

## Lecture 7 What Darwin Missed

### *Unit of Heritability\_1*

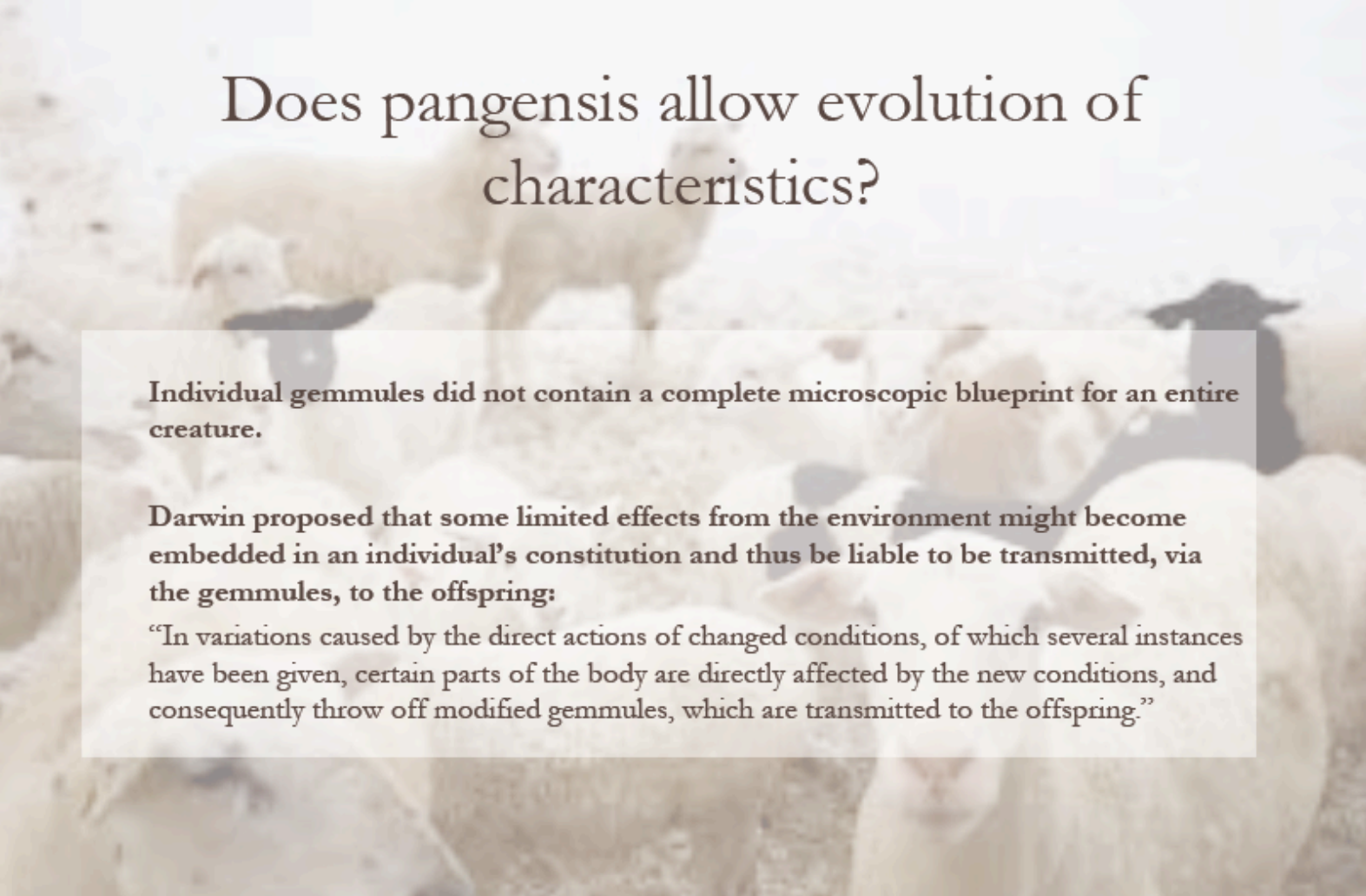
But how is the information that allows that change passed from one generation to the next?



## Gemmule (pangenes) theory

It is universally admitted that the cells or units of the body increase by self-division, or proliferation, retaining the same nature, and that they ultimately become converted into the various tissues and substances of the body. But besides this means of increase I assume that the units throw off minute granules which are dispersed throughout the whole system; that these, when supplied with proper nutriment, multiply by self-division, and are ultimately developed into units like those from which they were originally derived. These granules may be called gemmules. They are collected from all parts of the system to constitute the sexual elements, and their development in the next generation forms the new being; but they are likewise capable of transmission in a dormant state to future generations and may then be developed.)

**Charles Darwin in *The Variation of Plants and Animals under Domestication* (1868)**



## Does pangensis allow evolution of characteristics?

**Individual gemmules did not contain a complete microscopic blueprint for an entire creature.**

**Darwin proposed that some limited effects from the environment might become embedded in an individual's constitution and thus be liable to be transmitted, via the gemmules, to the offspring:**

**“In variations caused by the direct actions of changed conditions, of which several instances have been given, certain parts of the body are directly affected by the new conditions, and consequently throw off modified gemmules, which are transmitted to the offspring.”**



# Jean-Baptiste Lamarck

- Lamarck noted that the sons of blacksmiths have larger, stronger arms than the sons of weavers - he called this **the Inheritance of Acquired Characteristics**.
- The idea suggests that blacksmiths exercised their arm muscles as they worked and this caused growth of the muscles. Having acquired larger arm muscles the blacksmiths passed that trait onto their sons.
- Weavers did very little heavy work with their arms (certainly not as much as blacksmiths) so they failed to develop muscular arms and their sons inherited the same unremarkable arms as their fathers.



March 30, 1871.

General Sir EDWARD SABINE, K.C.B., President, in the Chair.

The following communications were read:—

- I. "Experiments in Pangenesis, by Breeding from Rabbits of a pure variety, into whose circulation blood taken from other varieties had previously been largely transfused." By FRANCIS GALTON, F.R.S. Received March 23, 1871.

Darwin's provisional theory of Pangenesis claims our belief on the ground that it is the only theory which explains, by a single law, the numerous



## Francis Galton's Experiments



X







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X



I have now made experiments of transfusion and cross circulation on a large scale in rabbits, and have arrived at definite results, negating, in my opinion, beyond all doubt, the truth of the doctrine of Pangenesis.

# Blending inheritance

- The idea of blending inheritance simply proposes that when male and female sex cells, the gametes (*gamos*, marriage) combine, the characteristics blend.

e.g. The height of a person, with one short parent and one tall parent, was thought to always be of some interim value between its two parents' heights.

- Problems:
  - 1. How can distinct former characters crop up in later generations?
  - 2. How can varieties favoured by natural selection be preserved and not diluted to oblivion.



<http://www.tubechop.com/watch/633956>





# William Bateson



Mendel's work was published in 1866 and ignored for 34 years until three botanists, Huger de Vries, Carl Correns, and Erich Tschermak independently rediscovered it.

Bateson rediscovered Mendel's work in 1900.

Today's reading The Monk's Bulldog is a chapter from 'A Monk and Two Peas' by Robin Marantz Henig

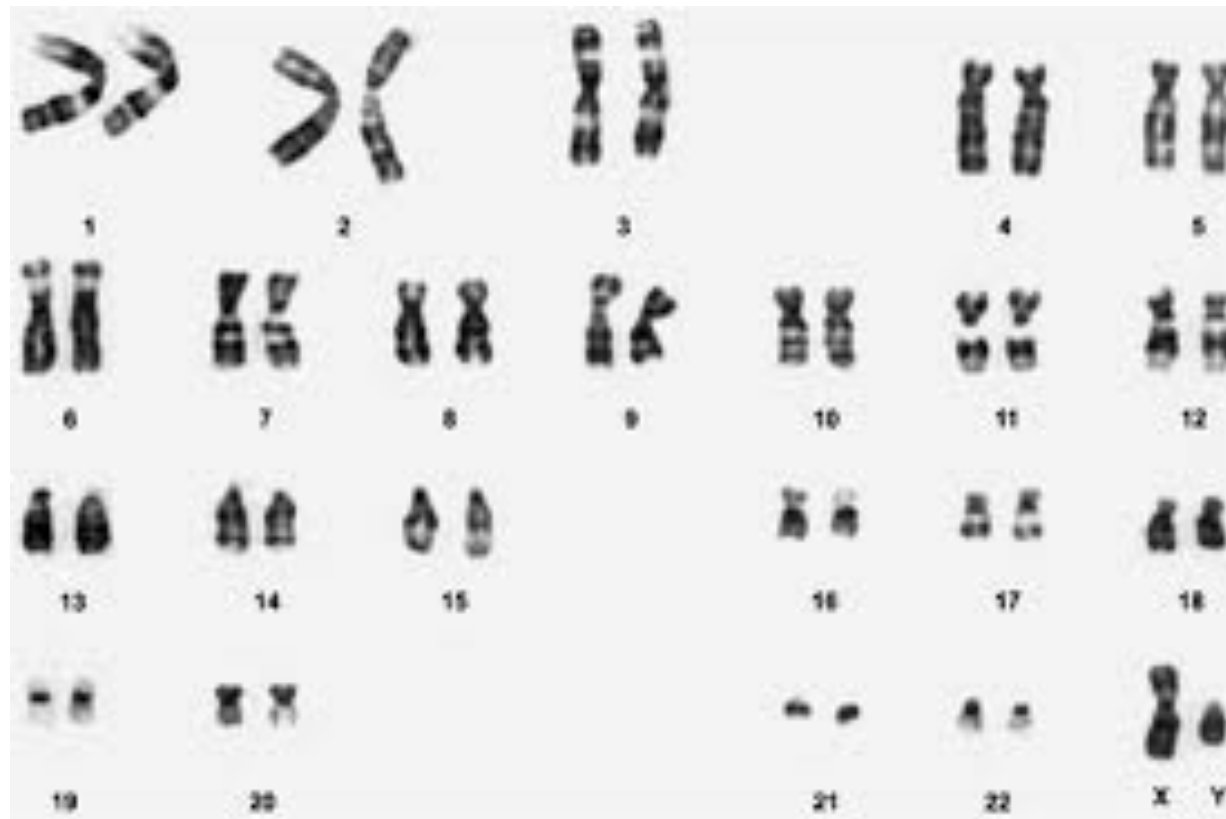
# Mendel's Experiments

**Mendel made two unique proposals:**

- Each element has two possible expressions in the same individual (today we call these alleles) - one dominant, one recessive = **Principle of Segregation**
- Inherited characters do not blend, but are transmitted in discrete parcels called Elementes (today we call these genes) = **Principle of Independent Assortment**

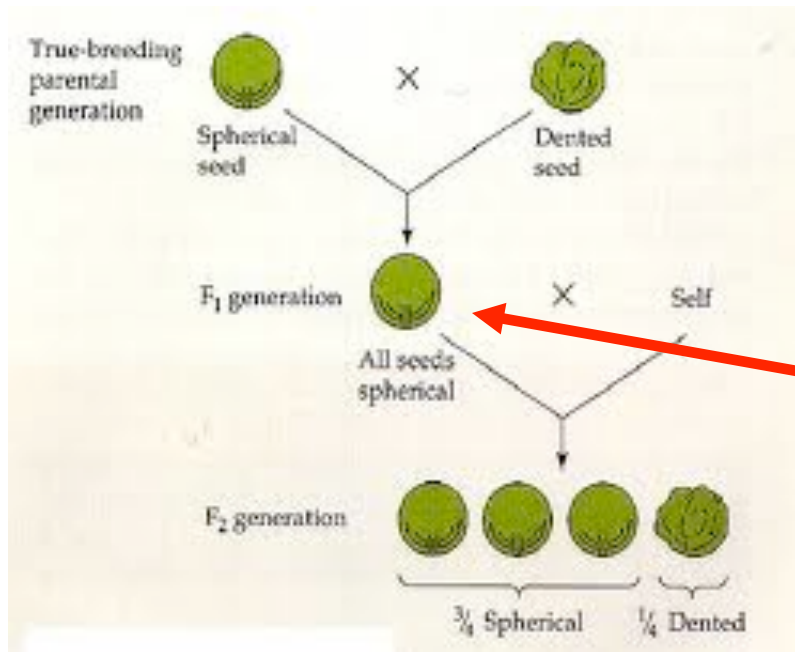
Most multicellular organisms have two sets of **chromosomes**, that is, they are diploid. Diploid organisms have one copy of each gene (and therefore one allele) on each chromosome.

If both alleles are the same, they are homozygotes. If the alleles are different, they are heterozygotes.





# Principle of Segregation - Cross 1



Mendel first crossed two different true breeding strains together, one that produced round peas and one that produced wrinkly peas.

We'll use letters to represent alleles. Capital "A" will represent the round pea allele and lowercase "a" will represent the wrinkly pea allele.

When Mendel looked at the results of his first mating (F<sub>1</sub>), he saw that all of the offspring had round seeds.

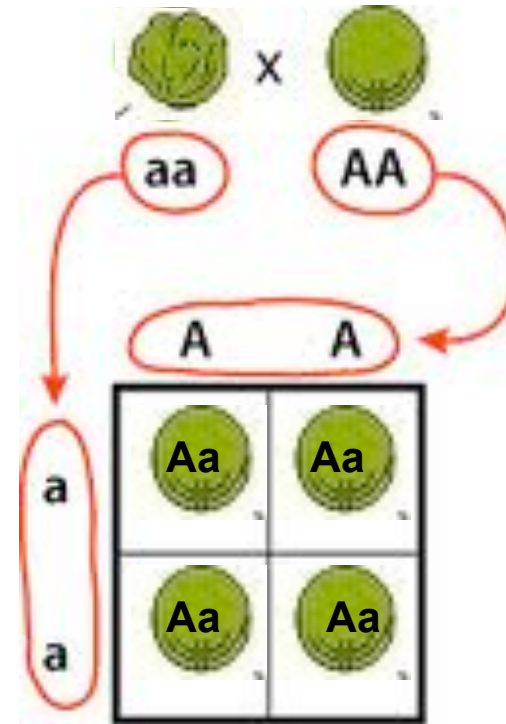
How did this happen?




# Principle of Segregation - Cross 1

1. Begin by writing the parent's genotype along the top and side of the Punnet Square.
2. Next, fill in each cell with two allele, one from the parent along the top and one from the parent along the side.
3. The letters in the middle show you all possible combinations of alleles that can happen from mating these two genotypes.

In this case, all offspring have the same genotype and phenotype.

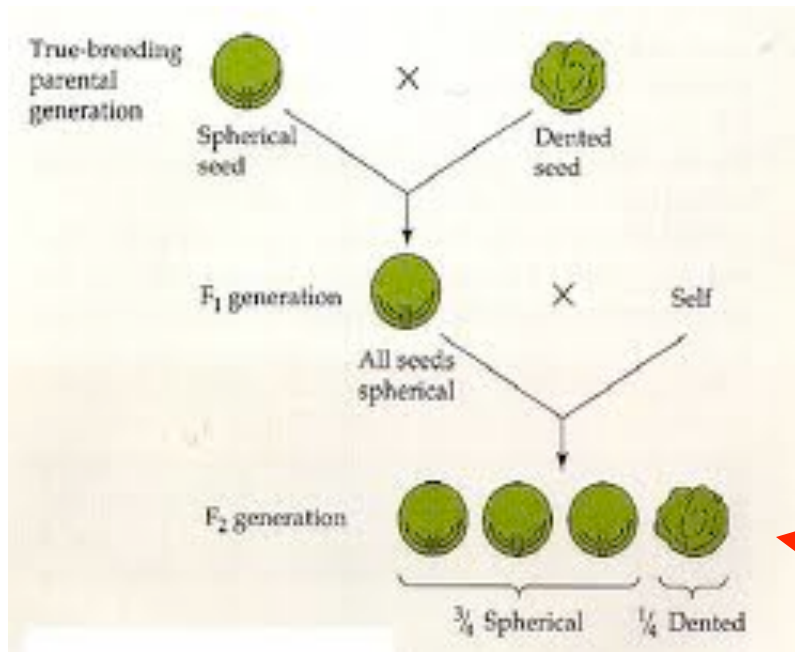


Genotypes	Phenotypes
Aa	 Round

"Genotype" is an organism's full hereditary information, even if not expressed.

"Phenotype" is an organism's actual observed properties, such as morphology, development, or behavior.





# Principle of Segregation - Cross 2



- For the second generation, Mendel mated the heterozygous offspring from the first generation together.
- When Mendel looked at the offspring from this mating, he noticed that 1/4 of the children plants had wrinkly seeds.
- **Why did this happen?**

# Principle of Segregation - Cross 2















- Let's once again use a Punnett Square to answer these questions and understand what's happening to the alleles in this crossing.
- By looking at the Punnett Square, we see that there are three possible genotypes that could result from this crossing: AA, Aa, aa.
- The genotypes AA and Aa will result in the round pea phenotype because A is dominant. Only aa will produce the green pea phenotype.

	A	a
A	 AA	 Aa
a	 Aa	 aa

# Mendel's Experiments

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Character	Dominant Trait	×	Recessive Trait	F <sub>2</sub> Generation Dominant:Recessive	Ratio
Flower color	Purple 	×	White 	705:224	3.15:1
Flower position	Axial 	×	Terminal 	651:207	3.14:1
Seed color	Yellow 	×	Green 	6022:2001	3.01:1
Seed shape	Round 	×	Wrinkled 	5474:1850	2.96:1
Pod shape	Inflated 	×	Constricted 	882:299	2.95:1
Pod color	Green 	×	Yellow 	428:152	2.82:1
Stem length	Tall 	×	Dwarf 	787:277	2.84:1





# Principle of Independent Assortment

- Alleles for one trait pass simultaneously to offspring independently, without affecting the segregation of alleles for another trait.





RrYy (Round/Yellow) x RRyy (Round/green)

		♂ gametes			
		$R Y$ $\frac{1}{4}$	$R y$ $\frac{1}{4}$	$r y$ $\frac{1}{4}$	$r Y$ $\frac{1}{4}$
♀ gametes	$R Y$ $\frac{1}{4}$	$RR YY$ $\frac{1}{16}$ 	$RR Yy$ $\frac{1}{16}$ 	$Rr Yy$ $\frac{1}{16}$ 	$Rr YY$ $\frac{1}{16}$ 
	$R y$ $\frac{1}{4}$	$RR Yy$ $\frac{1}{16}$ 	$RR yy$ $\frac{1}{16}$ 	$Rr yy$ $\frac{1}{16}$ 	$Rr Yy$ $\frac{1}{16}$ 
	$r y$ $\frac{1}{4}$	$Rr Yy$ $\frac{1}{16}$ 	$Rr yy$ $\frac{1}{16}$ 	$rr yy$ $\frac{1}{16}$ 	$rr Yy$ $\frac{1}{16}$ 
	$r Y$ $\frac{1}{4}$	$Rr YY$ $\frac{1}{16}$ 	$Rr Yy$ $\frac{1}{16}$ 	$rr Yy$ $\frac{1}{16}$ 	$rr YY$ $\frac{1}{16}$ 

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 Round, yellow	 Wrinkled, yellow
 Round, green	 Wrinkled, green



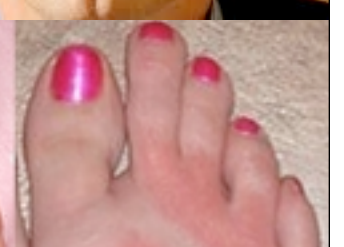
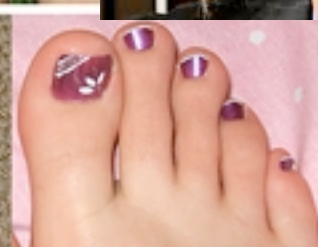
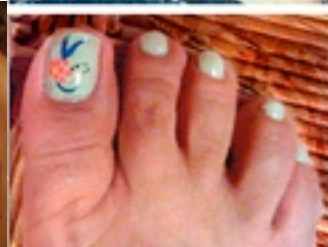
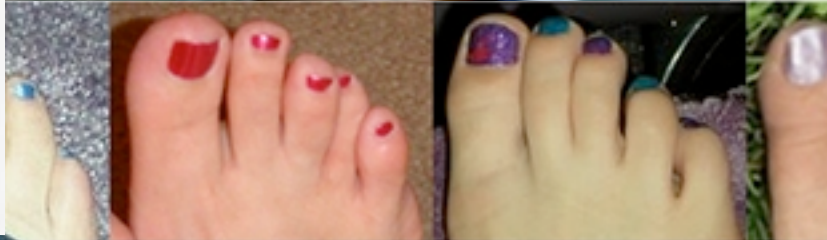
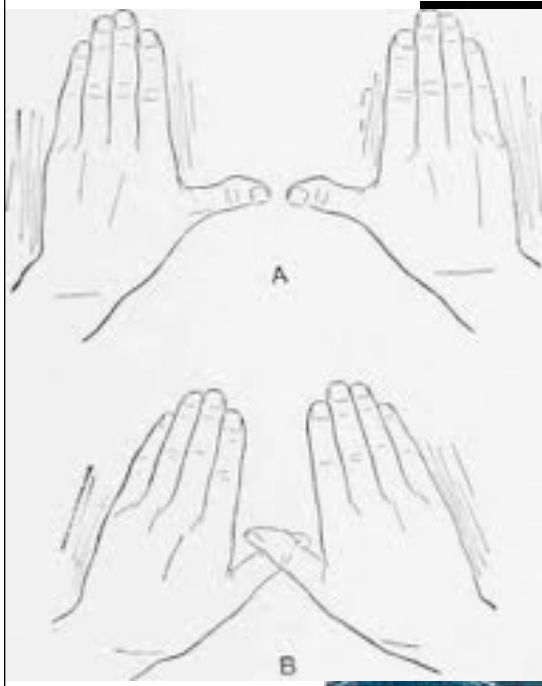
# Other Mendelian traits?



Regular thumb



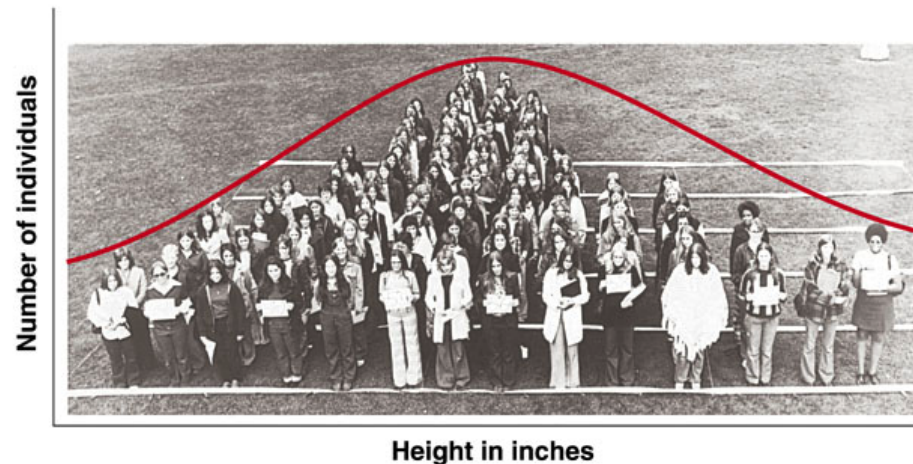
Hitchhiker's thumb



## For more on human variation...

- He is a little strong in throwing out all characters/traits as non-mendelian, but he is worth a look: <http://udel.edu/~mcdonald/mythintro.html>
- And for many traits **many genes affect one trait**, which means that we have continuous variation

Tobin/Dusheck, Asking About Life, 2/e  
Figure 16.6



# Gene pool

- there are not just two alleles, but **multiple alleles**  
e.g. blood groups (A/A, A/O, B/B, B/O, A/B or O/O), so each individual can only have two alleles, but there are many combinations in the population



Where does this variation come from/  
what creates a new allele?

Mutation

Viewed at the population level, we can track evolution by tracking the fate of alleles in the gene pool across generations e.g. tracked changes in allele frequencies in mosquitoes in response to pesticide spraying



# Kettlewell's peppered moth

<http://www.youtube.com/watch?v=LyRA807djLc>



And we can look for evidence of natural selection in the genome, and find regions that show positive selection.

# Adaptations to Climate-Mediated Selective Pressures in Humans

Table 3. SNPs with the strongest signals of selection among those associated with phenotypic traits in GWAS.

Trait category	Strongest disease or trait association	Ref SNP ID	Most significant climate correlation				Nearby genes
			Pop Set	Variable	$\log_{10}BF$	Rank Statistic	
Pigmentation and tanning	Hair Color	rs12913832	WW	Summer Maximum Temperature	7.06	$2.08 \times 10^{-25}$	HERC2
	Hair Color	rs12913832	WW	Summer Relative Humidity	8.11	$2.08 \times 10^{-25}$	HERC2
	Hair Color	rs28777	AWE	Winter Solar Radiation	10.4	$4.22 \times 10^{-25}$	SLC45A2
	Hair Color	rs28777	WW	Winter Relative Humidity	4.26	$3.29 \times 10^{-24}$	SLC45A2
	Eye Color	rs1667394	AWE	Winter Solar Radiation	8.33	$4.99 \times 10^{-25}$	OCA2
	Hair Color	rs1667394	AWE	Winter Solar Radiation	8.33	$4.99 \times 10^{-25}$	OCA2
	Tanning	rs35391	WW	Summer Relative Humidity	7.27	$6.81 \times 10^{-25}$	SLC45A2
	Tanning	rs35391	AWE	Winter Solar Radiation	6.63	$3.50 \times 10^{-24}$	SLC45A2
Immune and Autoimmune	Multiple sclerosis	rs6074022	AEA	Summer Precipitation Rate	6.98	$4.00 \times 10^{-24}$	CD40
	Multiple sclerosis	rs6074022	WW	Winter Minimum Temperature	11.1	$2.40 \times 10^{-24}$	CD40
	SLE	rs2313132	WW	Summer Solar Radiation	2.05	$4.52 \times 10^{-24}$	PCDH18
	SLE	rs2167668	AWE	Summer Relative Humidity	8.25	$1.82 \times 10^{-25}$	HLA-DQA1
	Celiac Disease	rs2167668	AWE	Summer Relative Humidity	8.25	$1.82 \times 10^{-25}$	HLA-DQA1
	Crohn's disease	rs4613763	WW	Summer Relative Humidity	2.19	$2.26 \times 10^{-24}$	PTGER4
	Psoriasis	rs10484554	AEA	Summer Precipitation Rate	7.23	$1.80 \times 10^{-24}$	HLA-C
	AIDS progression	rs10484554	AEA	Summer Precipitation Rate	7.23	$1.80 \times 10^{-24}$	HLA-C
Height	Height	rs185819	AEA	Summer Maximum Temperature	5.55	$4.79 \times 10^{-24}$	TNXB (HLA class III)
Cardiovascular	Stroke	rs10486776	AWE	Winter Solar Radiation	2.3	$2.94 \times 10^{-24}$	MEOX2
	Factor VII	rs10486360	AWE	Summer Precipitation Rate	6.76	$2.06 \times 10^{-24}$	SDK1
Other	Bone Mineral Density (Hip)	rs10490823	AWE	Winter Solar Radiation	5.53	$4.54 \times 10^{-24}$	CTNNA1
Other	Testicular germ cell tumor	rs210138	AEA	Summer Precipitation Rate	8.14	$1.50 \times 10^{-24}$	BAK1

This table contains SNPs with an empirical rank less than  $5 \times 10^{-24}$  and a GWAS p-value of less than  $1 \times 10^{-25}$ .  
doi:10.1371/journal.pgen.1001375.t003

# Pale advantage

- VD, the “sunshine vitamin” is a prohormone that regulating the concentration of calcium and phosphate in the bloodstream and promoting the healthy growth and remodeling of bone.

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3 October 2011 Last updated at 21:19 ET

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## Fair-skinned people may need extra vitamin D

By Michelle Roberts  
Health reporter, BBC News

**Fair-skinned people who are prone to sunburn may need to take supplements to ensure they get enough vitamin D, say experts.**

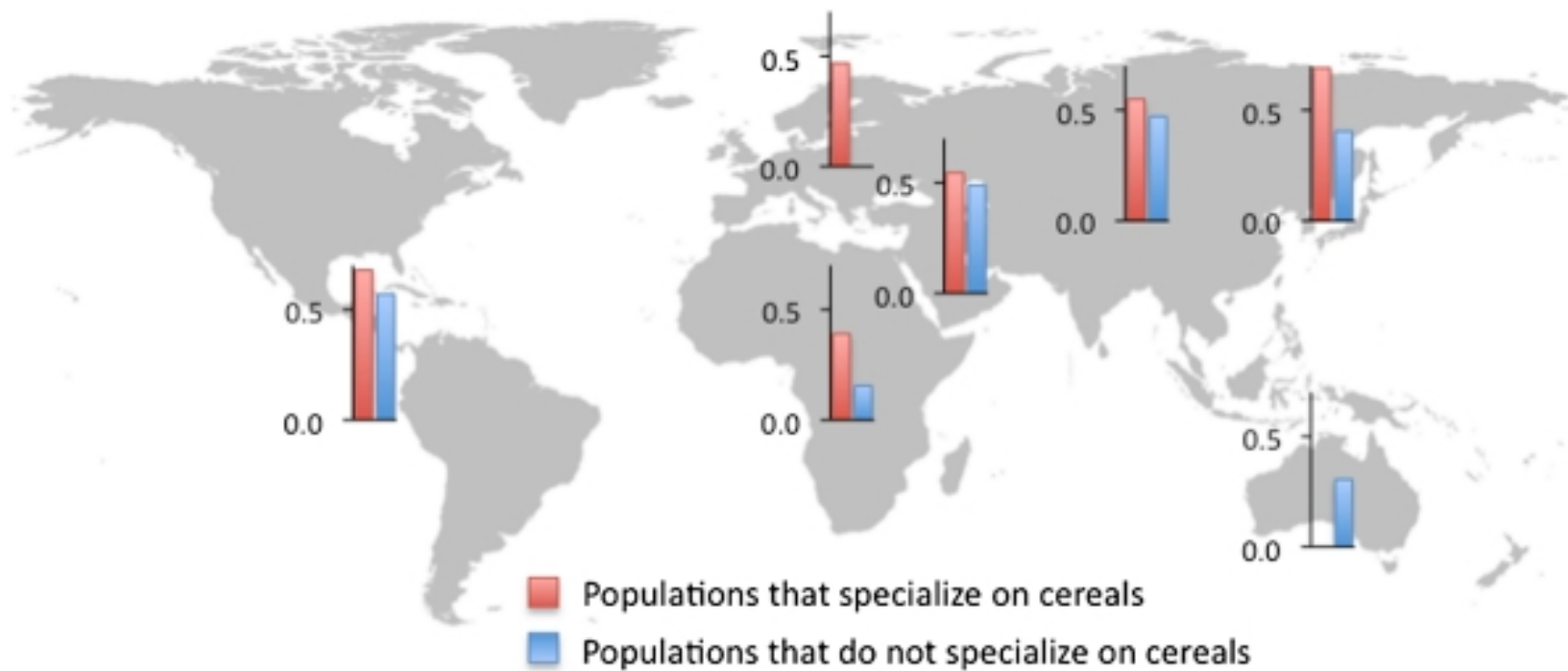
It appears that those with pale skin, while not deficient, may still be lacking in the essential vitamin that the body makes from sunlight.

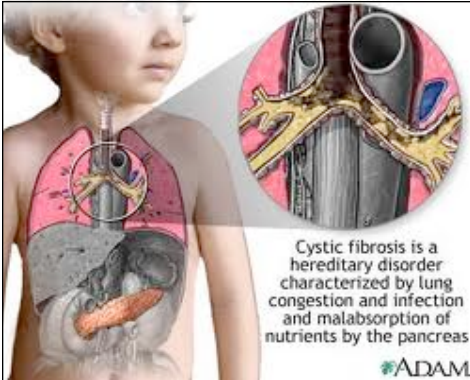
The Cancer Research UK-funded team say that



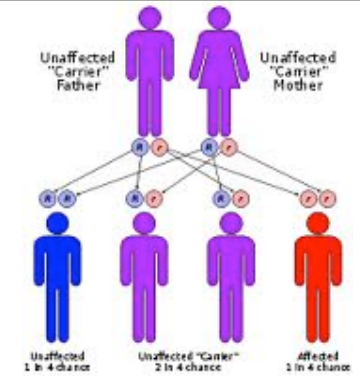
SPL

Pancreatic lipase-related protein 2 (PLRP2) is strongly correlated with the use of cereals as the main dietary component.





# Cystic fibrosis



- Recessive genetic disease affecting most critically the lungs, but also the pancreas, liver, and intestine caused by the abnormal transport of chloride and sodium across epithelium, leading to thick, viscous secretions.
- CFTR gene is present in one out of every 20 people of European origin
- The 25 percent of those children who inherit two mutant copies get cystic fibrosis, a lethal disease that attacks the lungs.
- Until the 1950s, almost all such newborns died in early childhood (today people tend to live into their 30s)
- Men with cystic fibrosis are usually sterile





# Why does the mutation persist?

- "People with only one copy of the mutated gene apparently gain protection from infection by the bacterium that causes typhoid," says Gerald Pier, professor of medicine at Harvard Medical School.
- Typhoid fever, also known as Typhoid,[1] is a common worldwide bacterial disease, transmitted by the ingestion of food or water contaminated with the feces of an infected person, which contain the bacterium *Salmonella enterica*.
- Another suggestion is that carrying one copy of the gene gave you resistance to cholera.

Evolution is when species undergo change over time

Evolution is when species undergo <sup>genetic</sup> change over time

Evolution is change in allele frequency through time

What's good about this definition, is that it defines evolution independent of the mechanism that causes it...

By defining evolution using the language of population genetics, we can focus on the question of \*whether\* evolution has occurred (and how much), independent of the question of \*how\* or \*why\* it occurred (what the cause is).

Or to put it in even simpler terms, it separates the \*fact\* of evolution, from the \*explanation\* of it.