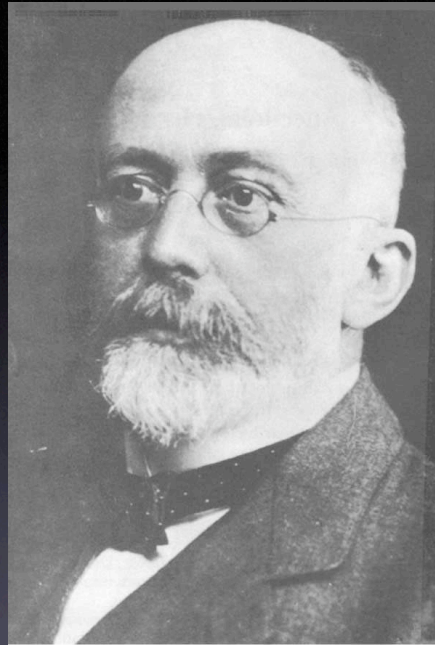
1000 loci ('genes'), 3 types each (alleles), genotype space has  $1000 \times (10-1) = 9000$  dimensions, and  $3^{1000}$  genotypes

A MATHEMATICIAN'S  
APOLOGY

G.H. HARDY / Foreword by C.P. SNOW



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