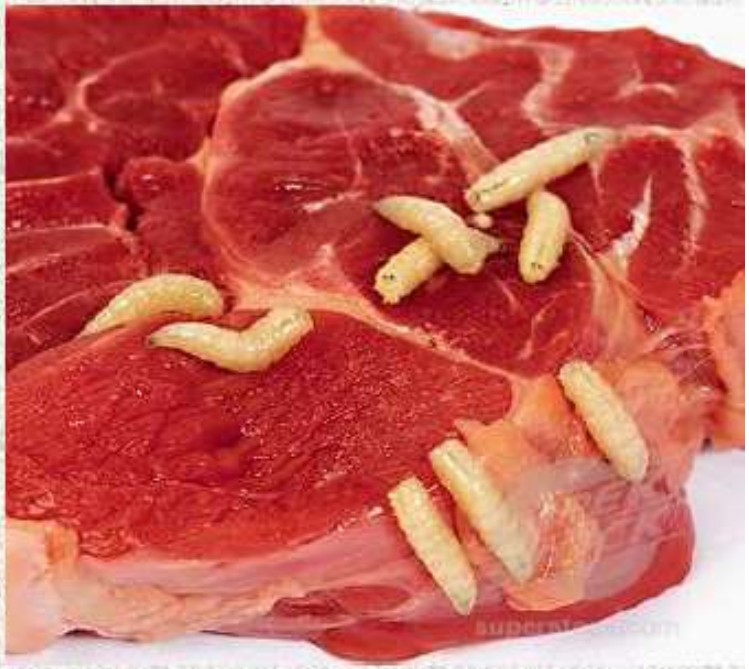
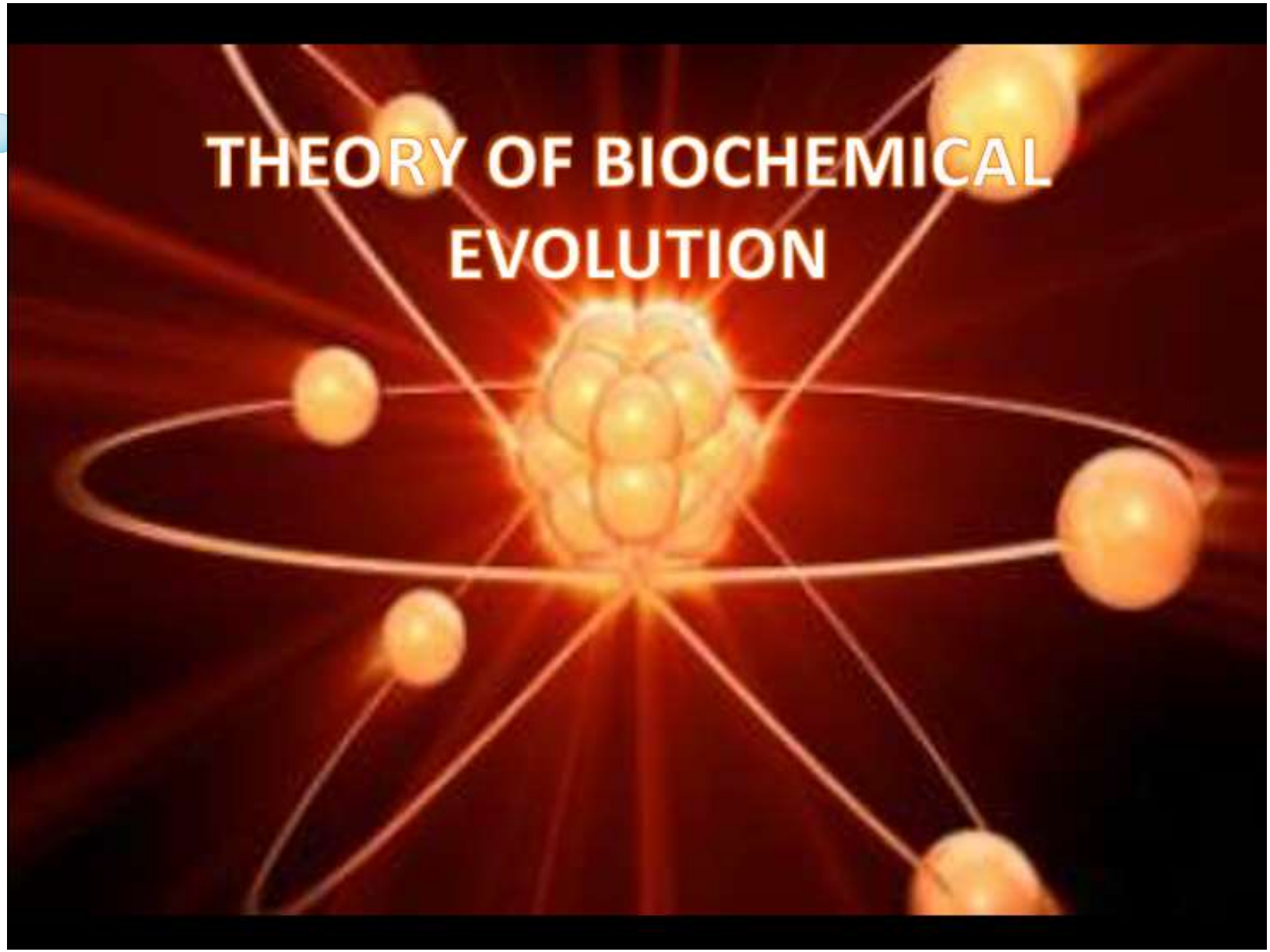
Conditions on early Earth

- Reducing atmosphere on the primitive Earth. **No free oxygen (O_2)**
- **Free hydrogen** (H_2) and **saturated hydrides** (CH_4, NH_3 and H_2O)
- **Energy** for chemical reactions between these gases could come from **electric discharge** in storms or **solar energy** (no ozone layer)
- The Earth's surface temperature probably **hotter** than today.

THEORY OF SPONTANEOUS GENERATION





Early Theories of Evolution

Theory of Use and Disuse

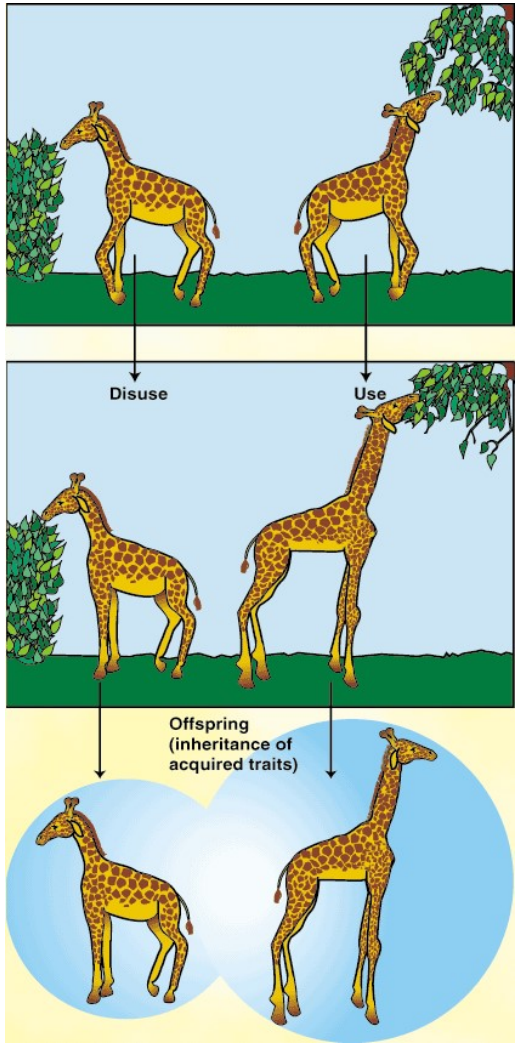
- Jean Baptiste LAMARCK (1744-1829)
- Theory was based on NEED
  - Organs needed if environmental stresses its function, while those organs not needed gradually disappeared because of disuse.
  - IF YOU DON'T USE IT, YOU LOSE IT!

Theory of Use and Disuse

- Lamarck believed in the inheritance of ACQUIRED CHARACTERISTICS
  - Body changes due to an organism's behavior or experience that occur within an organism's life could then be passed on to offspring
  - EXAMPLES:
    - Webbed foot of water birds – the repeated stretching of membrane between the toes was passed on to offspring
    - Organisms not using tail would produce offspring with smaller tails

Acquired Characteristics

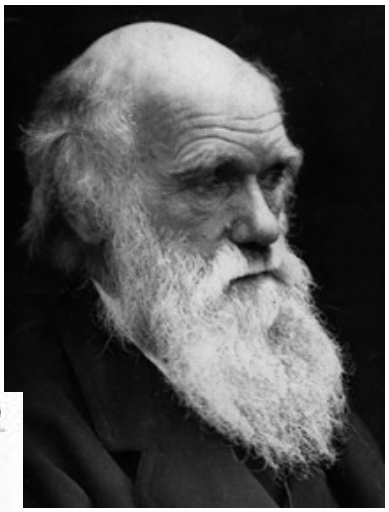
- Giraffe Example:
  - Giraffes must stretch their necks to reach leaves on the tops of trees
  - This longer neck then got passed to offspring



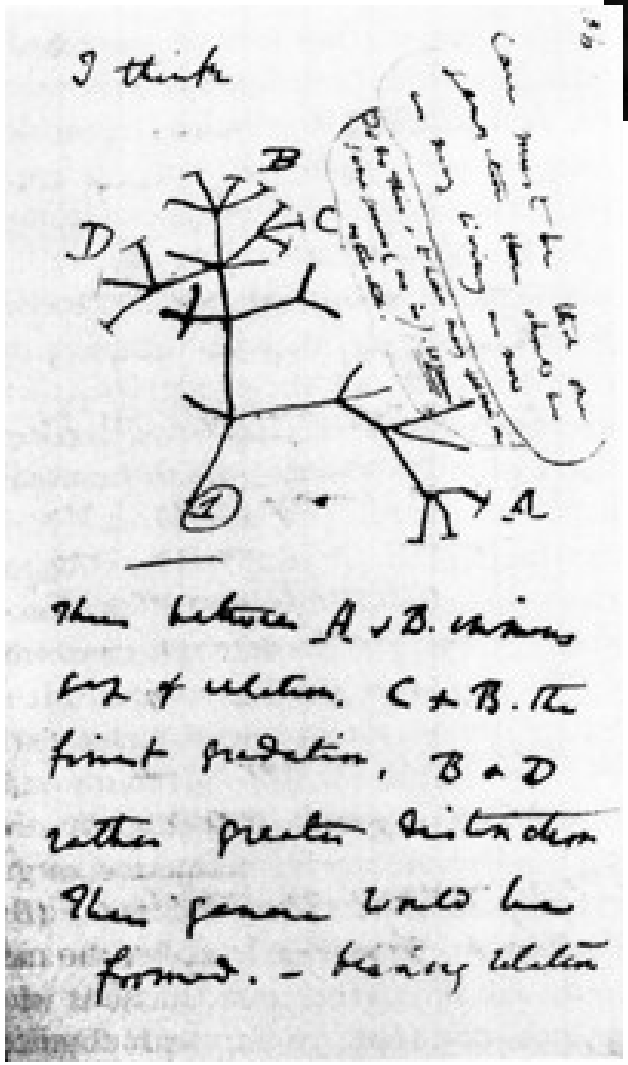
Disproving Lamarck

- Experiments were conducted to try to prove Lamarck's ideas, but none of them were successful
  - Petals on flowers
  - Tails of mice

Darwin's Theories



- Charles Darwin (1809-1882)
  - 1831 – traveled aboard HMS Beagle as a recorder/naturalist
  - Collected many specimens and documented many of his observations - noted much variety!



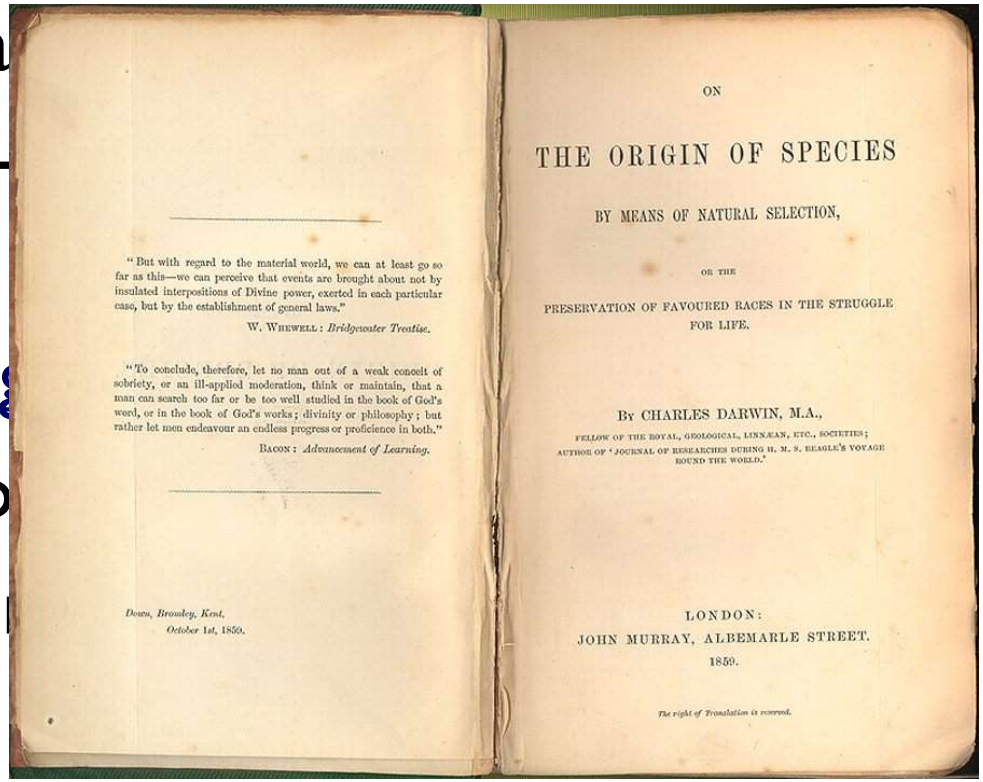
Darwin's Theories

- Spent time in the Galapagos Islands
  - Tortoises on different islands displayed different characteristics
    - Harriett was 5 when Darwin captured her. Lived to be 176 years old (Died June 2006)
  - Finch beaks (13 varieties) varied in size & shape from island to island
- Took 20 years to organize data and develop his theory of evolution!

Darwin's Theories

- Alfred WALLACE, independent of Darwin, also developed ideas that were very similar to Darwin's – they presented their idea
1858 (Linnaean Society in L

- Darwin wrote On The Orig
Species presenting his theo
of evolution based on natu
selection.



"But with regard to the material world, we can at least go so far as this—we can perceive that events are brought about not by insulated interpositions of Divine power, exerted in each particular case, but by the establishment of general laws."

W. Whewell: *Bridgewater Treatise.*

"To conclude, therefore, let no man out of a weak conceit of sobriety, or an ill-applied moderation, think or maintain, that a man can search too far or be too well studied in the book of God's word, or in the book of God's works; divinity or philosophy; but rather let men endeavour an endless progress or proficience in both."

Bacon: *Advancement of Learning.*

Down, Bromley, Kent,
October 1st, 1859.

ON

THE ORIGIN OF SPECIES

BY MEANS OF NATURAL SELECTION,

OR THE

PRESERVATION OF FAVOURED RACES IN THE STRUGGLE FOR LIFE.

By CHARLES DARWIN, M.A.,

FELLOW OF THE ROYAL, GEOLOGICAL, LINNÆAN, ETC., SOCIETIES;
AUTHOR OF 'JOURNAL OF RESEARCHES DURING H. M. S. BEAGLE'S VOYAGE ROUND THE WORLD.'

LONDON:
JOHN MURRAY, ALBEMARLE STREET.
1859.

What is The Theory of Natural Selection?

- NATURAL SELECTION – individuals within a population with the most favorable traits for an environment survive and pass on those traits
- Based on 4 statements
  - 1) Organisms produce many offspring and have potential to grow unchecked
  - 2) Variations exist within a species (at that time DID NOT know that it was a result of mutations & genetic recombination)

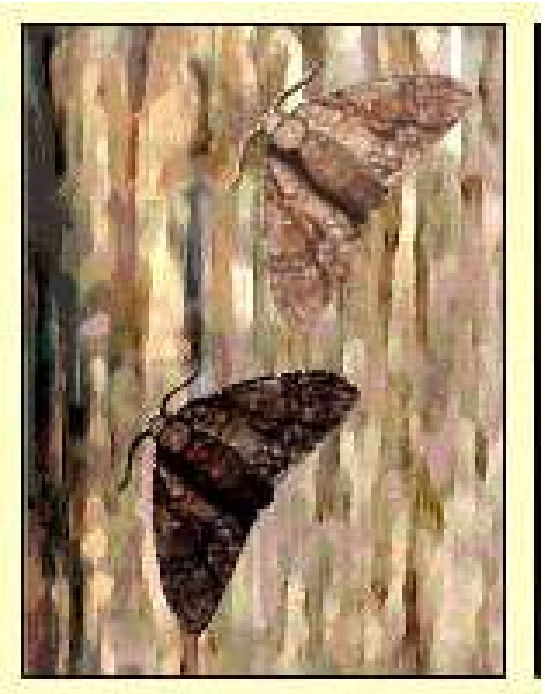
What is The Theory of Natural Selection?

- 3) Competition for limited resources (struggle for existence – food, disease, predators)
- 4) Environment selects organisms with favorable traits
  - "Survival of the fittest"
  - ADAPTATION – a variation that improves an organism's chance of survival
  - A population adapts to their environment as their proportion of genes for a favorable trait increases

- DARWIN'S THEORY IS STILL RELIED UPON TODAY AND IS SUPPORTED THROUGH EXPERIMENTATION.

Natural Selection Example

- The peppered moth
  - Before the industrial revolution in Britain, most peppered moths were of the pale variety & were well camouflaged against the pale birch trees that they like to sit on.
  - Moths with the mutant black coloring were easily spotted and eaten by birds - giving the white peppered variety an advantage



Natural Selection Example

- Then the industrial revolution came along in the 19th century.
- Airborne pollution in industrial areas mottled the birch tree bark with soot, and now the mutant black-peppered moths ble against the darkened bark, while t variety became much more vulne predators
- Over time the mutated black pep moths were naturally selected to became far more numerous in urban areas than the pale variety.
- Peppered Moth Simulation

Eugenics: 'well-born'

is a set of beliefs and practices that aim to improve the genetic quality of a human population by excluding certain genetic groups judged to be inferior, and promoting other genetic groups judged to be superior

Evolution & Genetic Variation

A population cannot evolve unless there is genetic variation

(A population of genetic clones, for example, would not be able to evolve …at least until some mutations had occurred.)

For Natural Selection to occur, there must be a variety of traits for "nature" to "select" from.

How does Genetic Variety arise within a population???

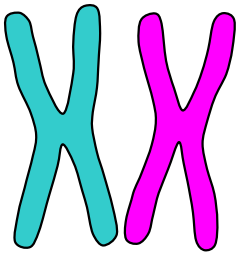
As it turns out, there are a handful of basic genetic mechanisms that generate an endless variety of traits among the members of a population…

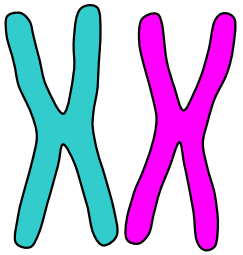
Five Sources of Genetic Variety

1) **<u>Independent Assortment</u> of chromosomes during meiosis:**

- Through meiosis, each sperm or egg receives only half (23) the original number of chromosomes (46), one from each homologous pair. During metaphase I, homologous chromosomes pair up along the equatorial plane, one on the left and one on the right. However, it's <u>random</u> as to which one lines up on the left and which one lines up on the right. The left/right arrangement of one pair of homologues has nothing to do with the left/right arrangement of the next pair. In short, homologous pairs "assort" themselves "independently" of one another. Therefore when the pairs later separate, it is completely random as to which 23 chromosomes each sperm (or egg) receives. Thus it is very unlikely for any two sperm or any two eggs to receive the same 23 chromosomes.

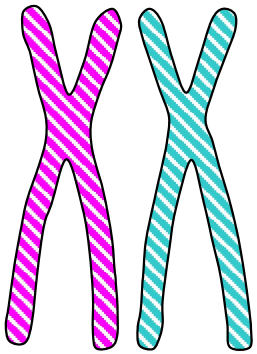
During Metaphase I, if the first two homologues pair up like this…

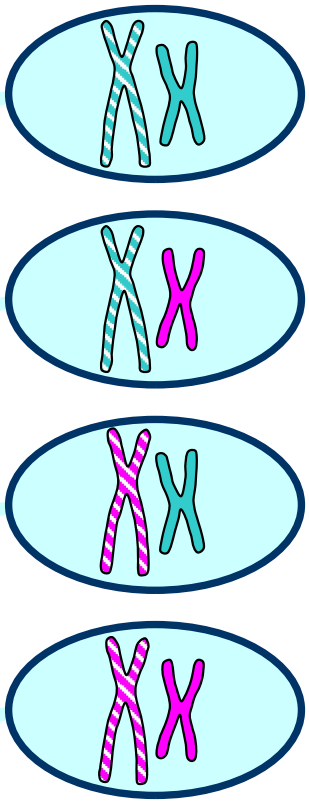




…then the second two homologues may pair up like this…

…OR like this…





With 2 pairs of chromosomes, then, <u>each</u> sperm (or egg) can get 2^2 (= 4) possible combinations of chromosomes.

With 23 pairs of chromosomes, there are 2^{23} possible combinations.

That's 8,400,000 possible different sperm per human male!!!

2) Sexual Reproduction (= two parents):

Father		Mother		
8,400,000 possible sperm	×	**8,400,000** possible eggs	=	**70,000,000,000,000** possible zygotes

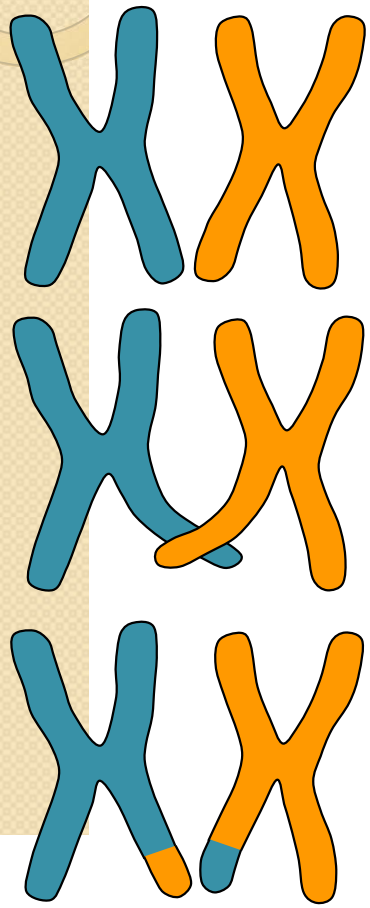
In short, a single married couple can, in theory, give birth to 70 trillion chromosomally different young' uns. That' s a really HUGE number!!!

3) Random Mating within a population:

Since any male can breed with any female, the number of possible zygotes further depends on the size of the adult population. For example, take even a tiny population of, say, 100 CBGS students (50 male and 50 female), and suppose that every student' s future spouse will be another CGBS student. That' s 50^2 or 2500 possible marriages, each of which can produce 70 trillion different offspring, which multiplies out to 175,000,000,000,000,000 possible CBGS babies.

4) "Crossing Over" of chromosomes:

During meiosis, homologous chromosomes often exchange long sections of DNA with one another. In effect, they are trading genes, thereby creating new chromosomes!!!



Step 1 - Homologues paired up during metaphase I of meiosis.

Step 2 - Now "crossing over" and trading DNA from the cross-over point down…

Step 3 - Chromosomes are different now! This process increases the number of possible sperm or eggs from 70 trillion to near infinite…

Not just reshuffling chromosomes here, but shuffling individual genes!

5) Mutations:

When replicating (copying itself), DNA sometimes makes a mistake …this alters the gene and so can generate a **new trait**!!!

Types of Mutations

(Background Info: in cells, DNA is "read" or "translated" in groups of three nitrogen bases, called codons. Each codon in turn is the code for a single amino acid in the protein to be synthesized.)

Original Sentence (all three letter words, like codons):

THE OLD DOG RAN AND THE FOX DID TOO

Substitution (or "Point" mutation) – A single letter is miscopied:

THE OLD HOG RAN AND THE FOX DID TOO

Frameshift Mutations

Deletion of a single letter (the "R" in "RAN"):

THE OLD DOG ANA NDT HEF OXD IDT OO

Insertion of an extra letter (copied "H" in "THE" twice):

THE OLD DOG RAN AND THH EFO XDI DTO O

Summary of Sources of Genetic Variation

I) **Sexual Reproduction and Meiosis reshuffle already existing genes, alleles, and traits:**

a) **independent assortment,**

b) **crossing over,**

c) **fertilization of eggs by sperm, and**

d) **random mating.**

e) **This is known as genetic recombination.**

I) **Mutations deal in new genes and alleles, and therefore entirely new traits.**

Meiosis and mutations provide the genetic variety necessary to drive the process of evolution. Genetic reshuffling (recombination) can fuel short-term "microevolution," but long-term "macroevolution" requires the accumulation of mutations in the gene pool.

Mendel's laws of Inheritance

Reasons for failure of earlier scientist

- The earlier scientist studied the plant as a whole
- Could not classified the plants in to clear cut classes
- Only described the characters in the progenies, Frequencies of different characters were not worked out
- Data of different generations were not kept
- No control on the pollination was made in F1 generation
- In many cases F1 was interspecific cross

Reasons for Mendel's success

- Ability for an accurate and clear cut analysis of reasons for failure of earlier workers
- Mendel studied the inheritance of only one pair of contrasting characters at a time
- Mendel selected pea varieties that had clearly different forms of one or more characters
- He classified all the plants in the population on the basis of the contrasting characters under studied
- Carried out experiments with great care and elaborations
- Knowledge of mathematics was asset for him
- Able to formulate the hypotheses and experimentally prove it

Finally ……. he was lucky

- All the seven characters selected were qualitative characters
- Contrasting form of all seven characters were govern by single gene
- In all cases the complete dominance was present

Law of Segregation

- The two alleles of a gene remain separate and do not contaminate each other in the F1 or the hybrid. At the time of gamete formation in F1, the two allele separate and passes in to different gametes
- "Law of purity of gametes"
- Began with 34 distinct varieties of pea
- Grown for purity for two years in separate plots
- Assess the stability of characters
- Twenty two varieties used for his experiment distinct for one or more characters
- Studied seven characters

Mendel's Pea Plant Traits

	Height	Seed Shape	Seed Color	Seed Coat Color	Pod Shape	Pod Color	Flower Position
Dominant	 Tall	 Round	 Yellow	 Green	 Inflated (full)	 Green	 Axial
Recessive Trait	 Short	 Wrinkled	 Green	 White	 Constricted (flat)	 Yellow	 Terminal

Trait	Dominant vs recessive	F_2 generations		Ratio
		Dominant	Recessive	
Seed Coat color		705	224	3.15 : 1
Seed colour		6022	2001	3.01 : 1
Seed shape		5474	1850	2.96 : 1
Pod colour		428	152	2.82 : 1
Pod shape		882	299	2.95 : 1
Flower position		651	207	3.14 : 1
Plant height		787	227	2.84 : 1

Generalizations

- Both the parents contribute equally for character development
- In F1 only one of the parent express itself, Dominant…. Recessive
- In F2 generation , characters of both the parents (Dominant and recessive) appears in definite proportion 3:1
- Recessive character appeared in F2 unchanged and identical to the parent (?)
- Dominant characters can be 2 types, Pure and Hybrid

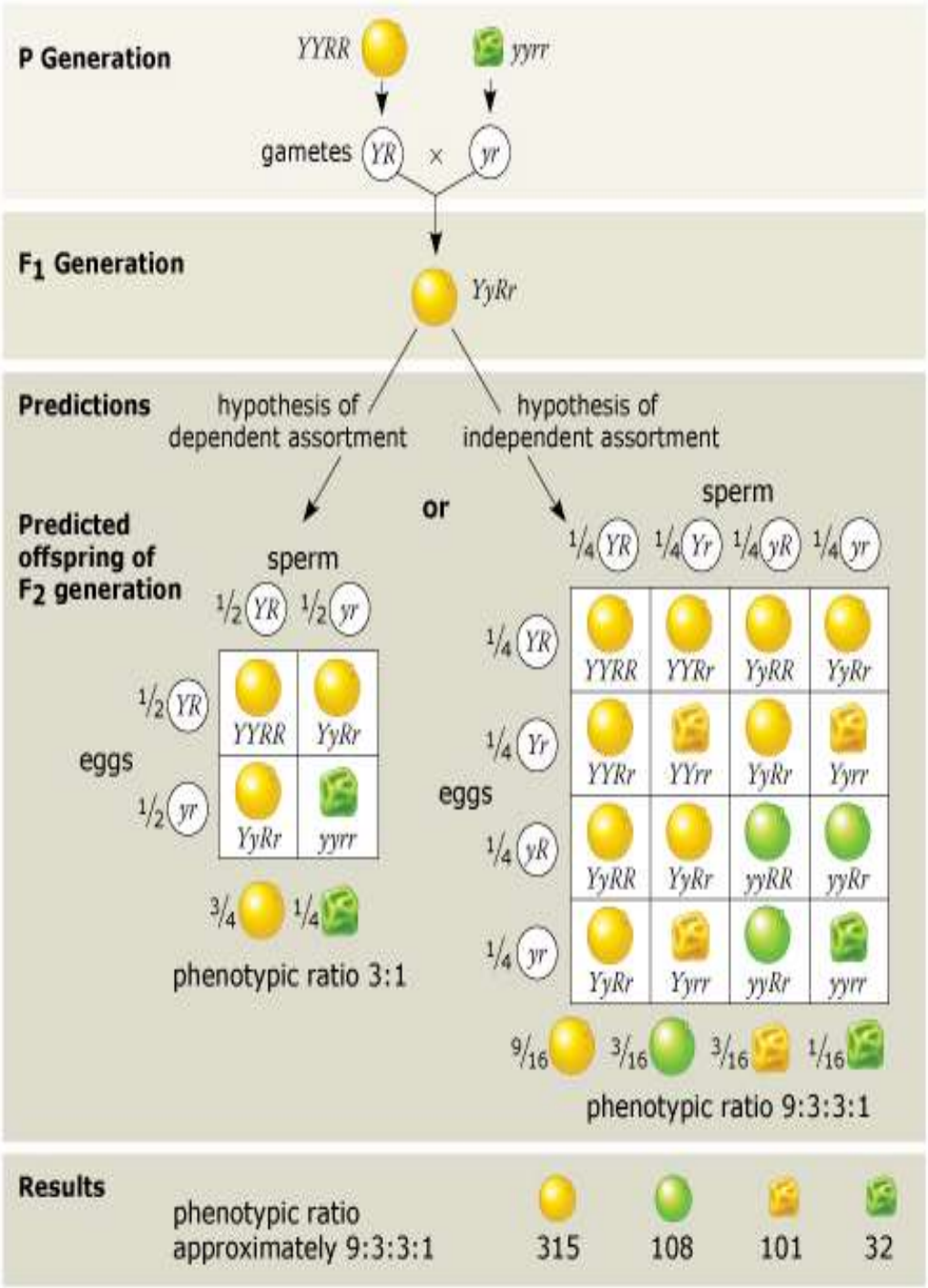
1/3 2/3

- Gene
- Allele
- Homozygote (Pure)
- Heterozygote (Hybrid)
- Dominant /Recessive
- Genotype/genetic constitution
- Phenotype
- Gene symbols

Law of Independent Assortment

- The segregation of the two or more characters in the same hybrid is independent of each other

- Began with 34 distinct varieties of pea
- Grown for purity for two years in separate plots
- Assess the stability of characters
- Twenty two varieties used for his experiment distinct for one or more characters
- Studied seven characters



Adapted from *Campbell Biology* by Reece et al. © Pearson Education, Inc.