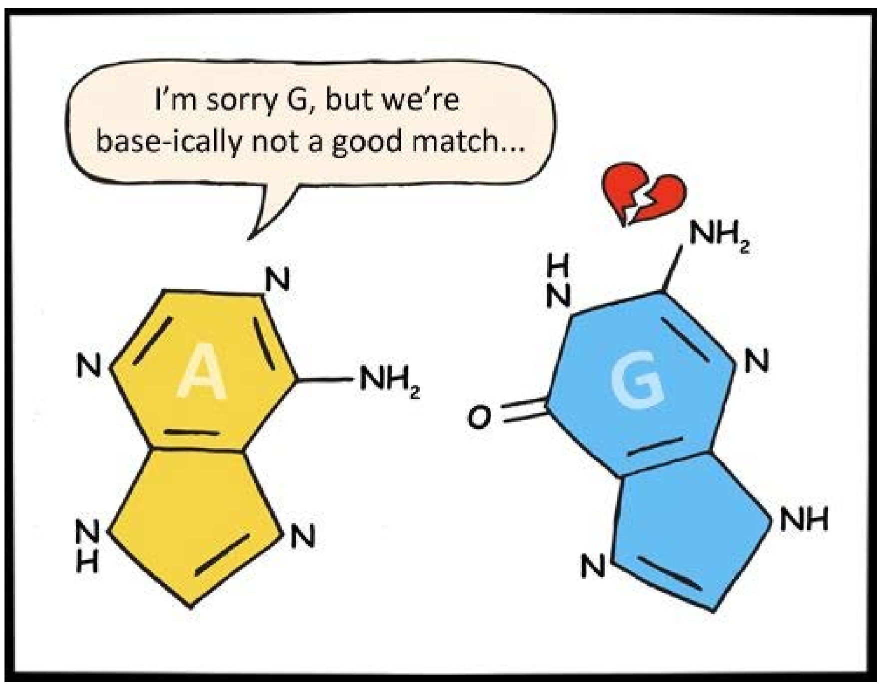
SCIENCE 10

UNIT 3: BIOLOGY



BOOK 1 DNA & INHERITANCE

NAME: Key

BLOCK: ____________

PART A - THE STRUCTURE OF DNA

History of DNA research

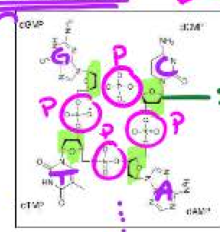
☐ DNA was discovered in 1869 by a chemist (Johann Friedrich Miescher) studying pus-coated medical bandage

☐ In 1881, this new substance was named deoxyribonucleic acid (DNA) the sugar (deoxyribose) found in the molecule and its acidic properties

☐ A series of experiments in the early 1990s showed that DNA causes bacteria to change their behavior and allowed viruses to infect cells, indicating that it played a special role in living organisms.

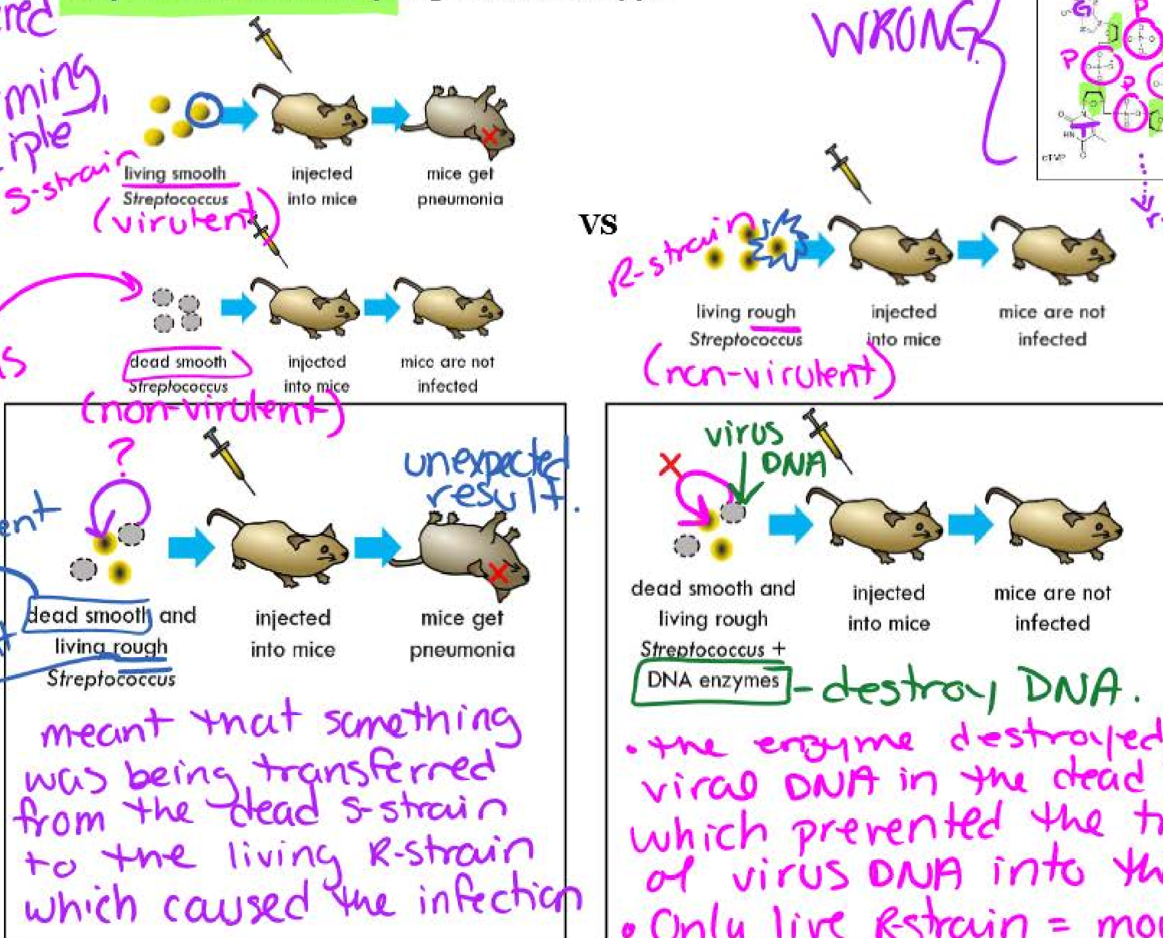
☐ in 1909 Russian-American biochemist Phoebus Levene discovered ribose (RNA) sugar and in 1929 deoxyribose sugar. (DNA)

☐ He is mostly remembered for proposing the incorrect tetranucleotide structure of DNA and suggesting a sequence of DNA where G - C - T - A repeat and exist in equal numbers.



1928 F. Griffith discovered the "Transforming Principle"

Avery MacLeod-McCarty Experiment (1944):



☐ in 1950 Austrian biochemist Erwin Chargaff proposed that the nucleotide sequence **did NOT repeat.** => aimed to prove Levene

☐ That instead the amounts of A : T and G : C are equal.

☐ This discovery of *base-pairing rules* is commonly referred to as "Chargaff Rules"

ATGC ≠ equal

A pairs with T
G pairs with C

A+T = equal
G+C = equal

Female

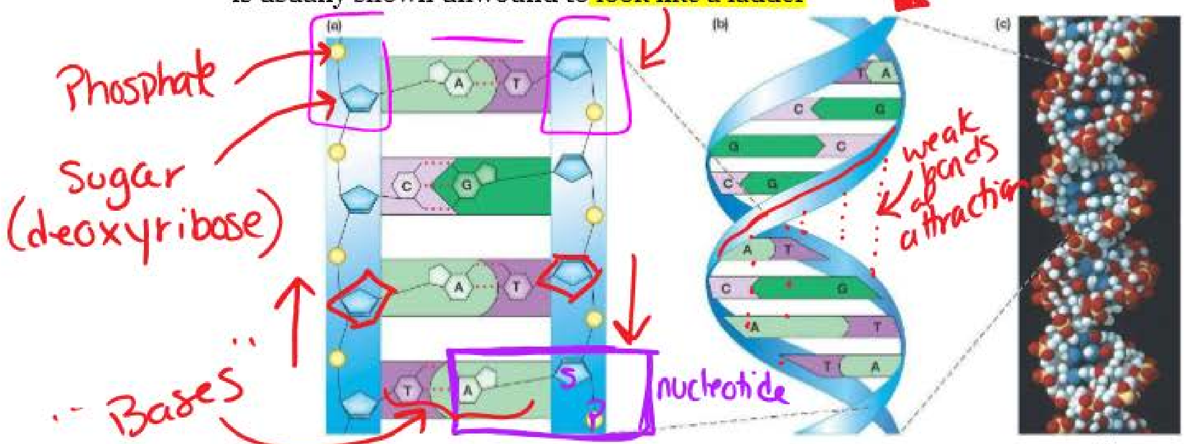
- ☐ Rosalind Franklin, English Chemist and X-Ray Crystallographer, made a crucial contribution to the discovery of the double-helix structure of DNA
- ☐ Her "photo 51," was shown to Watson by a colleague. This X-ray diffraction picture of a DNA molecule was Watson's inspiration *(the pattern was clearly a helix).*
- ☐ Using Franklin's photograph and their own data, Watson and Crick created their famous DNA model. Franklin's contribution was not acknowledged, but after her death Crick atmitted that her contribution had been critical.

stolen! work!

- ☐ In 1953, the structure of the DNA molecule was finally discovered by Watson + Crick

Structure of the DNA Molecule

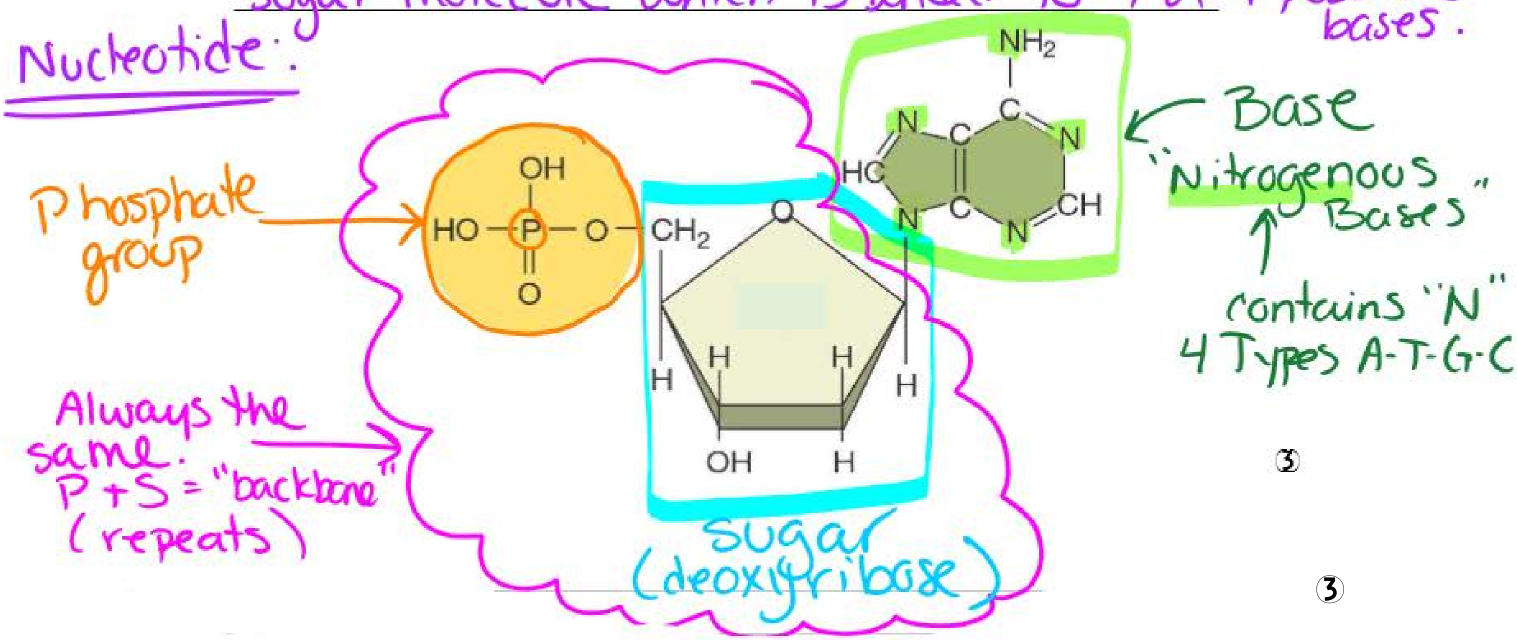
- ☐ DNA is an extremely large molecule containing thousands & millions of atoms joined by chemical bonds
- ☐ It is a Pair of separate strands twisted together to form a 'double helix,' however it is usually shown unwound to look like a ladder



Uncoiled Diagram Double Helix Space-Filling Model

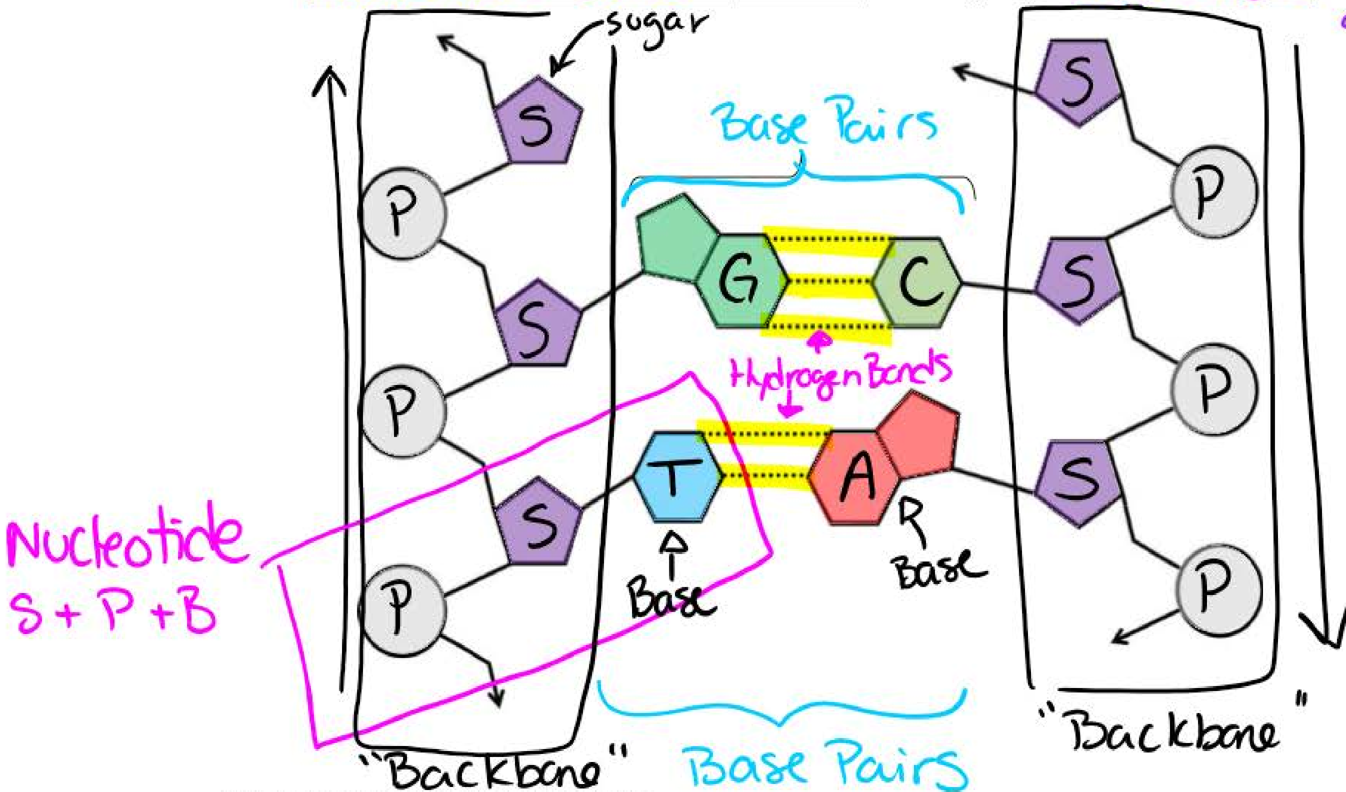
- ☐ Each DNA strand is made from repeated molecular units called Nucleotides
- ☐ A single nucleotide contains a phosphate attached to a sugar molecule which is bonded to 1 of 4 possible bases.

Nucleotide:



③

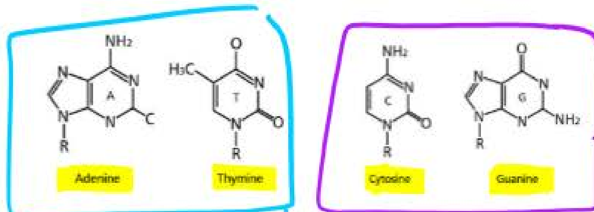
☐ The DNA strands are created when sugar and phosphate from two different nucleotides bond, forming the "backbone" or "rungs" of a ladder



Complementary Base Pairing

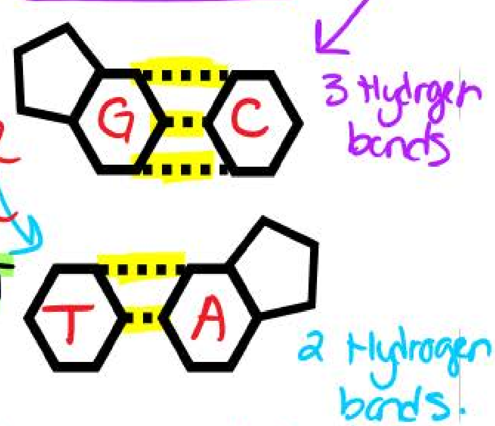
☐ There are four different bases in DNA:

1. Adenine (A)
2. Thymine (T)
3. Cytosine (C)
4. Guanine (G)



☐ These bases ALWAYS match a specific base on the other strand:

- Adenine pairs with Thymine
- Guanine pairs with Cytosine



Ways to Remember this:

→ curly letters C-G straight A-T

→ "COLGATE" = C-G A-T

☐ This relationship is called "complementary base pairing"

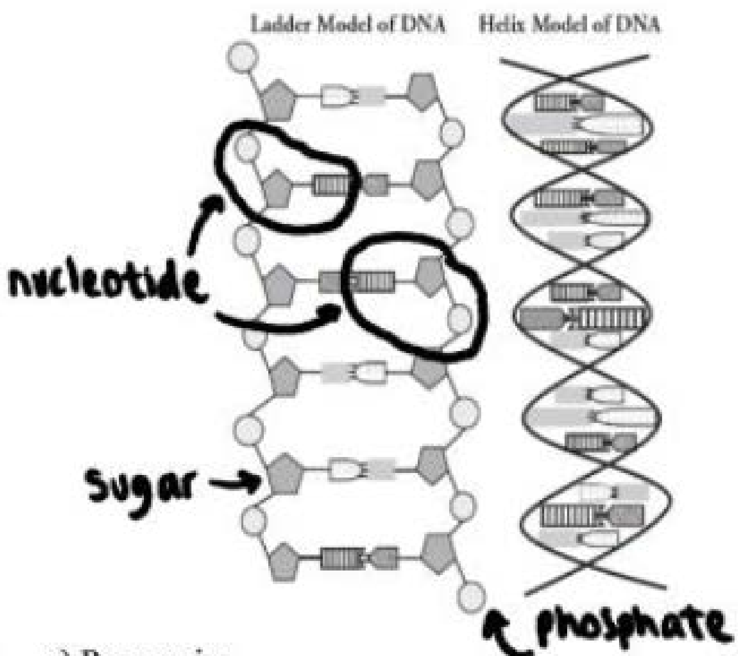
↳ anything other than A-T or G-C is considered an error (mutation)

Homework

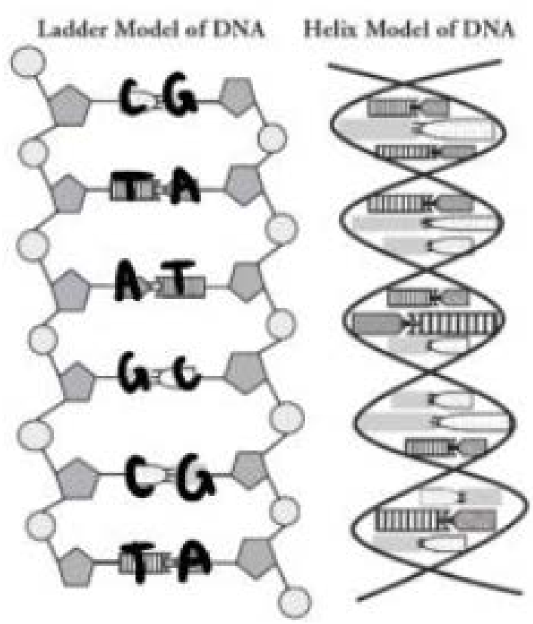
Assignment #1: Complete the following worksheet in the space provided below

ANSWERS:

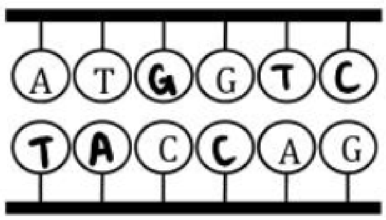
1. Deoxyribonucleic acid
2. Sugar, Phosphate, Base
3. Base
4. Adenine (A), Thymine (T), Cytosine (C), Guanine (G)
5. a) b)



5. c) Base pairs
5. d) Sugar and Phosphate
6.



7. Adenine
8. Guanine
9. Adenine ALWAYS pars with thymine & cytosine ALWAYS pairs with guanine
10.

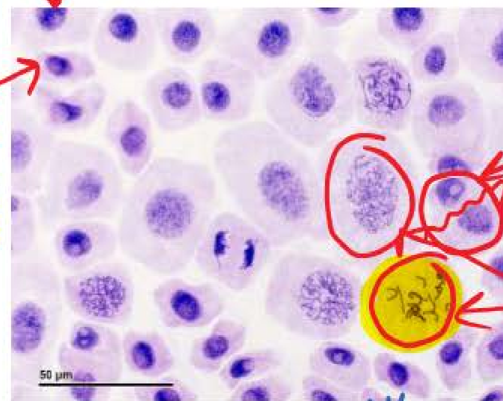


11.

Organism	Percentage of each type of base			
	Adenine	Guanine	Cytosine	Thymine
Human	31	**19**	19	**31**
Cow	28	22	**22**	**28**
Salmon	**29**	**21**	21	29
Wheat	27	**23**	**23**	**27**
Yeast	31	**19**	**19**	**31**

PART B - DNA ORGANIZATION

Location of the DNA Within the Cell



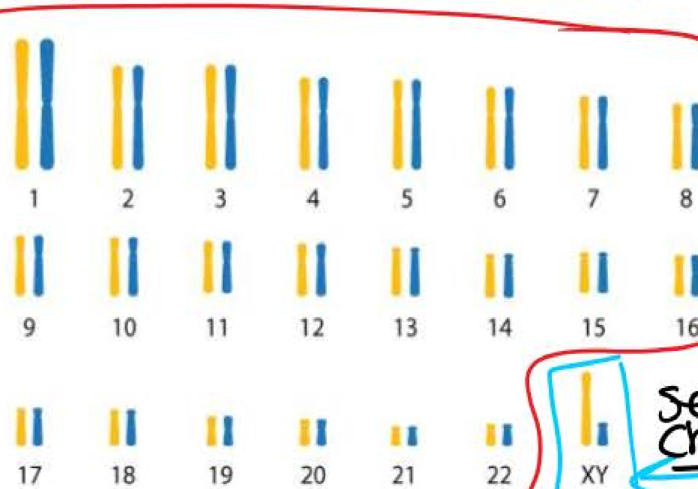
- ☐ DNA is always found inside the cell's nucleus
- ☐ The only exception to this is during cell division (mitosis), when the membrane of the nucleus dissolves, and the DNA is released into the cell

Chromosomes

- ☐ DNA in human cells is NOT a long continuous strand. It is broken up into 46 separate strands, which, when packed for cell division, are called chromosomes
- ☐ These form 23 pairs – normally the chromosomes in each pair are identical, except for pair 23 (which are the sex chromosomes – XX or XY)

Autosomes → "all body cells"

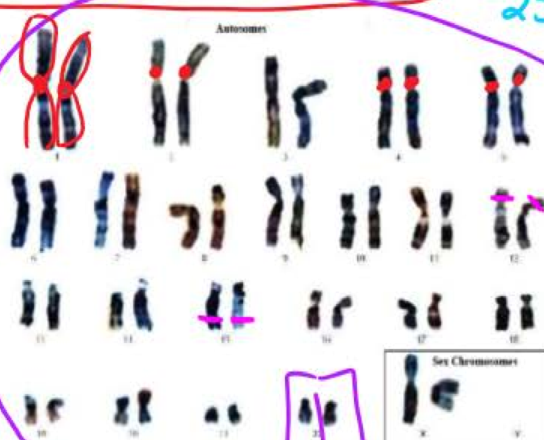
Diagram of Chromosome Pairs



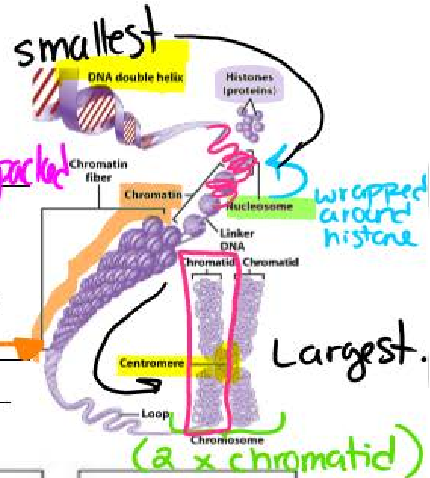
Sex chromosomes
XY - genetic male
XX - genetic female

"Karyotype"

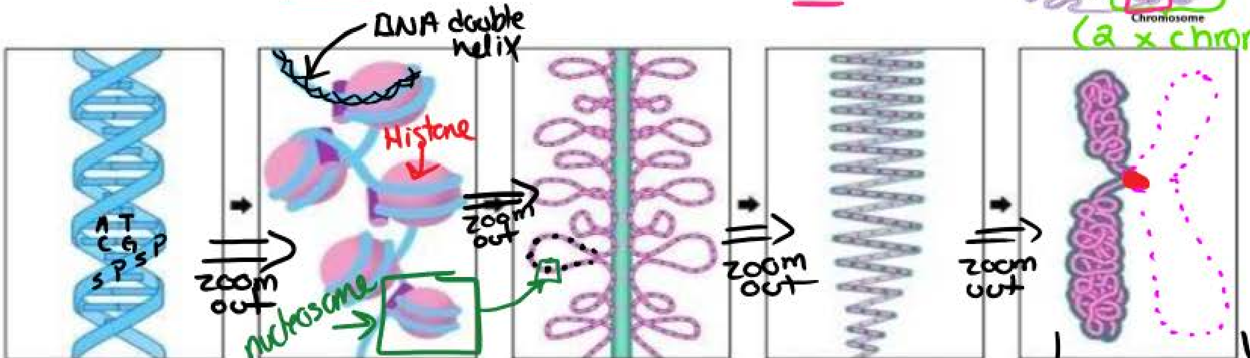
Image of Human Chromosomes
- image of chromosomes taken during cell division under very high power microscope



nucleus



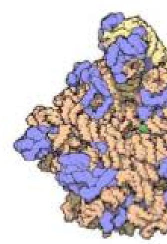
- [ ] In order to form chromosomes, DNA must be densely packed
  1. DNA double helix is wound around special proteins (Histones) => "nucleosome"
  2. This is then looped onto a protein 'scaffold' (chromatin)
  3. This is then twisted into a coil (condensed chromatin)
  4. This is then looped and packed into a chromatid



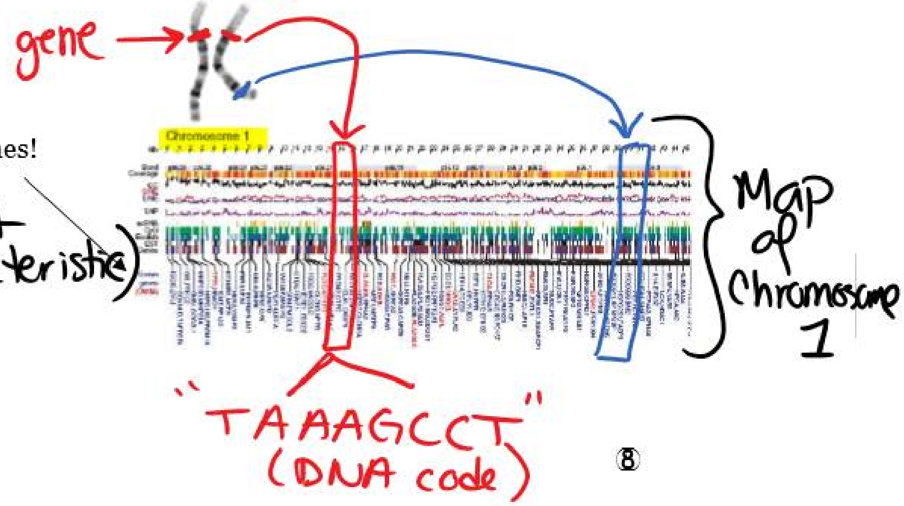
① Longest DNA double Helix	② DNA wraps around histone proteins to form a "Nucleosome"	③ Nucleosomes Loop onto a scaffold... to further condense.	④ DNA will twist into Rod shaped "chromatid"	⑤ 2 chromatid form a Chromosome

Genes

- [ ] Living cells contain thousands of complex molecules called proteins (the instructions to make), which perform all the important jobs inside the cell
- [ ] DNA "sequences" (makes) of hundreds to thousands of base pairs that contain the 'instructions' for making a protein are called genes



These are all genes!



DNA (genes) → Proteins → Trait (characteristic)

gene: ATGCATTCC

codon → amino acid; a.a; a.a

8

☐ Human DNA contains about ~27,000 genes spread across the 23 chromosomes

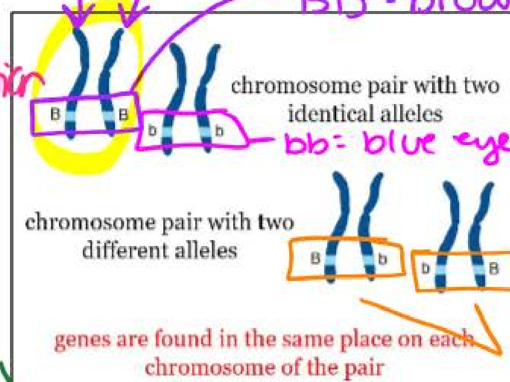
Number of Genes in Organisms	
Carsonella ruddii (bacterium)	180
Streptococcus pneumoniae (bacterium)	2,300
Escherichia coli (bacterium)	4,400
Saccharomyces cerevisiae (yeast)	5,800
Drosophila melanogaster (fruit fly)	13,700
Caenorhabditis elegans (nematode)	19,000
Strongylocentrotus purpuratus (urchin)	23,300
Homo sapiens (human)	27,000
Mus musculus (mouse)	29,000
Oryza sativa (rice)	50,000

number of gene ≠ complex organism

☐ Every chromosomes has the same genes in the same position as its partner, but the genes on each chromosome can have a slightly different base sequences

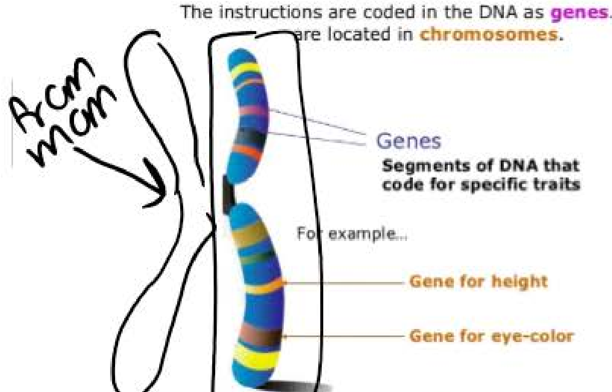
"code" A-T-C-G....

☐ Different versions of the same gene are called Alleles: because their sequences are different, they create phenotypes (what it Looks Like)



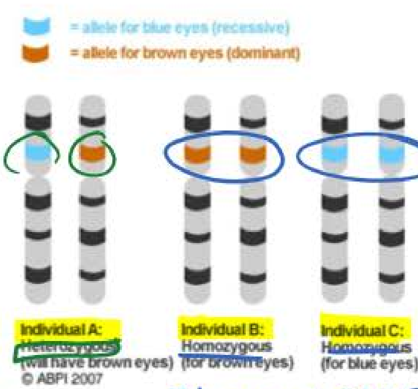
GENETICS

The instructions are coded in the DNA as **genes**. Genes are located in **chromosomes**.



This is not an accurate example. It's just used to illustrate a point

chromatid (from dad)



Gene: Place on chromosome and determines certain trait

Allele: variation of that trait

Ex:

Gene: Eye color
Located on 5th gene from the top
Alleles: Brown, Blue, Green, Gray

Homozygous = 2 copies of the same allele eg. BB or bb

Heterozygous = 1 copy of each allele eg. Bb a llele that can't form pigment

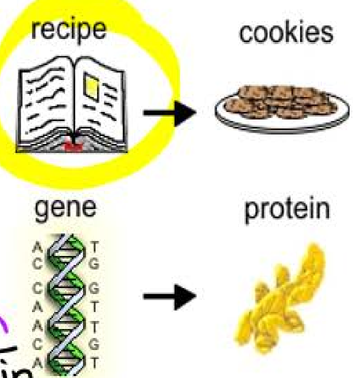
allele that CAN form pigment

Different eye colour alleles in *Drosophila*

3 alleles for eye colour

Alleles are different versions of the same gene: gene TYR has an allele which creates a protein that cannot form pigment

(nucleus)
DNA code → protein → trait / characteristic

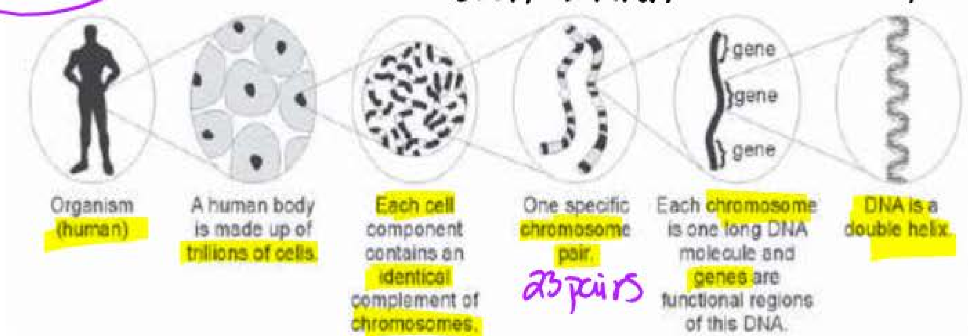


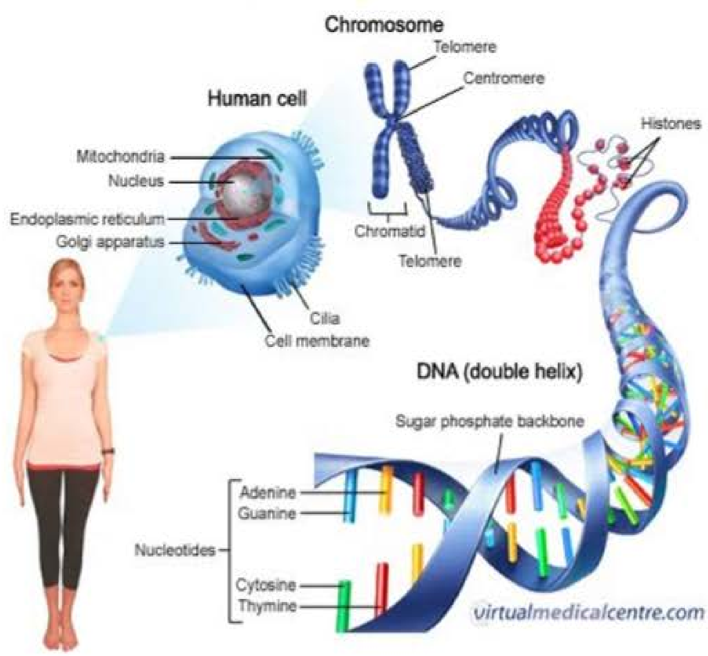
DNA Function & Replication

- ☐ Genes are 'read' inside the nucleus, but proteins are built in the cell outside the nucleus in the cell itself
- ☐ This cannot occur while DNA is packed tightly into chromosomes, so normally the DNA is unwound for reading

→ Transcription (DNA → RNA) + Translation (RNA → protein)

Heirarchy:





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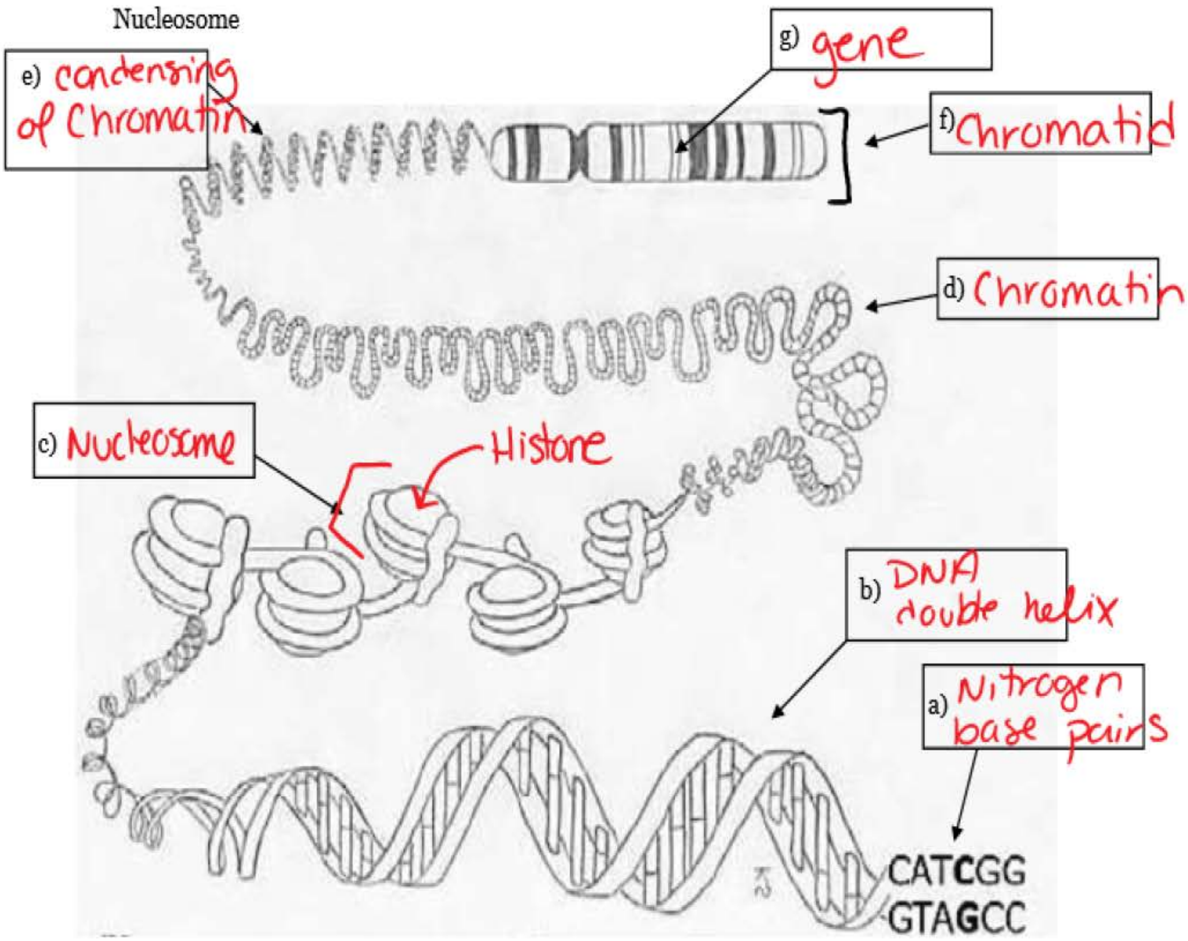
Homework

Assignment #2: Complete the following worksheet in the space provided below

1. Write what each arrow is pointing at in the diagram below. Choose from the following: Condensing of Chromatin; Nitrogen Base Pairs; Chromosome; Chromatin; Gene; Double Helix DNA; Nucleosome



2. Where in the human cell is DNA stored?

Nucleus

3. Organize the following terms based on size, from smallest to largest: *chromatin, nucleus, chromosome, cell, nucleotide, nitrogen containing bases, DNA double helix.*

Smallest ⟶ Largest

nitrogen bases < DNA double helix < Nucleotide < Chromatin < Chromosome < Nucleus < Cell

4. a) How many chromosomes does each human cell have? 46 chromosomes

   b) How many identical pair(s)? 22 identical pairs (#1-22)

   c) How many different pair(s)? 1 different pair (#23 sex chromosomes)

5. An analogy relates one thing to a completely unrelated thing. Identify a genetics term that could be an analogy for each of the following:

a) Letter – base pairs

b) Word – portion the DNA sequence that codes for a protein

c) Sentence – gene

d) Chapter – chromosome

e) Book – all the genes in the body (genome)

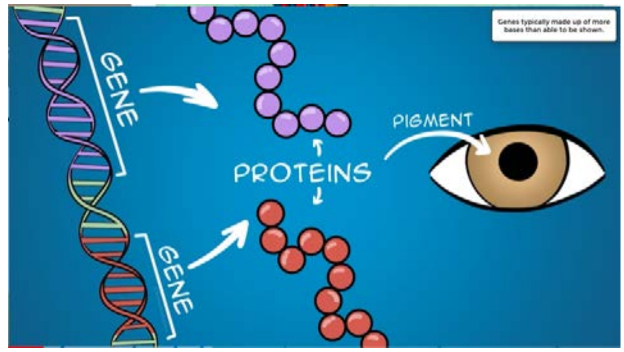
ANSWERS:

1. a) Nitrogen Base Pairs
   b) DNA Double Helix
   c) Nucleosomes
   d) Chromatin
   e) Condensing of Chromatin
   f) Gene
2. Nucleus
3. Nitrogen Containing Bases, DNA Double Helix, Nucelotide, Chromatin, Chromosome, Nucleus, Cell
4. a) 46 chromosomes
   b) 22 identical pairs
   c) 1 different pair
5. a) Base Pairs
   b) Portion of sequence of DNA that codes for a protein
   c) Gene
   d) Chromosome
   e) All the genes in the body (this is called the genome

Protein Synthesis

PART C - HOW DOES DNA ACTUALLY RESULT IN A TRAIT? ...PROTEIN SYNTHESIS

Let's take the trait for eye colour, for example. Yes, DNA has the genetic information that codes for the color of your eyes. But how? Eye colors is based on the pigment that is found inside the eye. In order to have that pigment, your genes (sections of DNA) must code for specific proteins which help to make that pigment that gives your eye colour.



SO WHATS SO GREAT ABOUT PROTEINS?

Proteins are involved in nearly every bodily process. They are involved in t<u>ransport</u>, in s<u>tructure</u>, they act as e<u>nzymes</u> in cellar and chemical reactions, they make all kinds of m<u>aterials</u>, they are involved in p<u>rotecting</u> the body...and much, MUCH MORE! Your body **must** make proteins. Proteins are <u>essential to live</u>.

PROTEIN SYNTHESIS:

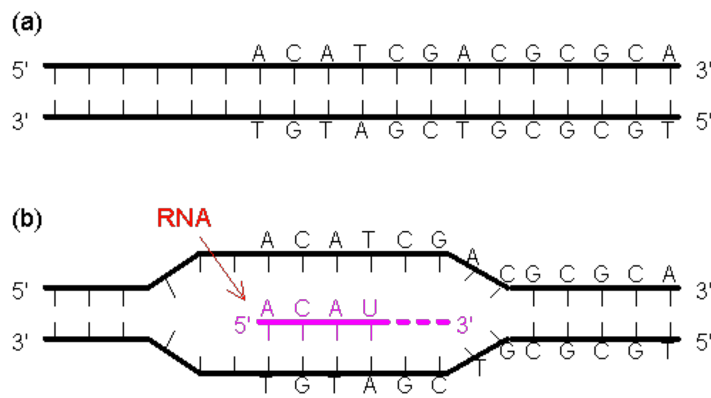
Protein synthesis is the process in which cells make proteins.
It occurs in two stages: transcription and translation.

1. ***Transcription*** occurs in the <u>nucleus</u> and is the transfer of genetic instructions in <u>DNA→mRNA</u>
2. ***Translation*** occurs at the <u>ribosome</u>, where the instructions in mRNA are read and a chain of <u>amino acids</u> is made.

1. **Transcription:**

As you can see in the diagram to the right, to begin the process of protein synthesis, the DNA must first be <u>opened</u> and an <u>RNA</u> molecule must be made.

RNA is different from DNA in a couple ways. It's made of the sugar <u>ribose</u> rather than deoxyribose, it uses <u>"U"=uracil</u> instead of <u>"T"=thymine</u>, and most importantly, it **CAN** leave the nucleus.



<u>messenger</u> RNA (mRNA) is made by matching complimentary <u>nucleotides</u> to their partners.

Practice determining the mRNA sequence from the original DNA sequence.
Hint: When you would have put a T, put a U now.

DNA	A	T	G	T	T	C	A	G	A
mRNA	U	A	C	A	A	G	U	C	U

DNA	T	A	G	G	A	T	C	C	G
mRNA	A	U	C	C	U	A	G	G	C

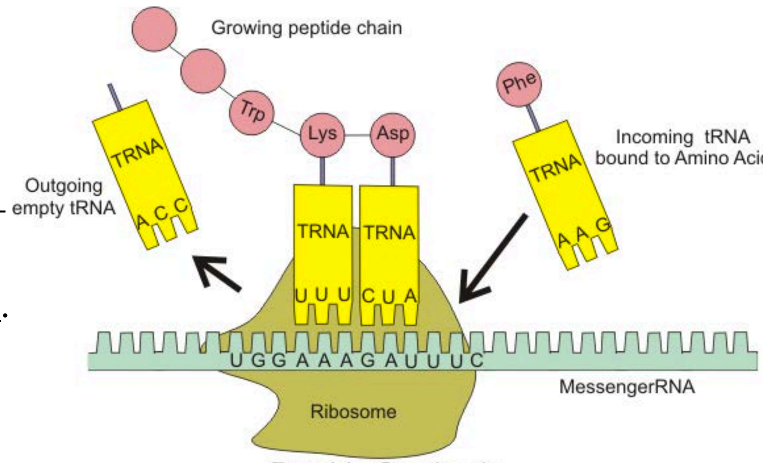
2. Translation

After it is created, the mRNA will leave the nucleus and travel to a ribosome.

Inside the ribosome the mRNA is matched in 3 letter segments with complementary transfer RNA or (tRNA).

These three letter segments are called codons.

Each codon codes for a specific amino acid, which will be bonded to the tRNA and added to the peptide chain as it is matched to the complementary mRNA codon.



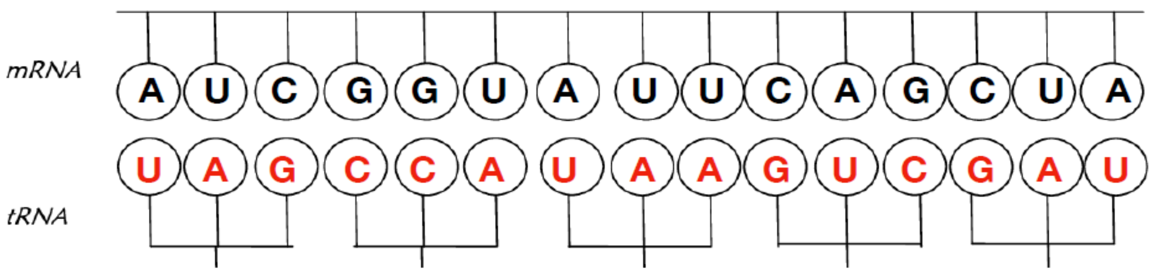
Peptide Synthesis

peptide = small chain of a.a.

many peptides = protein (large)

PRACTICE

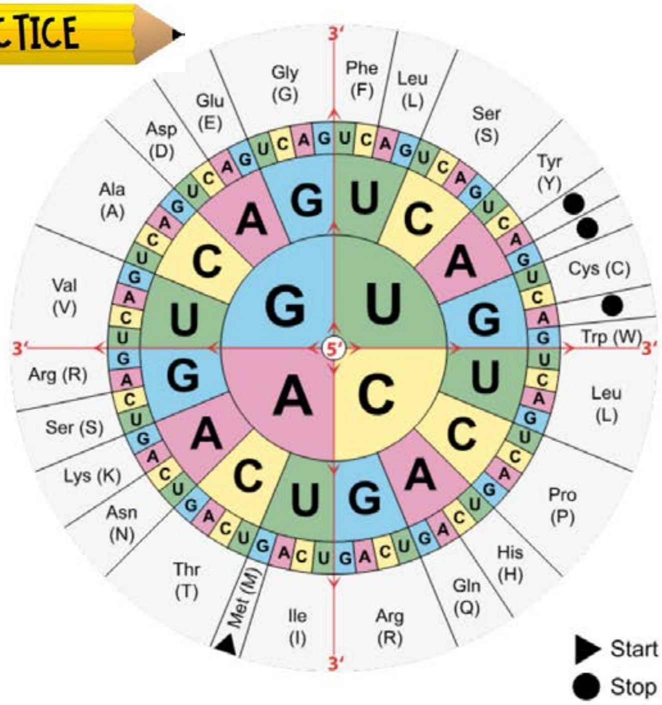
Practice matching mRNA with the complementary tRNA strand. *Again, remember that any where you would have had a T, you will again have a U.*



In order to determine which amino acid will be added to the growing peptide chain, we look at the codon, or three letter code, in the mRNA, NOT the tRNA. Consider the tRNA as just the vehicle which transports the amino acid to it's place. ***The mRNA is the keeper of the actual message.***

Use the table by matching the codon *starting from the center* and following the letters towards the outside.

PRACTICE



Practice determining which amino acid will be added based on each codon.

mRNA Codon	Amino Acid
AUG	MET
GUA	VAL
UAC	TYR
CAU	HIS
UUA	LEU
GGC	GLY
UAG	TER
UGA	TER
CCC	PRO
CAG	GLN
AAC	ASN

Assignment #3: Complete the following worksheet in the space provided below

Finally, you should be able to transcribe and translate a molecule of DNA from start to finish. Helpful hints to remember:

- Only DNA has thymine (T), from there, all T's should be replaced with U's (uracil)
- The amino acid is determined using the codon in the mRNA, not the tRNA. Make sure you're looking at the right row!
- You can't determine amino acids without the help of a decoder like the one on the previous page. Flip back!

DNA	G	T	A	A	T	A	C	G	A	T	C	G	A	A	C
mRNA	C	A	U	U	A	U	G	C	U	A	G	C	U	U	G
tRNA	G	U	A	A	U	A	C	G	A	U	C	G	A	A	C
Amino Acids	HIS			TYR			ALA			SER			LEU		

DNA	C	A	G	T	A	C	C	G	T	A	C	G	T	A	T
mRNA	G	T	C	A	U	G	G	C	A	U	G	C	A	U	A
tRNA	C	A	G	U	A	C	C	G	U	A	C	G	U	A	U
Amino Acids	VAL			LEU			ALA			CYS			ILE		

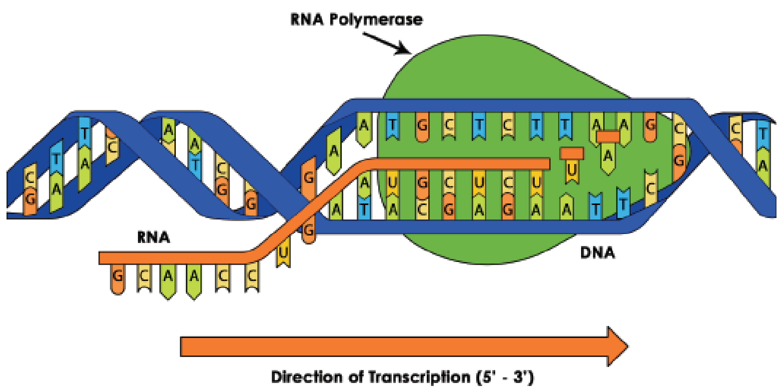
DNA	TAC	ACT*	AAC*	CGG*	TTT*	GCC*	TAA*	GTT*	CCC*	CTT*
mRNA	AUG	UGA*	UUG*	GCC*	AAA*	CGG*	AUU*	CAA*	GGG*	GAA*
tRNA	UAC	ACU*	AAC*	CGG*	UUU*	GCC*	UAA*	GUU*	CCC*	CUU*
Amino Acid	Met	Ter	Leu	Ala	Lys	Arg	Ile	Gln	Gly	Glu

* = multiple possible answers

DNA	ATG	TTA	AGC	CAC*	CAT	CCT	ACA*	TTT	TAC	GAC
mRNA	UAC	AAU	UCG	GUG*	GTA	GGA	UGU*	AAA	AUG	CTG
tRNA	AUG	UUA	AGC	CAC*	CAU	CCU	ACA*	UUU	UAC	GAC
Amino Acid	TYR	ASN	SER	Val	VAL	GLY	Cys	LYS	MET	LEU

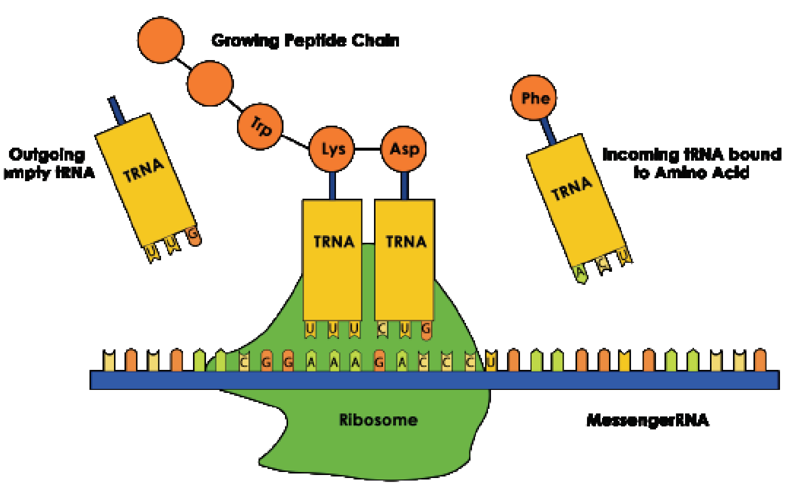
Describe the process of ***transcription***

In transcription, DNA is partially uncoiled so that complimentary nucleotides can be matched, forming a strand of Messenger RNA. mRNA differs from DNA in that it is able to leave the nucleus as well as thymine will now be replaced by uracil.



Describe the process of ***translation***

Translation is the process in which the mRNA is decoded to form a peptide chain in the ribosome. Every 3 nucleotides in the mRNA is known as a codon, and matches with a complimentary segment of Transfer RNA. tRNA has the job of bringing the correct amino acid to add to the growing chain which will eventually become a protein.



Peptide Synthesis

PART D - MENDEL AND THE DISCOVERY OF INHERITANCE

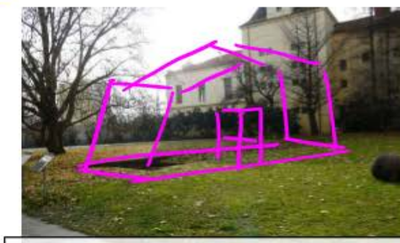
https://www.teachertube.com/videos/113499 

PART C - MENDEL AND TEH DISCOVERY OF INHERITANCE

The Life of Gregor Mendel

- ☐ Gregor Johann Mendel was born in __1822__ in what is now the Czech Republic
- ☐ As the son of a poor farming family, he joined the Catholic Church and became a friar in the Augustinian Monastery in Brno
- ☐ Mendel experimented between 1856 and 1863 with __edible pea plants__ grown in the monastery's garden
- ☐ He grew around __~28,000 plant__, focusing on the seven traits, such as flower colour, seed colour, and seed shape (see diagram below).

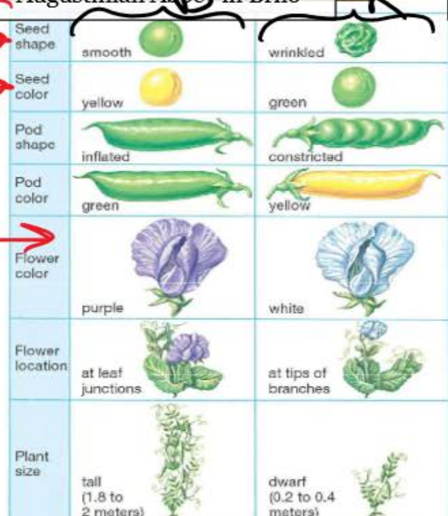
Augustinian Abbey in Brno



Foundation of Mendel's greenhouse

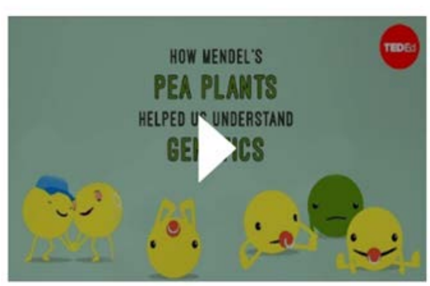
video

Traits Mendel studied



2 versions (Alleles) for each gene.
1 is dominant, the other recessive

How Mendel's pea plants helped us understand genetics - Hortensia Jiménez Díaz



An Example of a Mendel Experiment:

- ☐ Mendel began with peas that had the following characteristics:

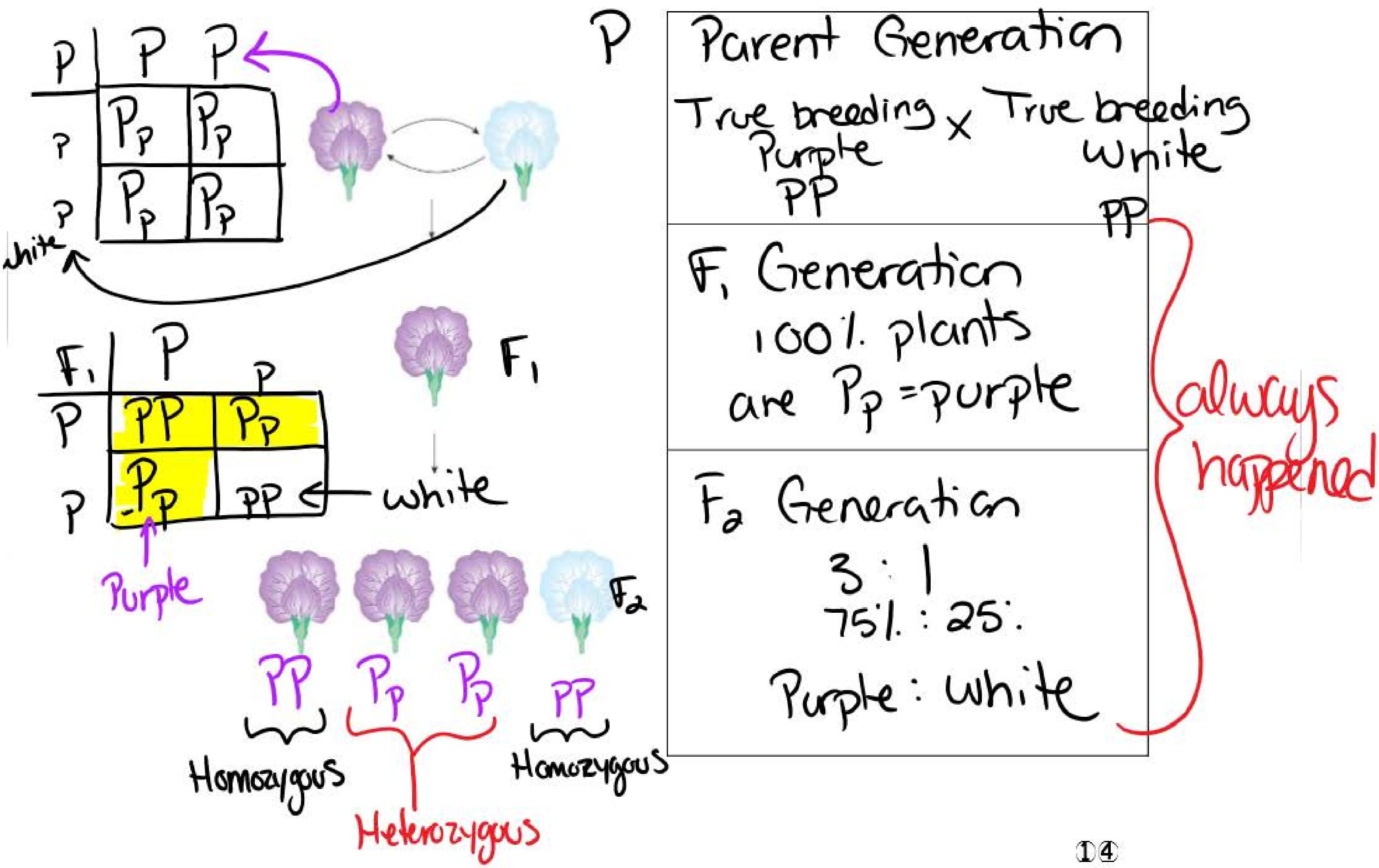
P-generation (Parent)

1. True-breeding (the peas always passed down certain visible traits to its offspring) eg. always yellow seeds.
2. The offspring always resembled the parents
3. Plants that grew purple flowers or white flowers

F_1 (offspring)

- ☐ He bred together one plant of each colour to make a first generation (F_1): every offspring plant had purple flowers identical to their purple parents
- ☐ He then bred these F1 offspring with themselves to make a second generation (F_2): he counted 705 plants with purple flowers, and 224 plants with white flowers identical to the original white parents (a ratio of 3:1, purple : white)

$F_1 \times F_1 \rightarrow F_2$



Mendel's Conclusions

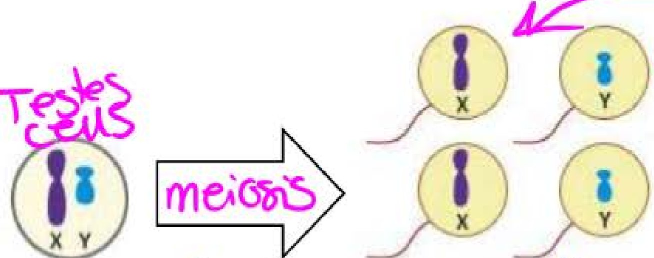
- ☐ Mendel realized that he had discovered the rules that controlled inheritance: the passing on of characteristics from parents to offspring
- ☐ He proposed that "hereditary units/factors" were responsible for the traits of organisms, and that there were different versions of these factors.
- ☐ We now know these 'factors' are genes, and their different versions are alleles
- ☐ Mendel's research was ignored during his lifetime, but his work was rediscovered around 1900 and his discoveries were summarized into two 'Laws':

Law 1: Every organism has 2 alleles for each gene (because they are on two paired chromosomes). These separate during the formation of gametes (sex cells) (eggs or sperm) so that each gamete randomly receives just 1 allele.

During fertilization, from each parent combines to form a new pair. egg(23) + sperm(23) = 46 (you)

"**This is called the Principle of** Segregation" (LAW)

Example: Testes cells go through meiosis, producing 4 sperm cells with one chromosome from each chromosome pair.



Law 2: "Independant Assortment"

certain alleles dominate the expression over others. This causes the organism to have the dominat trait even if it has both alleles

- ☐ **Dominant** = when one allele _overrides_ the expression of another allele, such as the _purple flower_ allele; often given a _capital_ letter, e.g. X^R or W
- ☐ **Recessive** = when one allele is _hidden_ by the expression of another (dominant) allele, such as the _white flower_ allele; often given a _lower case_ letter, e.g. X^r or w

vs.

Example 1: Having a curved hairline (widow's peak) is a _dominant_ allele, and a straight hairline is a _recessive_ allele. This means that if you inherit one of each allele from your parents, you will have a _widows peak_.

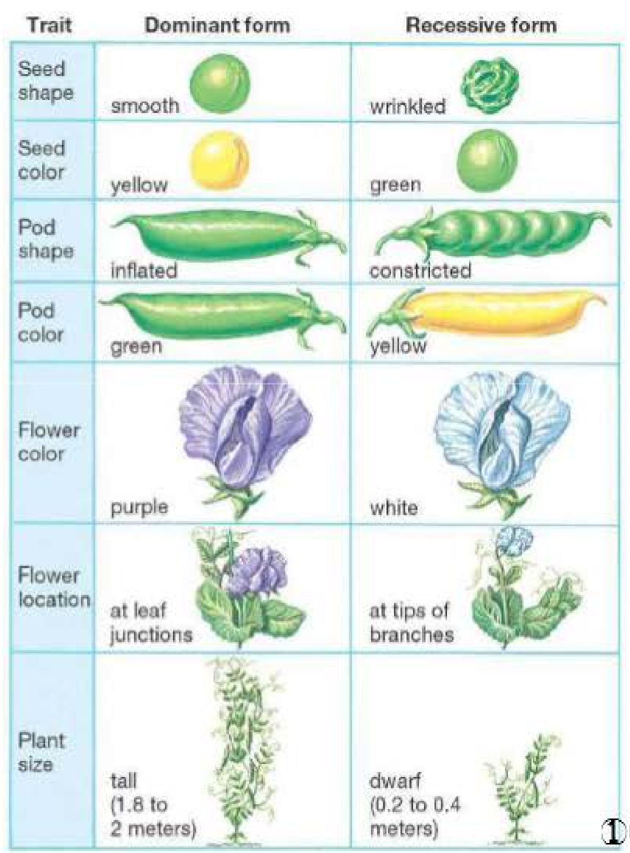
	W	W
w	Ww	Ww
w	Ww	Ww

widows peak.

Example 2: Dominant and recessive traits of human genetic traits.

Hairline	Widow peak _D_ & straight hairline _R_
Eyebrow shape	Separated _D_ & joined _R_
Earlobes	Free lobe _D_ & attached _R_
Freckles	Freckles _D_ & no freckles _R_
Tongue rolling	Roller _D_ & nonroller _R_
Tongue folding	Inability _D_ & ability _R_
Bent little finger	Bent _D_ & straight _R_
Interlaced fingers	Left thumb over right _D_ & right over left _R_

Example 3: Dominant and recessive traits of Mendel's pea plants.



Assignment #4: Complete the following worksheet in the space provided below

ANSWERS:

1 a) C & c
b) no crest & crest
2. C is dominant. When the pigeon has one C allele and one c allele, it has no crest. This is the trait associated with the C allele.
3. a) S & N
b) Full Slippers (allele combination SS)
Partial Slippers (allele combination SN)
No Slippers (allele combination NN)
4. The crest gene was either crest of no crest. When the pigeon had one of each allele, C dominated and the pigeon had no crest. The slippers gene has three possible traits. When the pigeon has one of each allele, it has "partial slippers". It doesn't appear as though one allele is dominating over the other, like in the crest gene.
5.

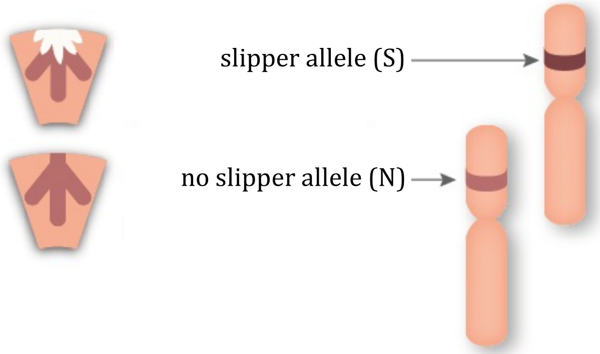
	F_2		
Trait	**Dominant**	**Recessive**	**Ratio** (to two decimal places) **Dominant : Recessive**
Seed form	5474	1850	2.96 : 1
Seed color	6022	2001	3.01 : 1
Flower position	651	207	3.14 : 1
Flower color	705	224	3.15 : 1
Pod form	882	299	2.95 : 1
Pod color	428	152	2.82 : 1
Stem length	787	277	2.84 : 1

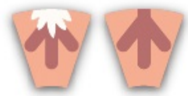
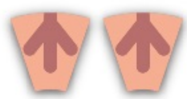
6.

a.	Chromatin	Tightly wrapped nucleosomes. The purpose of it is to package DNA into a more compact shape, prevent DNA damage, and to control gene expression.
b.	Chromosome	Separate strands of DNA found inside the nucleus of the cell, packed into dense structures during cell division. Humans have 23 pairs of chromosomes, all of which are identical except for the sex chromosomes (which are XY in males). The same gene is found in the same position on each chromosome of the pair, but they may be different alleles.
c.	Complementary Base Pairing	The nitrogen-containing bases (guanine, cytosine, adenine, thymine) found in DNA always pair in a specific way: guanine always pairs with cytosine and adenine always pairs with thymine.
d.	DNA	The hereditary molecule which stores the information for making proteins as a series of genes.
e.	Dominant	An allele of a gene whose phenotype overwrites the expression of a recessive allele.
f.	F1	First generation of offspring
g.	F2	Second generation of offspring, from crossing two F1 offspring.
h.	Gene	A region of DNA which contains the instructions for building a specific protein. Genes are found on chromosome
i.	Mendelian Genetics	A form of inheritance described by Gregor Mendel in which the genes show complete dominance.
j.	Nucelosome	DNA wound around special proteins/
k.	Nucleus	The part of the cell that contains the genetic information (in the form of chromosomes), except during cell division.
l.	Principle of Segregation	Allele pairs separate during gamete formation, and randomly unite at fertilization.
m.	Protein	A complex, three-dimensional molecule whose shape allows it to perform a specific function within living cells. Genes provide the instructions for the assembly of specific proteins.
n.	Recessive	An allele of a gene whose phenotype is concealed by the presence of a dominant allele.

Section 2 – The *slipper* Gene

There are two alleles for the *slipper* gene which creates a slipper of feathers on the feet:



Alleles	Traits
 SS	 full slipper
 SN	 partial slipper
 NN	 no slipper

3. Consider the information in above.
   a. What are the different alleles for slippers in pigeons?

   b. What are the different traits for slippers found in pigeons? What combination of alleles results in each of these traits?

4. What is different about the traits of the *slipper* gene, compared to the traits of *crest* gene?

Part 2 – Mendel's Experimental Results

5. Mendel crossed one pea plant with each trait together (to form the F1 generation). In every case, he found that the F1 generation all showed the same trait as ONE of their parents (the dominant trait). He then self-fertilized the F1 plants (crossed two F1 plants together), and found different results. These results are shown in the table below. Calculate the ratio (to two decimal places) of the dominant to recessive traits.

Table 1: A Summary of Mendel's Results.

	F_2		
Trait	**Dominant**	**Recessive**	**Ratio** (to two decimal places) **Dominant : Recessive**
Seed form	5474	1850	
Seed color	6022	2001	
Flower position	651	207	
Flower color	705	224	
Pod form	882	299	
Pod color	428	152	
Stem length	787	277	

REMINDER: To find ratio, divide BOTH numbers by the smaller one.

Part 3 – Definitions

6. Define the following vocabulary terms using complete sentences. Make sure to be detailed.

a. Allele	
b. Chromatin	
c. Chromosome	
d. Complementary Base Pairing	
e. DNA	
f. Dominant	
g. F1	
h. F2	
i. Gene	
j. Mendelian Genetics	
k. Nucelosome	
l. Nucleus	
m. Principle of Segregation	
n. Protein	
o. Recessive	

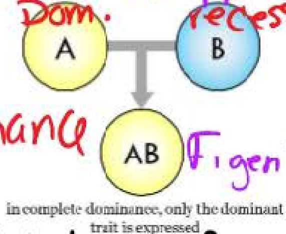
PART E - UNDERSTANDING INHERITANCE

2 Laws: Segregation + Independant Assortment

Mendel's Inheritance

- ☐ The system of inheritance described by Mendel is now known as Mendelian Inheritance in his honour
- ☐ In peas, he had discovered several genes where the dominant allele covers completely the expression of the recessive allele. This is called complete dominance
- ☐ All of Mendel's pea plants showed complete dominance

P.: PP × pp
Dom. recess.



F_1 gen = Pp

in complete dominance, only the dominant trait is expressed

	P	P
p	Pp	Pp
p	Pp	Pp

100% ⇒ F_1 gen all heterozygous genotype. Purple phenotype.

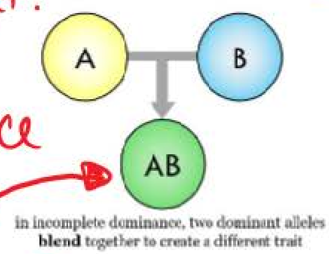
["Non-Mendellian" Inheritance]

Incomplete Dominance

is no dominat.

- ☐ When neither allele completely masks the other, and the two alleles combine to create a new trait that is a blend of both alleles, this is called Incomplete dominance

* neither allele is dom./rec.
* both blend ⇒ new phenotype (heterozygous genotype)

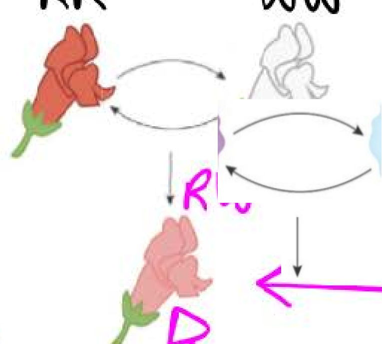


in incomplete dominance, two dominant alleles **blend** together to create a different trait

Example: In snapdragons, the gene for flower color shows incomplete dominance. When red and white-flowered parents are crossed together, the offspring have pink flowers (a blend of the RED and white alleles).

True breeding (homozygous) Pgen.

RR WW



	R	R
W	RW	RW
W	RW	RW

F_1 gen. 100% heterozygous genotype.

appearance of the NEW pink phenotype.

Genetics - Exceptions to Mendelism - Lesson 7 | Don't Memorise

Both / together

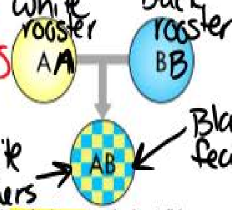
covers recessive / most common phenotype.

"version of the gene"

Co-Dominance

- When neither allele completely dominates, and the two alleles are expressed TOGETHER! at the same time, this is called co-dominance.

Heterozygous offspring (AB) has a phenotype that shows BOTH traits



in co-dominance, two dominant alleles are expressed together at the same time

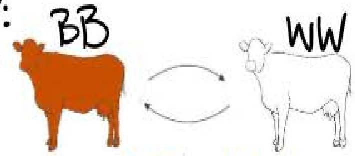
F1

F1	A	B
A	AA	AB
B	AB	BB

F2 gen
1 : 2 : 1
white : speckled : black

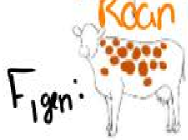
Example: In cattle, a gene for hair color shows co-dominance. When brown and white-haired parents are crossed together, all of the offspring have brown + white hair (they show BOTH brown and white hair).

True breeding P: Homozygous genotype



	B	B
W	BW	BW
W	BW	BW

100% heterozygous genotype



100% expression of both A + B

Sex-Linked Inheritance

not on chromosomes 1-22 ... only #23

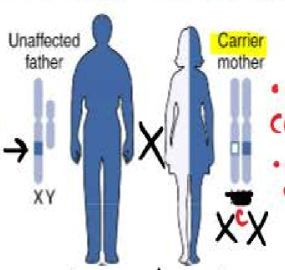
XX = genetic female

XY = genetic male.

- Sometimes the genes (and their alleles) that we are interested in are found on the sex chromosomes, either X or Y in humans
- This leads to a special form of inheritance called sex-linked inheritance, in which the alleles are expressed differently in males (XY) and females (XX)

recessive allele (to be color-blind = need 2 copies)

Example: Red-green colour blindness in humans is caused by an allele of a gene on the X-chromosome. males are much more likely to have this colour blindness because they don't have a "backup" version on their Y chromosomes. For females to be



• NOT color blind
• carries the gene

XY - unaffected male
X^cY - color blind male
XX - unaffected female
X^cX - carrier female
X^cX^c - color-blind female

	X^c	X
X	X^cX	XX
Y	X^cY	XY

outcomes	genotype	Phenotype
25%	X^cX	carrier female
25%	XX	unaffected female
25%	X^cY	color blind male
25%	XY	unaffected male

	X^c	X
X^c	X^cX^c	X^cX
Y	X^cY	XY

much less likely.

affected, BOTH of their X chromosomes must have the-green colour blindness allele.

Predicting Inheritance with Punnett Squares

- ☐ It is possible to predict the alleles inherited by offspring using a technique called a punnett square
- ☐ **STEPS:**
  1. Determine the genetic characteristics of the parents: what alleles do they have for the gene in question?
  2. Separate the alleles in each parent and place one parent's alleles on the top and the other parent's alleles on the side of a 2x2 grid (this is the square)
  3. Fill in the grid by combining the alleles as though they were fertilizing each other to create an offspring

Example: A smooth pea plant (SS) is crossed with a wrinkled pea plant (ss). What is the outcome?

	S	S
s	Ss	Ss
s	Ss	Ss

100% Heterozygous F1 offspring

smooth phenotype

Punnett Square Examples

Example 1: Use Punnett squares to confirm the results of Mendel's experiment on pea plants (remember, his pea plants showed complete dominance):

	P	P
W	PW	PW
W	PW	PW

F1 Generation: one purple (PP - dominant) plant was crossed with one white (WW - recessive) plant.

- ☐ Outcome: 100% of the plants inherited 1 dominant (P) allele and 1 recessive (W), which means that they all show the dominant purple phenotype.

F_2	P	W
P	PP	PW
W	PW	WW

F2 Generation: two of the F1 generation plants (PW) were crossed.

- ☐ Outcome: 25% of the plants inherited 2 dominant alleles (PP), 50% of the plants inherited 1 of each allele (PW), and 25% of the plants inherited 2 recessive alleles (WW). This means that:
  phenotype: purple: 75% (PP) (PW)
  white: 25% (WW)

Example 2: In snapdragons, the gene for flower colour shows incomplete dominance. If you cross a pink and white flowered plant, what is the chance that the offspring are pink?

	R (Pink)	W
W (white)	RW	WW
W	RW	WW

Red: RR
White: WW
Pink: RW

Pink means it inherited 1 copy of each allele.

outcome	genotype	Phenotype
50%	RW	pink
50%	WW	white.

Example 3: Red-green color blindness (b) is a recessive allele on the X chromosome. A colorblind male marries a normal female, will any of their children be colour blind?

	X^b	Y
X	X^bX	XY
X	X^bX	XY

colorblind male = X^bY
"normal" female = XX

outcome	genotype	phenotype
50%	X^bX	"carrier" female
50%	XY	"normal" male

Assignment #5: Complete the following worksheet in the space provided below

ANSWERS:
1. The chance that the offspring will inherit two dominant alleles from this cross is 50% or 2/4.
2. The probability of children who can roll their tongues, from two parents that cannot roll their tongues, is 0% or 0/4.
3. The chance that they would have an erminette chick is 100% or 4/4.
4. The percentage of offspring with white flowers is 25% or 1/4.
5. The chance that the offspring will have short tails is 50% or 2/4.
6. The percentage of kittens that will have black hair is 25% or 1/4.
7. The probability of male children with hemophilia is 25% or 1/4. The probability of female children with hemophilia is 0% or 0/4.

1. In peas, the allele for yellow pea colour (Y) is completely dominant over green peas (y). If you crossed a true-breeding yellow pea plant (YY) with a hybrid yellow pea plant (Yy), what is the chance that the offspring will inherit two dominant alleles?

2. Some people can roll their tongues into a U-shape. The ability to do so is a dominant allele. If a father and mother cannot roll their tongues, what is the probability that their children will be able to form a U-shape with their tongues?

3. In some chickens, the gene for feather colour has two co-dominant alleles: an allele for black feathers (B) and an allele for white feathers (W). Hybrids with both alleles (BW) have a mix of black and white feathers known as erminette. If a black chicken is crossed with a white chicken, what is the chance that they would have an erminette chick?

4. In Japanese four o'clock plants, red flower color (R) is incompletely dominant over white flowers (r), and the combination (Rr) results in plants with pink flowers. If you crossed a pink flowered plant with itself, what percentage of the offspring would have white flowers?

5. In some cats the gene for tail length shows incomplete dominance. True-breeding cats can have long tails or no tails, and cats with one long tail allele and one no-tail allele have short tails. If you crossed a long tail cat and a short tail cat, what is the chance that the offspring will have short tails?

6. In cats, the gene for hair colour has a black allele (B) and a yellow allele (b) that shows co-dominance, combining to create black and yellow spots called tortoiseshell. This gene is found on the X chromosome. If you cross a tortoiseshell female with a yellow male, what percentage of the kittens will have black hair?

7. In humans, the blood-clotting disease hemophilia is a recessive allele found on the X chromosome. The normal allele creates a protein that forms blood clots after an injury. If a female who is a carrier for hemophilia – she has both alleles – has children with a male with normal blood-clotting, what is the probability of male children with hemophilia, and female children with hemophilia?

Assignment #6: Bikini Bottom Genetics Activity *(quiz prep)*

Scientists at Bikini Bottoms have been investigating the genetic makeup of the organisms in this community. Use the information provided and your knowledge of genetics to answer each question.

1. For each genotype below, indicate whether it is a heterozygous (He) OR homozygous (Ho).

TT _____ Bb _____ DD _____ Ff _____ tt _____ dd _____

Dd _____ ff _____ Tt _____ bb _____ BB _____ FF _____

Which of the genotypes in #1 would be considered purebred? ________________________________

Which of the genotypes in #1 would be hybrids? ____

2. Determine the phenotype for each genotype using the information provided about SpongeBob.

Yellow body color is dominant to blue.

YY ________________ Yy ________________ yy ________________

Square shape is dominant to round.

SS ________________ Ss ________________ ss ________________

3. For each phenotype, give the genotypes that are possible for Patrick.

A tall head (T) is dominant to short (t).

Tall = _______________ Short = _______________

Pink body color (P) is dominant to yellow (p).

Pink body = _____________ Yellow body = _________________

4. SpongeBob SquarePants recently met SpongeSusie Roundpants at a dance. SpongeBob is heterozygous for his square shape, but SpongeSusie is round. Create a Punnett square to show the possibilities that would result if SpongeBob and SpongeSusie had children. HINT: Read question #2!

A. List the possible genotypes and phenotypes for their children.

B. What are the chances of a child with a square shape? ____ out of ____ or ____%

C. What are the chances of a child with a round shape? ____ out of ____ or ____%

5. Patrick met Patti at the dance. Both of them are heterozygous for their pink body color, which is dominant over a yellow body color. Create a Punnett square to show the possibilities that would result if Patrick and Patti had children. HINT: Read question #3!

A. List the possible genotypes and phenotypes for their children.

B. What are the chances of a child with a pink body? ____ out of ____ or ____%

C. What are the chances of a child with a yellow body? ____ out of ____ or ____%

6. Everyone in Squidward's family has light blue skin, which is the dominant trait for body color in his hometown of Squid Valley. His family brags that they are a "purebred" line. He recently married a nice girl who has light green skin, which is a recessive trait. Create a Punnett square to show the possibilities that would result if Squidward and his new bride had children. Use B to represent the dominant gene and b to represent the recessive gene.

A. List the possible genotypes and phenotypes for their children.

B. What are the chances of a child with light blue skin? ____%

C. What are the chances of a child with light green skin? ____%

D. Would Squidward's children still be considered purebreds? Explain!

7. Assume that one of Squidward's sons, who is heterozygous for the light blue body color, married a girl that was also heterozygous. Create a Punnett square to show the possibilities that would result if they had children.

A. List the possible genotypes and phenotypes for their children.

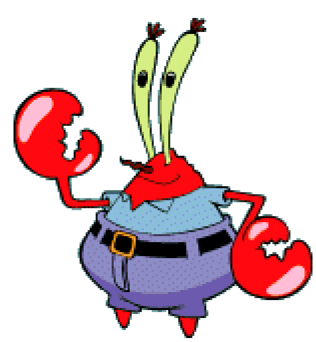
B. What are the chances of a child with light blue skin? ____%

C. What are the chances of a child with light green skin? ____%

8. Mr. Krabbs and his wife recently had a Lil' Krabby, but it has not been a happy occasion for them. Mrs. Krabbs has been upset since she first saw her new baby who had short eyeballs. She claims that the hospital goofed and mixed up her baby with someone else's baby. Mr. Krabbs is homozygous for his tall eyeballs, while his wife is heterozygous for her tall eyeballs. Some members of her family have short eyes, which is the recessive trait. Create a Punnett square using T for the dominant gene and t for the recessive one.

A. List the possible genotypes and phenotypes for their children.

B. Did the hospital make a mistake? Explain your answer.



Bikini Bottom Genetics 2 Name ___________________________

Use your knowledge of genetics to complete this worksheet.

1. Use the information for SpongeBob's traits to write the phenotype (physical appearance) for each item.

Trait	Dominant Gene	Recessive Gene
Body Shape	Squarepants (S)	Roundpants (s)
Body Color	Yellow (Y)	Blue (y)
Eye Shape	Round (R)	Oval (r)
Nose Style	Long (L)	Stubby (l)

(a) LL-______________ (e) Rr-________________

(b) yy-________________ (f) ll- ________________

(c) Ss-________________ (g) ss- ________________

(d) RR - ______________ (h) Yy -_______________

2. Use the information in the chart in #1 to write the genotype (or genotypes) for each trait below.

(a) Yellow body - ___________ (e) Stubby nose - ___________

(b) Roundpants - ___________ (f) Round eyes - ____________

(c) Oval eyes - ______________ (g) Squarepants - ___________

(d) Long nose - ______________ (h) Blue body - ____________

3. Determine the genotypes for each using the information in the chart in #1.

(a) Heterozygous round eyes -_____ (c) Homozygous long nose - ______

(b) Purebred squarepants - ______ (d) Hybrid yellow body - ______

4. One of SpongeBob's cousins, SpongeBillyBob, recently met a cute squarepants gal, SpongeGerdy, at a local dance and fell in love. Use your knowledge of genetics to answer the questions below.

(a) If SpongeGerdy's father is a heterozygous squarepants and her mother is a roundpants, what is her genotype? Complete the first Punnett square to show the possible genotypes.

Based on your results, what would Gerdy's genotype have to be? _________

(b) Complete the second Punnett square to show the possibilities that would result if Billy Bob & Gerdy had children.
NOTE: SpongeBillyBob is heterozygous for his squarepantsshape.

(c) What is the probability of kids with squarepants? _____ %

(d) What is the probability of kids with roundpants? _____ %

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5. SpongeBob's aunt and uncle, SpongeWilma and SpongeWilbur, have the biggest round eyes in the family. Wilma is believed to be heterozygous for her round eye shape, while Wilbur's family brags that they are a pure line. Complete the Punnett square to show the possibilities that would result if SpongeWilma and SpongeWilbur had children.

(a) Give the genotype for each person. Wilma - _______ Wilbur - ________

(b) Complete the Punnett square to show the possibilities that would result if they had children.

(c) What is the probability that the kids would have round eyes? ____ %

(d) What is the probability that the kids would be oval eyes? ____ %

6. SpongeBob's mother is so proud of her son and his new wife, SpongeSusie, as they are expecting a little sponge. She knows that they have a 50% chance of having a little roundpants, but is also hoping the new arrival will be blue (a recessive trait) like SpongeSusie and many members of her family. If SpongeBob is heterozygous for his yellow body color, what are the chances that the baby sponge will be blue? Use the Punnett square to help you answer this question.

7. SpongeBob's aunt is famous around town for her itty, bitty stubby nose! She recently met a cute squarepants fellow who also has a stubby nose, which is a recessive trait. Would it be possible for them to have a child with a regular long nose? Why or why not? Use the Punnett square to help you answer this question.

8. If SpongeBob's aunt described in #7 wanted children with long noses, what type of fellow would she need to marry in order to give her the best chances? Use the Punnett square to help you answer this question.

Bikini Bottom Genetics
Incomplete Dominance

SpongeBob loves growing flowers for his pal Sandy! Her favorite flowers, Poofkins, are found in red, blue, and purple. Use the information provided and your knowledge of incomplete dominance to complete each section below.

1. Write the correct genotype for each color if R represents a red gene and B represents a blue gene.

Red - _____ Blue - ______ Purple - _____

2. What would happen if SpongeBob crossed a Poofkin with red flowers with a Poofkin with blue flowers. Complete the Punnett square to determine the chances of each flower color.

(a) Give the genotypes and phenotypes for the offspring.

(b) How many of the plants would have red flowers? _____%

(c) How many of the plants would have purple flowers? _____ %

(d) How many of the plants would have blue flowers? _____ %

3. What would happen if SpongeBob crossed two Poofkins with purple flowers? Complete the Punnett square to show the probability for each flower color.

(a) Give the genotypes and phenotypes for the offspring.

(b) How many of the plants would have red flowers? _____%

(c) How many of the plants would have purple flowers? _____ %

(d) How many of the plants would have blue flowers? _____ %

4. What would happen if SpongeBob crossed a Poofkin with purple flowers with a Poofkin with blue flowers? Complete the Punnett square to show the probability for plants with each flower color.

(a) Give the genotypes and phenotypes for the offspring.

(b) If SpongeBob planted 100 seeds from this cross, how many should he expect to have of each color?

Purple flowers - ______ Blue flowers - ______ Red flowers - ______

SpongeBob and his pal Patrick love to go jellyfishing at Jellyfish Fields! The fields are home to a special type of green jellyfish known as Goobers and only really great jellyfishermen are lucky enough to catch some on every trip. Many of the jellyfish are yellow (YY) or blue (BB), but some end up green as a result of incomplete dominance. Use this information to help you complete each section below.

5. What would happen if SpongeBob and Patrick crossed two “goobers” or green jellyfish? Complete the Punnett square to help you determine the probability for each color of jellyfish.

(a) Give the possible genotypes and phenotypes for the offspring.

(b) What percentage of the offspring would be yellow? _____%

(c) What percentage would be blue? _____ %

(d) What percentage would be “goobers” (green)? _____ %

6. What would happen if they crossed a yellow jellyfish with a goober? Complete the Punnett square to help you determine the probability for each color of jellyfish.

(a) Give the possible genotypes and phenotypes for the offspring.

(b) What percentage of the offspring would be yellow? _____%

(c) What percentage would be blue? _____ %

(d) What percentage would be “goobers” (green)? _____ %

7. What would happen if they crossed a blue jellyfish with a yellow jellyfish? Complete the Punnett square to help you answer the questions.

If 100 jellyfish were produced from this cross, how many would you expect for each?

Yellow - _____ Blue - _____ Goobers - ______

8. What would happen if they crossed a blue jellyfish with a goober? Complete the Punnett square to help you answer the questions.

If 100 jellyfish were produced from this cross, how many would you expect for each?

Yellow - _____ Blue - _____ Goobers - ______

Bikini Bottom Genetics ANSWER KEY

November 13, 2018 12:31 PM

Bikini Bottom Genetics

Answer Key

1. Ho He Ho He Ho Ho
He Ho He Ho Ho Ho

Purebreds - TT, DD, BB, FF, ff, dd, bb, tt
Hybrids - Dd, Bb, Ff, Tt

2. Yellow body Yellow body Blue body
Square shape Square shape Round shape

3. Tall - TT or Tt Short - tt
Pink - PP or Pp Yellow – pp

4.

	s	s
S	Ss	Ss
s	ss	ss

A. SS - square shape, Ss - square shape, and ss - round shape
B. 2 out of 4 or 50%
C. 2 out of 4 or 50%

NOTE: Some of your students may feel that the roundpants gene should be the dominant trait as SpongeBob's TV parents are both roundpants. However, these are only his parents on the TV show and his real parents are both heterozygous for squarepants.

5.

	P	p
P	PP	Pp
p	Pp	pp

A. PP - pink body, Pp - pink body, and pp - yellow body
B. 3 out of 4 or 75%
C. 1 out of 4 or 25%

6.

	b	b
B	Bb	Bb
B	Bb	Bb

A. Bb - light blue skin
B. 100%
C. 0%
D. Squidward's children would not be considered purebred, since each would have a gene pair made up of a dominant gene and a recessive gene.

7.

	T	t
T	TT	Tt
T	TT	Tt

A. TT - tall eyeballs or Tt - tall eyeballs
B. The hospital must have made a mistake, since the genotype "tt" would not be possible based on the genotypes of Mr. and Mrs. Krabbs.
NOTE: Students may come up with other possible scenarios, such as Mr. Krabbs not really a homozygous tall-eyed crab or a mutation. A few of my students suggested that Mr. Krabbs might not be the father!

NOTE: Some of your students may comment that Mr. Krabbs was married to a whale. However, this was only for the TV show and he is happily married to a beautiful crab in real life. (Ok, so it's not "real" life!)

Bikini Bottom Genetics 2

Answer Key:

1. A - long nose, B - blue body, C - squarepants, D - round eyes, E - round eyes, F - stubby nose, G - roundpants, h - yellow body

2. A - Yy & YY, B - ss, C - rr, D - LL & Ll, E - ll, F - RR & Rr, G - SS & Ss, H - yy

3. A - Rr, B - SS, C - LL, D - Yy

4A - See square at right, Gerdy's genotype = Ss,
4B - BillyBob's genotype = Ss
4C - SS & Ss = squarepants and ss = roundpants
4D - 75%
4E - 25%

4A	S	s
s	Ss	ss
s	Ss	ss

4C	S	s
S	SS	Ss
s	Ss	ss

5A - Wilma = Rr, Wilbur = RR
5B - See square at right
5C - RR & Rr = round eyes
5D - 100%
5E - 0%

5	R	r
R	RR	Rr
R	RR	Rr

6. The Punnett square shows that they would have a 50% chance (2 out of 4) for a little sponge with a blue body color.

	y	y
Y	Yy	Yy
y	yy	yy

7. Since both people are recessive, the Punnett square shows that they have 0% chance for a child with a long nose.

	l	l
l	ll	ll
l	ll	ll

8. SpongeBob's aunt would have to marry a purebred long nosed man (LL) in order to have the best chances for long-nosed children.

	l	l
L	Ll	Ll
L	Ll	Ll

Bikini Bottom - INCOMPLETE DOMINANCE ANSWER KEY

ANSWER KEY:

1. Red - RR, Blue - BB, Purple - RB

2A. RB - purple
2B. 0%
2C. 100%
2D. 0%

3A. RR - red, BB- blue, RB - purple
3B. 25%
3C. 50%
3D. 25%

4.A. RB - purple, BB - blue
4B. Purple - 50 plants, Blue - 50 plants, Red - 0

5A. YY -yellow, BB - blue, YB - green

5A. YY -yellow, BB - blue, YB - green
5B. 25%
5C. 25%
5D. 50%

6A. YY - yellow, YB - green
6B. 50%
6C. 0%
6D. 50%

7A. YB - green
7B. Yellow - 0, Blue - 0, Goobers - 100

8A. YB - green, BB - blue
8B. Yellow - 0, Blue - 50, Goober - 50