Unit Three
Cell Division, Genetics, Evolution

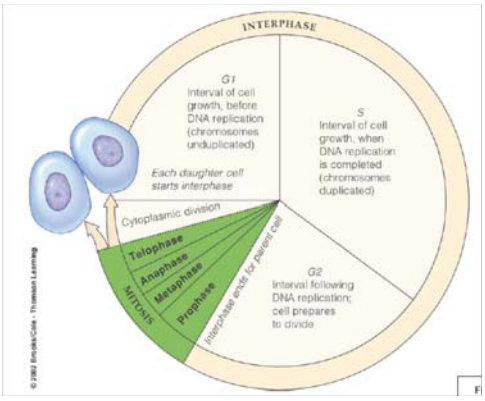
1. Cell Division

A. Mitosis

1) cell cycle G_1 >S > G_2

cytokineses - cell division

karyokinesis - nuclear division



2)Chromosomes

nucleosome- cluster of 8 histones

histones - proteins

homologous - similar chromosomes

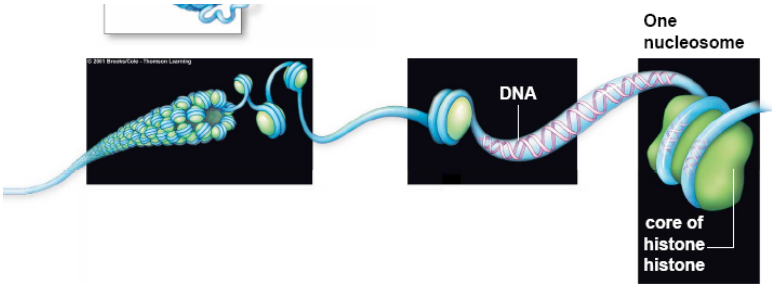
chromatids - duplicate chromosome

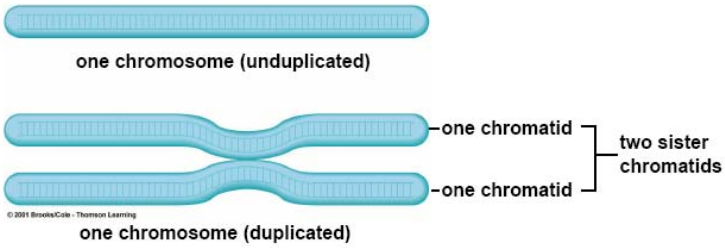
centromere - non-genetic portion

spindle - formed structure

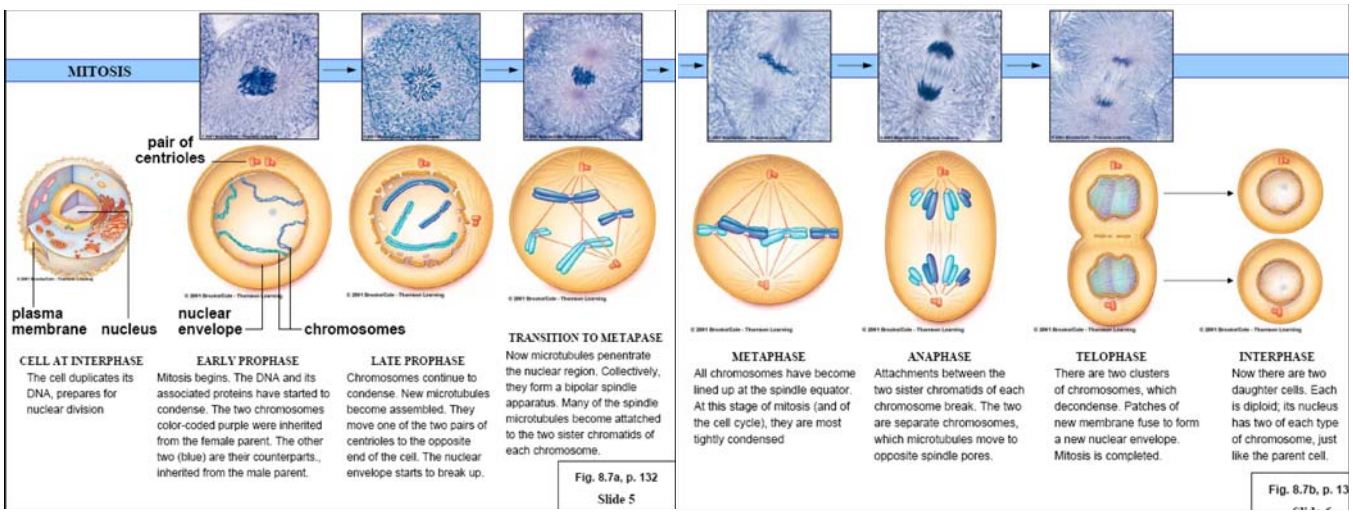
asters - star-like formation

centrioles - non functional

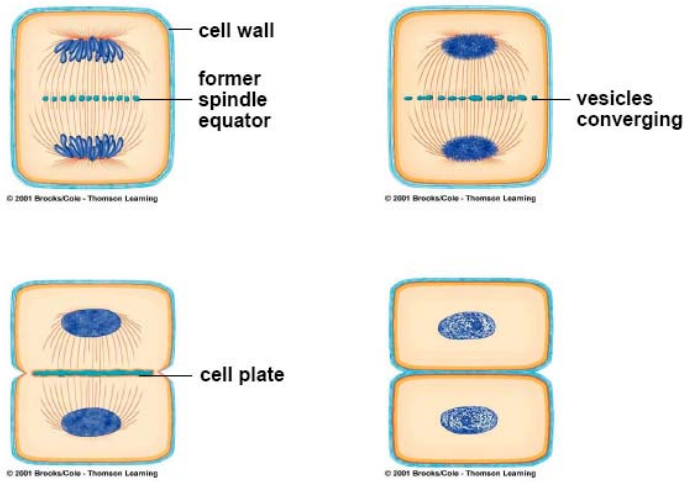




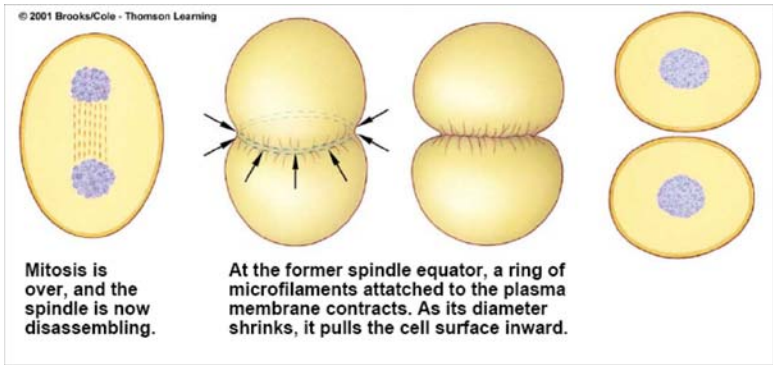
3) Phases
prophase
metaphase
anaphase
telophase



Plant Mitosis
Cell plate - start of cell wall



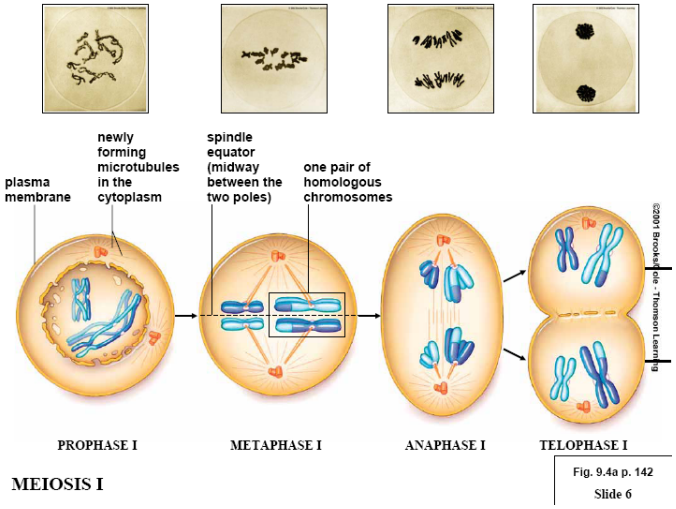
Animal Mitosis
Cleavage furrow - pinches



B. Meiosis-Occurs in the sexual organs of animals ie ovaries and testis

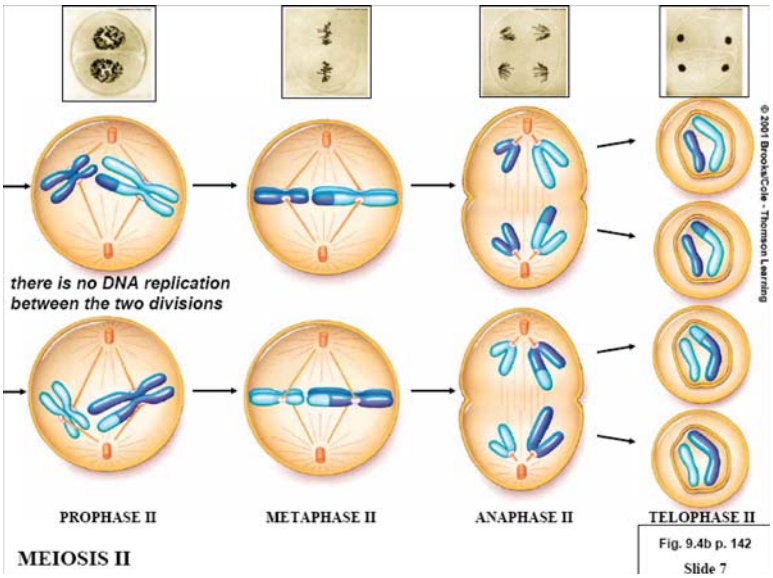
Meiosis I

1) prophase I
2) metaphase I
3) anaphase I
4) telophase I



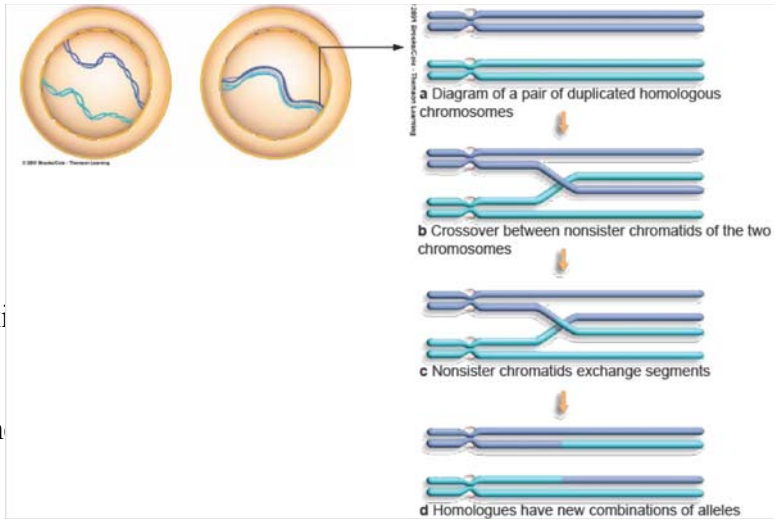
Meiosis II

5) prophase II
6) metaphase II
7) anaphase II
8) telophase II

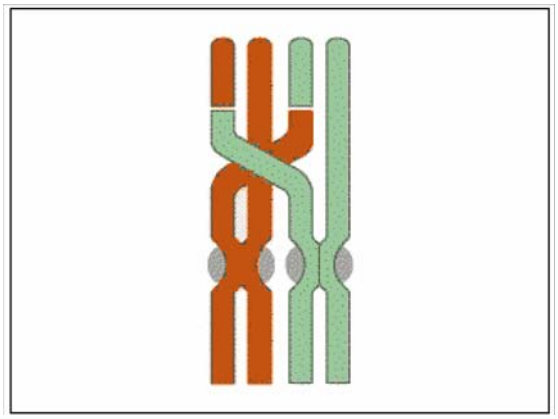


terms:

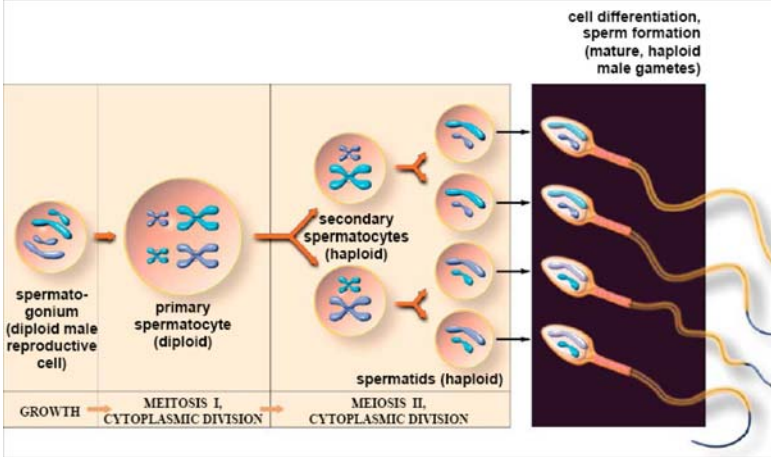
- synapsis - coming together
- crossing over
- tetrads - 4 chromosomes
- diploid - both homologs
- haploid - 1 homolog
- spermatogenesis -sperm
- oogenesis - egg production
- nondisjunction - homolog sticki
- polyploidy - many sets
- parthenogenesis - virgin birth
- tetraploid - 4 times chromosom



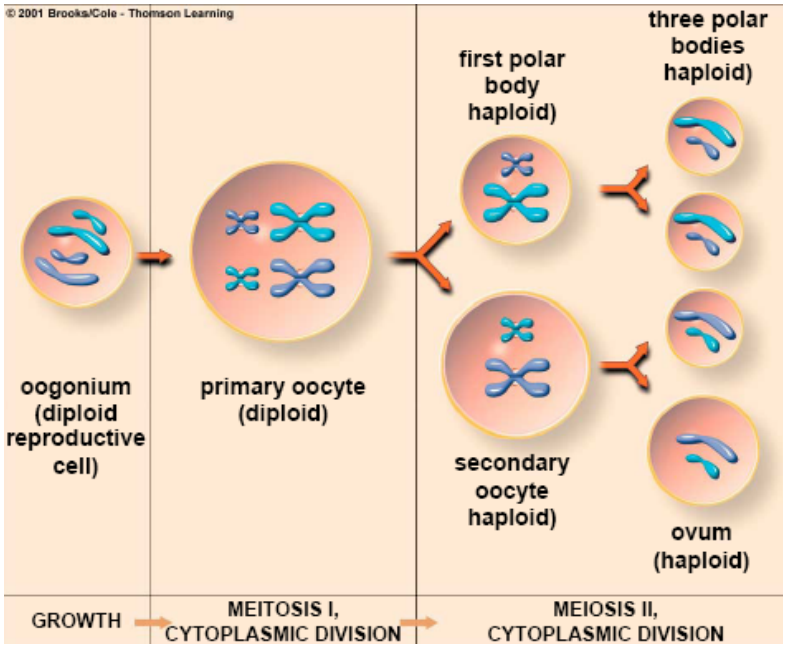
Crossing Over animation



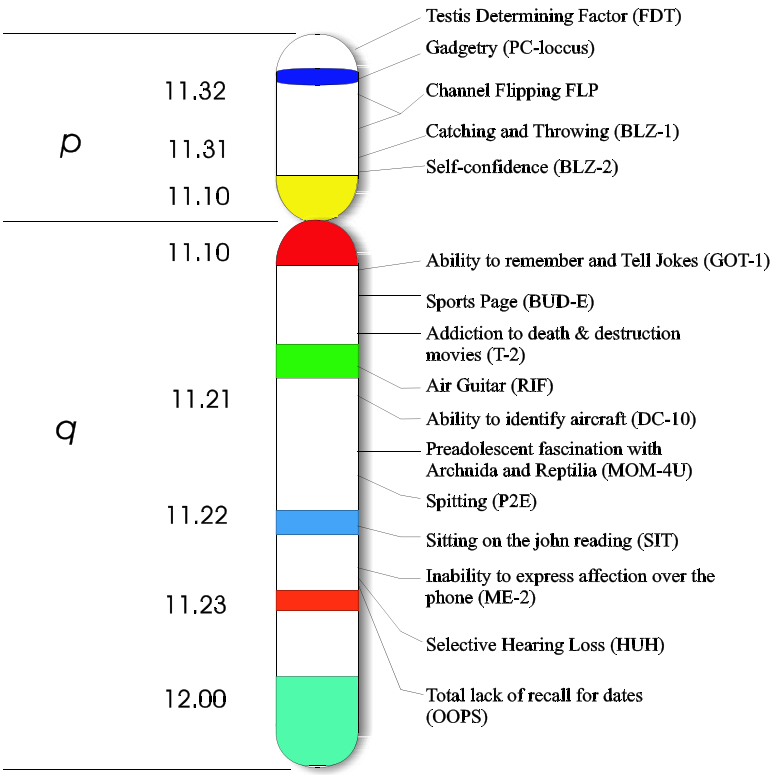
Spermatogenesis



Oogenesis egg cell formation

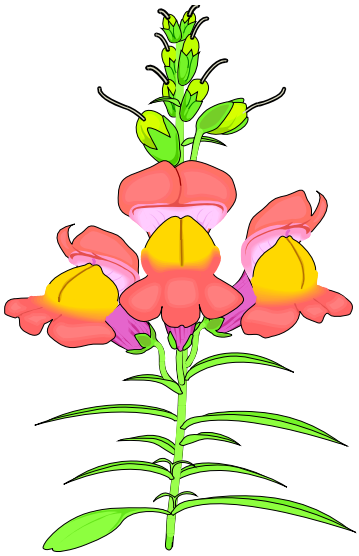


Map of "Y" Chromosome



2. Genetics

A. Gregor Mendel life and experiments



Garden Pea

1822 -1884 Austria

Chose garden peas for study

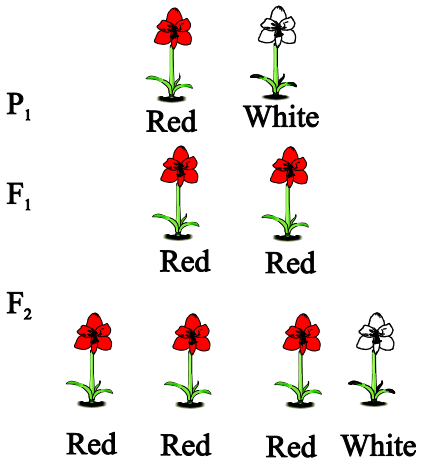
Anatomy of the garden pea

Mendel worked over a period of eight years to come up with his conclusions.
A cross involving pure breeding red flowering peas were crossed with pure breeding white flowering peas. The actual results were 705 red flowered plants to 224 white flowering plants. The actual ratio was 3/4 to 1/4 or 3 to 1.

Mendel coined the term "discrete units" to name the units that we now call genes.

Monohybrid Cross -Complete Dominance

1. *Law of Segregation:* no two alleles in the same gamete.



P_1: RR x rr Red times White

gametes _____ _____

F_1: Rr x Rr

gametes: R, r R, r

F_2:

	R	r
R		
r		

Phenotype ratio_____ to _____

Genotype Ratio _____ to _____ to _____

Clear Form

Test Cross or Back Cross

To determine the genotype of a suspected heterozygote

R? x rr Red times White

Probable gametes R, r x r r

	r	r
R		
r		

Phenotype ratio_____ to _____

Genotype Ratio _____ to _____

Monohybrid Cross - Incomplete Dominance

P_1 RR X rr Red times White

F_1 Rr X Rr Pink times Pink

F2

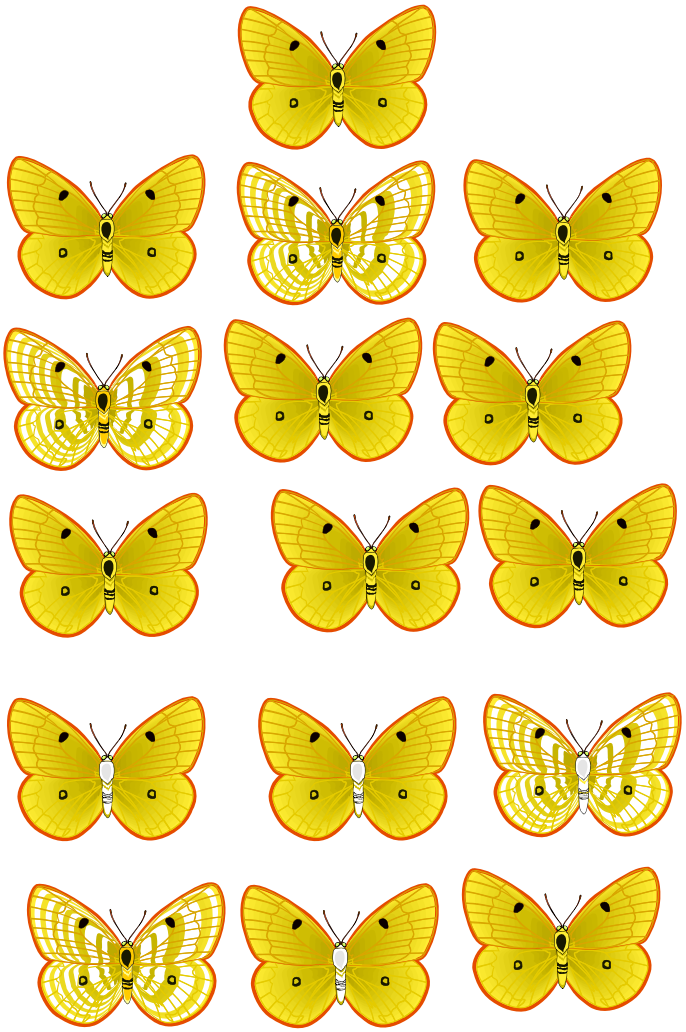
	R	r
R		
r		

Genotype Ratio: _____ to _____ to _____

Phenotype Ratio: _____ to _____ to _____

Clear Form

Dihybrid Cross - Complete Dominance



2. *Law of Independent Assortment* Non-alleles separate independently from one another.

P_1 WWBB x wwbb Dark Wing-Dark Body times Light Wing-Light Body

gametes _____ X _____

F_1 WwBb X WwBb

gametes _____, _____, _____, _____

F_2

	WB	Wb	wB	wb
WB				
Wb				
wB				
wb				

_____ Dark-Wing, Dark-Body

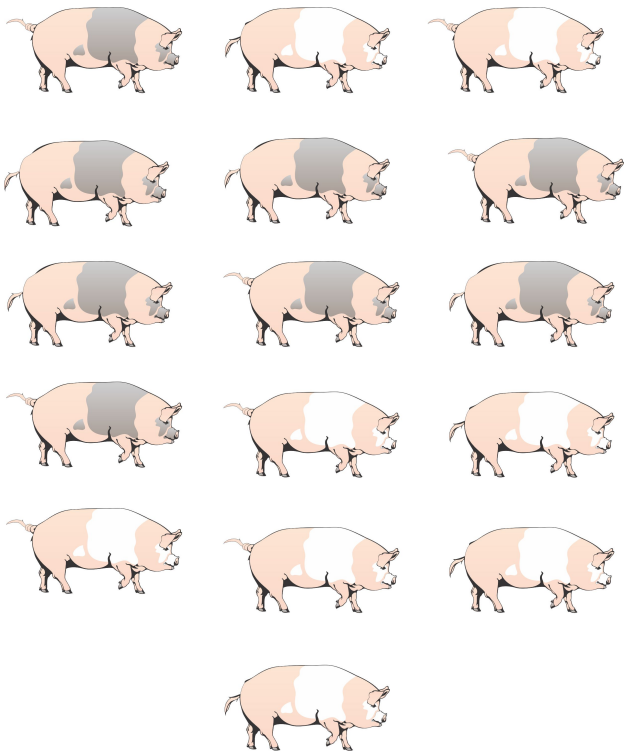
_____ Dark-Wing, Light Body

_____ Light-Wing, Dark- Body

_____ Light -Wing, Light Body

Phenotype ratio: _____ to _____ to _____ to_____

Clear Form



Pigs which have curly tails “T” (point up) and straight tails “t” (point down), and dark spots “S” and light spots “s”

Dihybrid Cross - Test Cross (to test suspected heterozygote)

T?S? X ttss

probable gametes

TS, Ts, tS, ts times ts, ts, ts, ts

	ts	ts	ts	ts
TS	TtSs			
Ts				
tS				
ts				

_____ Curly-Dark

_____ Curly-Light

_____ Straight-Dark

_____ Straight-Light

Phenotype Ratio:

_____

to _____

to _____

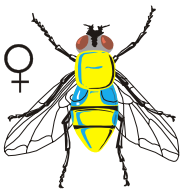
to _____

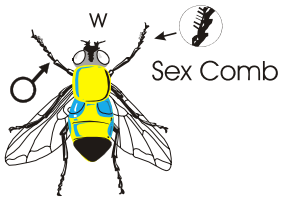
Clear Form

B. Post Mendelian Genetics

1. Thomas Hunt Morgan 1910.

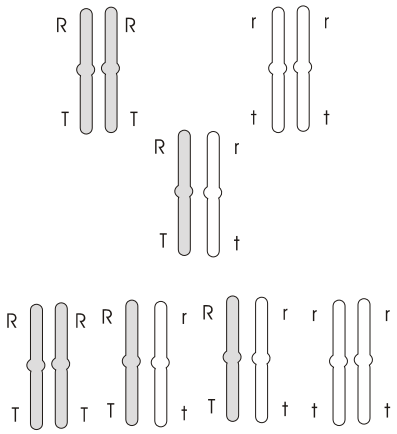
Use of fruit flies for genetics experiments and made the discovery of the inheritance of sex. Proposed the use of autosomes to describe the non sex chromosomes. Found sex linked traits.





2. Sutton -1902 Chromosome theory that genes were located on the chromosomes, not free in the cytoplasm.

3. Linked traits - loss of phenotypes. Traits are located on the same chromosome.



4. Sex linked traits: color blindness, hemophilia

5. Multiple alleles: Blood types

Blood type	Antigen	Antibody	Genotype	U.S. Percent
A	A	B	AA or Ao	45 %
B	B	A	BB or Bo	10 %
AB	A and B	None	AB	4 %
O	None	Both A & B	oo	45 %

6. Multiple genes- Non allelic genes, three or more, all acting together to code for a trait.
   Tall - AABBCCDDEE
   Medium: AABBccddEE aabbCCDDEE AAbbCCddEE Short - aabbccddee

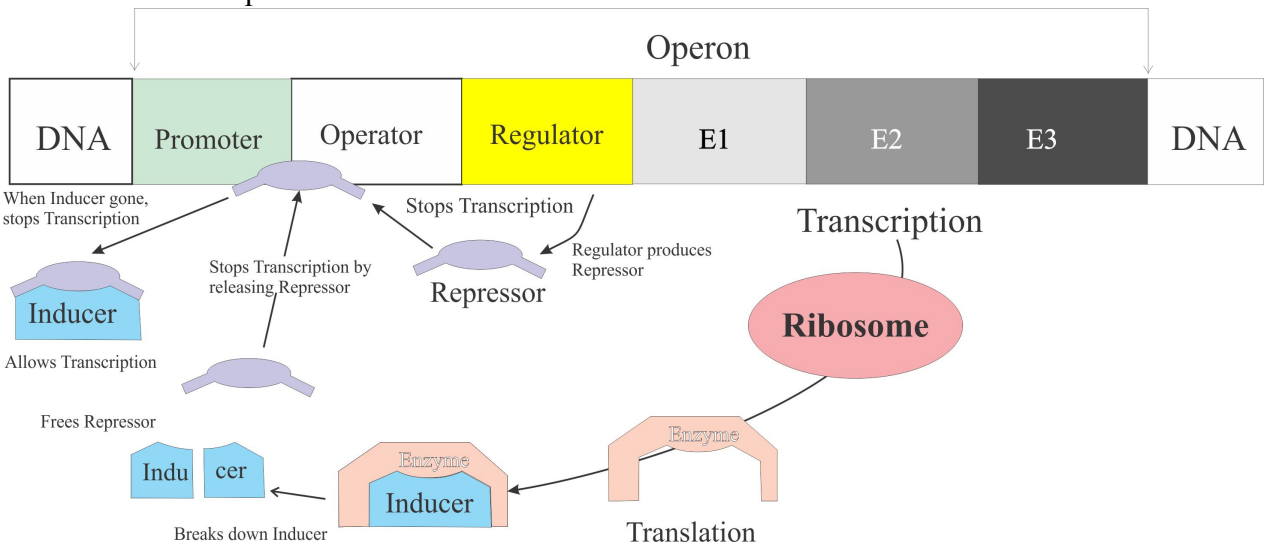
Common Human Traits

Human Trait	Dominant	Recessive	Comments
Dark hair color	Dark Hair	Tawny or Blonde	
Red Hair color	Non red hair	Red hair	If dark hair is combined with red hair color then it is dark with reddish highlights
Hair line	Widow's peak	Straight or curved	
Forelock (hair)	White Forelock	Self-colored Hair	
Eye lash length	Long eye lashes (over 3/8ths of a inch)	Short eye lashes.	
First finger shape	Bent away	Straight	
Little finger Shape	Bent away	Straight	
Brown eye color	Brown eye color	Blue or gray	
Hair texture	Curly Hair	Straight Hair	Incompletely dominant, the heterozygous condition will produce wavy.
Dimples	Dimples	No dimples	
Darwin's Ear point	Darwin's point	No Darwin's point	Found on the inner aspect of the ear, sometimes only on one ear.
Freckles	Freckles	No freckles	

3. Molecular Genetics

Jacob and Monod theory of gene control and action. (Operon Theory)

Operon - set of structure genes.
Promoter - gene that signals the start of the operon. RNA polymerase
Regulator gene - a gene that encodes for a Repressor.
Operator gene - gene that allows transcription.
Repressor substance- a protein produced by the regulator that inhibits transcription by binding with the operator.
Inducer - the substrate binding with the Repressor to allow transcription.



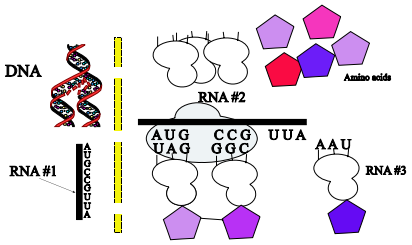
Review the structure of DNA molecule, especially the nitrogen bases.

G-C A-T

Genetic Code - the sequence of nitrogen bases which spell out a particular amino acid or peptide. Using three letters at a time, the possibility of 64 different amino acids could be account for. With only 23 amino acids in nature why do so many codes call for the same amino acid? The primary code source is contained in the DNA.

RNA's role in the process.

a. Messenger RNA or mRNA. Strands of DNA would separate, RNA polymerase moves along the strand and assembles itself onto the complementary portions of the exposed DNA. The assembled sequence of nucleotides is called a codon. The RNA nucleotides are linked together to form a mRNA strand. The mRNA moves away and out into cytoplasm and DNA winds up again. This is called Transcription. Messenger RNA or mRNA encodes the genetic message from DNA and transports the message to the ribosomes.

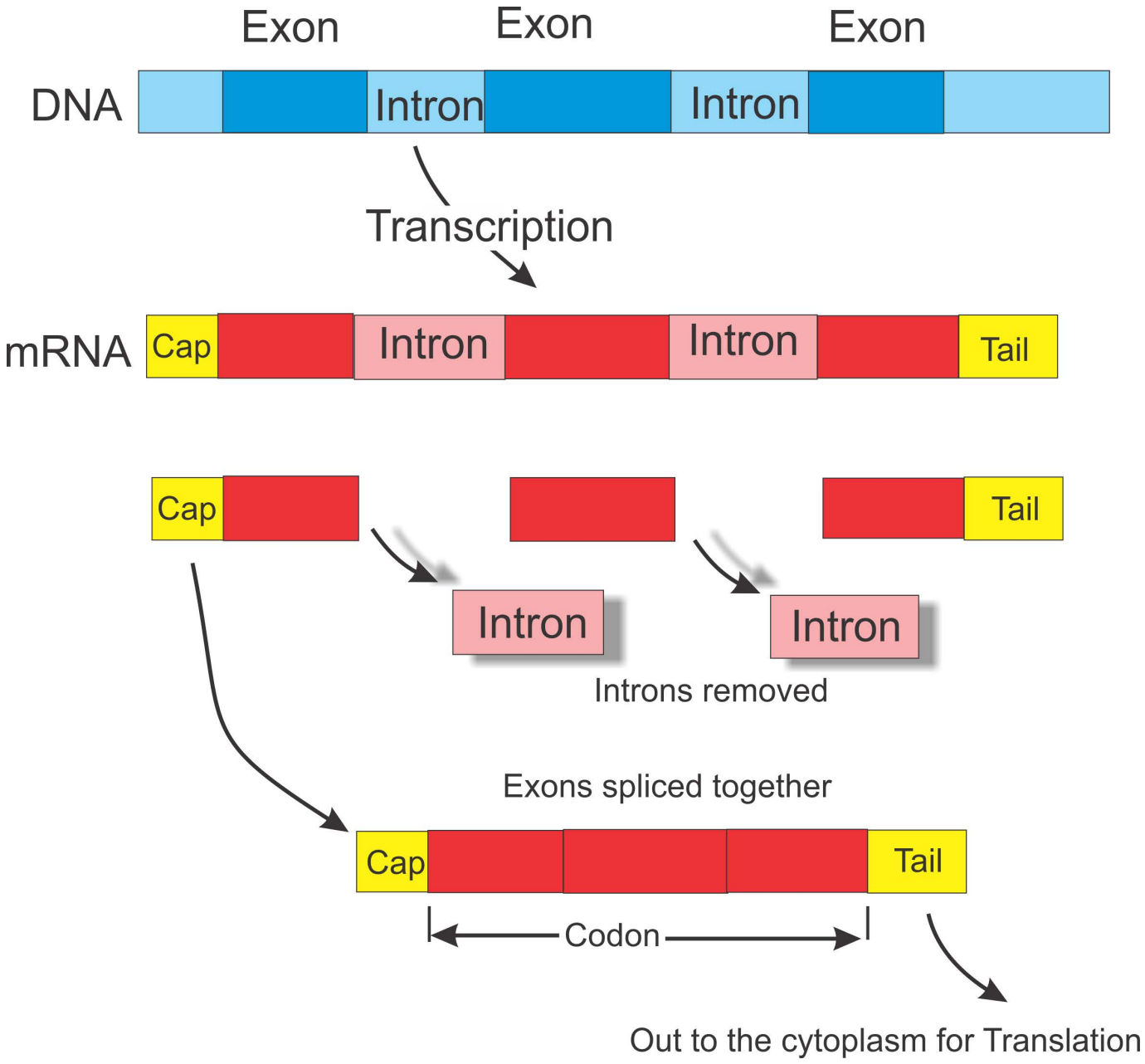


b. Ribosomal RNA or rRNA. The ribosome forms a complex unit imbedded on the rough E.R. The ribosome has three binding sites, one for mRNA and two for tRNA.

c. Transfer RNA or tRNA. Each transfer RNA has a built-in, three nitrogen base sequence or anticodon. When the mRNA binds to the ribosome, its codon is matched to each tRNA anticodon. When a certain tRNA is called upon, then that transfer RNA picks up an amino acid and binds itself to the ribosome opposite the codon on the first site. This is repeated with the second site and the appropriate tRNA. The adjacent amino acid is joined by a peptide bond and the first tRNA moves over and drops off to allow the next tRNA to bind. This is called Translation. This process may be repeated to form proteins that consist of anywhere from 20 to 3,000 amino acids.

Protein Synthesis diagram

Eukaryotic Processing of mRNA before Translation



	Amino acids that correspond to base triplets:				
FIRST BASE	SECOND BASE OF A CODON				THIRD BASE
	U	C	A	G	
U	phenylalanine	serine	tyrosine	cysteine	U
	phenylalanine	serine	tyrosine	cysteine	C
	leucine	serine	STOP	STOP	A
	leucine	serine	STOP	tryptophan	G
C	leucine	proline	histidine	arginine	U
	leucine	proline	histidine	arginine	C
	leucine	proline	glutamine	arginine	A
	leucine	proline	glutamine	arginine	G
A	isoleucine	threonine	asparagine	serine	U
	isoleucine	threonine	asparagine	serine	C
	isoleucine	threonine	lysine	arginine	A
	methionine (or START)	threonine	lysine	arginine	G
G	valine	alanine	aspartate	glycine	U
	valine	alanine	aspartate	glycine	C
	valine	alanine	glutamate	glycine	A
	valine	alanine	glutamate	glycine	G

4. Evolution

A. Theories of Evolution

1. Spontaneous generation and immutability of the species. Each species was created separately out of dust and dirt and would never change.
2. This was disproved by Louis Pasteur.

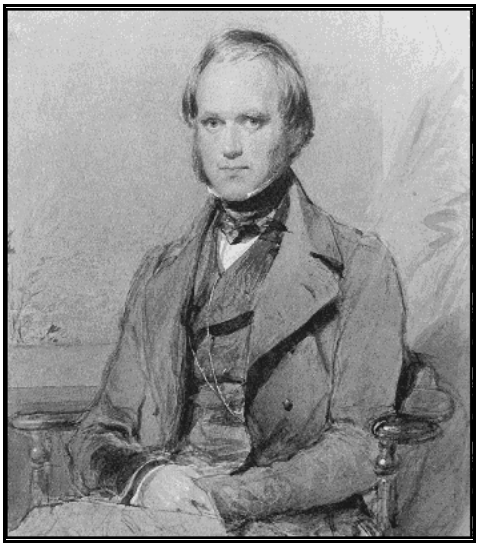
3. First major theory of Evolution

a. Jean Baptiste Lamarck 1809.
"Theory of acquired of characteristics".
The environment introduces a need for some structural change in the organism. The organism attempts to meet this need. In response to the efforts the organism is changed and its changes are passed down to its offspring.

b. Lamarck was refuted by Weismann who by cutting tails off of mice for several generations without having tail less offspring.

B. Charles Darwin 1809 -1882.

A. Born the same year that Lamarck published his theory. His father and grandfather were both physicians. At the age of 18 Charles was shipped off to the University of Edinburgh to study medicine. An absolute failure, could not stand the sight of blood, he become bored and dropped out. Since he would not become a doctor his father thought he should become a preacher. He was sent to Christ College in Cambridge and received his B.A. degree in 1831.

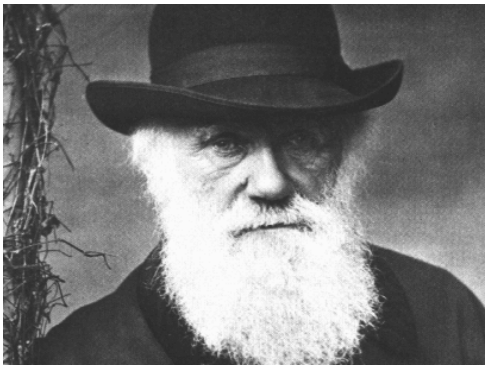


Darwin at 22

At Cambridge he met a professor of botany John Henslow. It was John Henslow that gave Darwin a chance to serve aboard the H.M.S. Beagle. A five year trip that sailed around the world including South America and the Galapagos Islands were to greatly influence his life. He arrived back in England in 1839 and spent the next 20 years writing his papers.

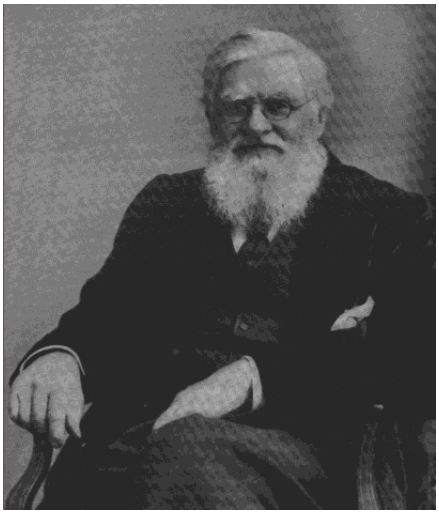
Darwin at 29

On the morning of June 18, 1858 Darwin received a letter from Alfred Lord Wallace. Wallace was a young naturalist working in Malaysia. Along with the letter was a paper written by Wallace entitled: "On tendency of varieties to depart indefinitely from the original type". Darwin was to read and comment.



Darwin at 70

On July 1, 1858 both Darwin's essay and Wallace's paper were jointly presented to the Linnean Society. Darwin's "Origin of the Species" was published in 1859 and sold out the first day.



Wallace

2. General conclusions from Origin of Species

Within a population there exists considerable variation amongst the individuals.

The population tends to produce more individuals than can possibly survive.

The offspring must compete for the limited resources that are available.

Of these offspring, those individuals that are best fitted will survive, because the selection is made by the environment.

Darwin called this Natural Selection.

Darwin's ideas were refuted at the time of publication and some people still will not accept them today. Darwin was dismayed at the weak criticisms of his theory, for he could write the most "damning criticisms of all."

Modern Interpretation of Evolution.

Darwin, like Lamarck, had little understanding of the basis of variation or genetics.

Even though Gregory Mendel published in 1865 only six years after Darwin's Origin of Species, Mendel's work went undiscovered until the 1900's.

Modern views would say it was not just the survival of the fittest, but which individuals survived and produced the most young. Competition between organisms becomes something other than physical strife, it becomes competition for space, light, nutrients, growth, etc.

Types of Adaptations in Organisms.

1. **Morphological Adaptations**: thorns in plants, large cells in grasses for folding during drought, marine mammals in the ocean.

2. **Physiological Adaptations**: Use of DDT on flies, antibiotics on bacteria, jellyfish ranging from cold waters to warm waters can keep the same swimming rate.

3. **Behavioral Adaptations**: Masking Crab gluing plants on its back, release of "ink" in the squid to simulate body shape.

Forces of Evolution

1. Variation: Natural selection acting on the genetical variations that appear among the members of the population.

Gene pools can be freely exchanged within a species between sexually contacting populations.

Genetic variations can arise by sexual recombination, mutation or both. In each generation some individuals appear who posses new variant traits as a result of either recombinational or mutational processes.

2. Differential Reproduction. Some members of the population leave more offspring.

Those having more offspring contribute a proportionally greater percentage of genes to the gene pool of the next generation than those having fewer offspring.

Animals which leave the most offspring are:

Usually those best adapted to the environment: healthier animals better fed, find mates more readily, defend themselves better.

Although, what matters is how many offspring of the species manage to survive.

3. Evolution is a two step process:

A. Appearance of genetic variations by sexual recombination and mutation.

B. Spreading those genetic variations through a population by differential reproduction in successive generations.

Only populations evolve, not individuals.

Genetic traits of individuals are fixed and do not change over a period of time.

Differential reproduction results in the characteristics of succeeding populations to change in response to the ever changing environmental conditions.

Evolution does not progress in fixed or predetermined directions.

Genetic variations appear at random, and therefore evolutionary

innovations appear at random.

There is a guiding force: adaptation towards its own end to the environment.

Natural selection is a creative force, spreading new genetic novelties into the environment.

Natural selection therefore operates through reproduction, not through the struggle for survival.

Natural selection will eliminate the reproductively "unfit", but will not eliminate the behaviorally or socially "unfit".

Speciation or the Formation of Barriers to Gene Flow.

1. **Physical Barriers:** continental drift, climatic barriers, etc

2. **Temporal Barriers**: one species does not breed at the same time as another closely related species.

3. **Behavioral Barriers**: Difference in behavior during or preceding mating.

4. **Hybrid Inviability**: Allows mating to take place, but the hybrids either die during gestation or before breeding or are sterile.

5. **Polyploidy.** Increasing the total chromosome count by at least one set. It is responsible for at least ½ of all species of plants.

Adaptive Radiation

1. The slow progressive steps in change, with geographic isolation, providing the necessary conditions.

2. All presently living organisms are contemporaries, appearing in the uppermost branches of the evolutionary tree.

3.The sum total of all these branches leading away form the common ancestor represents adaptive radiation.

4. All such radiations show divergence or the development of dissimilar traits as they descended from a common ancestor.

5. Not all lines lead to the top, some terminate abruptly at intermediate points

(Extinction).

6. Some are replaced (replacement) with newer types usually in the role of the older type. i.e. marsupials replaced by Placentals.

Sympatric and Allopatric species. Sympatric species live together, that is, they make physical contact but are reproductively isolated. Allopatric species are both geographically and reproductively isolated.

Convergent and Parallel Evolution

1. Replacing organisms usually show some degree of evolutionary convergence. Convergent evolution occurs in animals or plants who look alike, occupy the same habitat but are unrelated. Parallel evolution occurs in animals and plants who look alike, occupy similar habitats (not the same), and are not related.

2. The solution to the environmental problem is a common one resulting in look-a-likes, i.e. the eyes of squid and fishes are structurally similar and function the same way but were formed completely differently.

Coevolution

Two species evolve or change together and they operate biologically as a team, i.e. pronuba moth, termites and their intestinal protozoa.

The Measurement of Evolution- the Hardy Weinberg Law

A progressive change of gene or genotype frequencies results in evolution.

How to measure that progressive change? The Hardy Weinberg Law.

When a population is in genetic equilibrium and gene frequencies do not change, the rate of evolution is zero.

Genes can be reshuffled by sexual recombination and genetic variation will continue to originate from this source.

Overall gene frequencies do not change.

Conditions of the Hardy-Weinberg

1. Mating is random.

2. Mutations do not occur.

3. No genetic drift.

Calculations of gene (p and q) frequencies and genotype (p^2,2pq,and q^2) frequencies.

$p + q = 1$ p = dominant allele percentage in population q = recessive allele percentage in population
$(p + q)(p + q) = 1$ The result of two organisms mating

$p^2 + 2pq + q^2 = 1$ expanded binomial

Steps in solving for "p" and "q".

1. Determine the homozygous recessive (q^2)

2. Take the square root of q^2

3. Subtract the q value from 1.0, this becomes the value "p".

4. Square the of "p" for p^2.

5. Multiply the value of "p" times "q" times 2.

Review Questions

1. Be able to label an unlabeled mitosis diagram.

2. Be able to label an unlabeled meiosis diagram.

3. Who proposed the theory of Spontaneous Generation?

4. When a trait is coded by a series of genes all on different chromosomes, this is called what?

5. With complete dominance and monohybrid cross, what will the phenotype and genotype ratios be in the F_2?

6. In a linkage cross, unexpected phenotypes are the result of what?

7. Two cells that formed from the result of mitosis have how many chromosomes relative to the starting cell?

8. If a trait is passed from father to son then to his son, the gene is located on which chromosome?

9.Who proposed the laws of genetics?

10. What would the genotype plus the environmental forces produce?

11. What is the difference between a trait which is allelic and one that is nonallelic?

12. Assume dark coat color is dominant over light. If you cross two dark animals of unknown parentage, what would the offspring be colored?

13. Who is known for his work on sex inheritance and fruit flies?

14. If two alleles are the same, this is called what?

15. If the two alleles are different, what is this called?

16. Where in the body does meiosis occur?

17. If two traits are linked, what does this mean?

18. If you had to map a chromosome, what would you need to know?

19. What is the first law of genetics?

20. What does independent assortment refer to?

21. In a dihybrid cross with complete dominance, what would the F_1 phenotype ratio be?

22. If a genetic cross produced 9/16 red tall, 3/16 red short 3/16 white tall and 1/16 white short, what was the hybrid cross (F_1)?

23. In the symbolism of "Aa", what does the "a" usually indicate?

24. If the genotype is AaBb what would all the gamete combinations be?

25. Who developed his own theory of evolution, just as Darwin was getting ready to publish?

26. Give the genotype of a heterozygous dark body (D) sex-linked white eye male(w).

27. With a backcross a heterozygous individual times homozygous recessive individual, what will the resulting phenotype ratio would be?

28. In protein synthesis, where does transcription and translation occur?

29. What is the role of messenger RNA?

30. What is the role of transfer RNA?

31. On which RNA is the anticodon located?

32. On which RNA is the codon located?

33. How many nitrogen bases are needed to code for one amino acid?

34. Sickle cell anemia is a recessive trait. If both parents are carriers, what is the probability of a child with sickle cell anemia?

35. When unrelated organisms resemble each other from the same environment, this is an

example of what kind of evolution?

36. What is a general definition of species?

37. How do plants use polyploidy?

38. Give an example of a trait which is a multiple alleles.

39. How long did it take for Darwin to finish his book "Origin of the Species" after he got back from his trip around the world?

40. Does natural selection work on every bad gene?

41. In a population, 99% of the people do not show a homozygous recessive disease. What percent of the population carry the bad gene?

42. What is necessary in the process of Speciation?

43. If two different species mate and produce viable young, but the young are infertile, what does this represent?

44. Relate the role of repressor, regulator, operator, and operon to gene action.

45. What is genetic drift?

46. With incomplete dominance, what is the relationship between the number of phenotypes and the number of genotypes?

47. What is Sutton know for?

48. What was the relationship between Darwin and Mendel?

49. What was Weismann contribution to the understanding of evolution?

50. What is an autosome?

51. What does the Hardy-Weinberg Law measure?

52. Name the conditions of the Hardy-Weinberg Law.