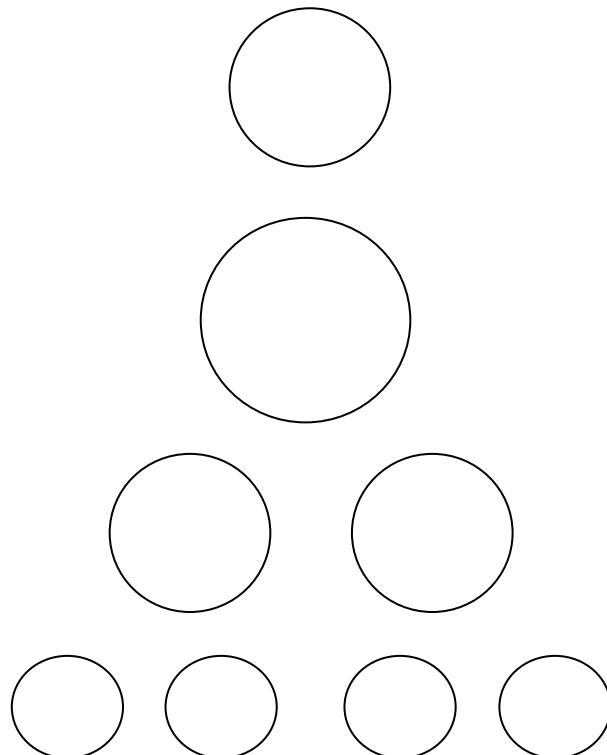
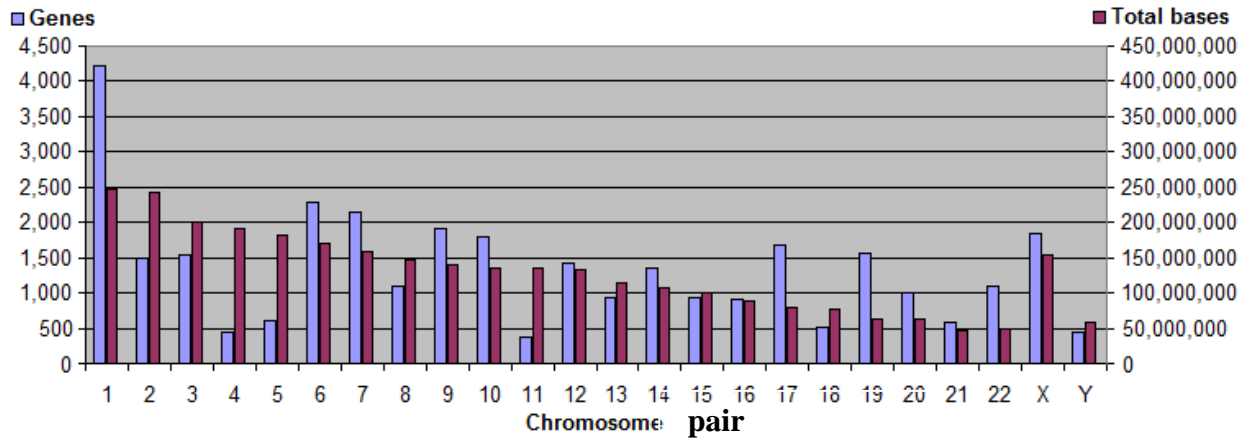


22. Genetics

A- Introduction What you need to know about chromosomes:

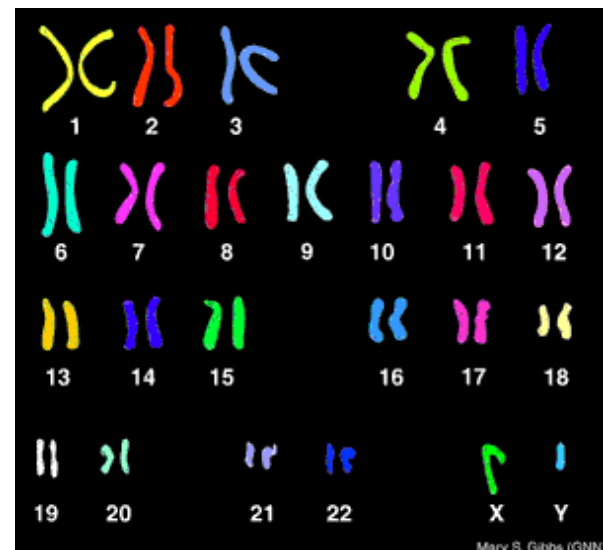
- 1) A **chromosome** is an organized structure of [DNA](#) (hereditary molecule) and [protein](#) that is found in [cells](#).
- 2) In humans, chromosomes come in 23 pairs. So there are 46 chromosomes in all.
- 3) Pairs of chromosomes have similar but not necessarily identical genes. A gene has information to make one type of protein.
- 4) Each sex cell has only one member of each chromosome pair, so a sex cell only has 23 chromosomes in all.



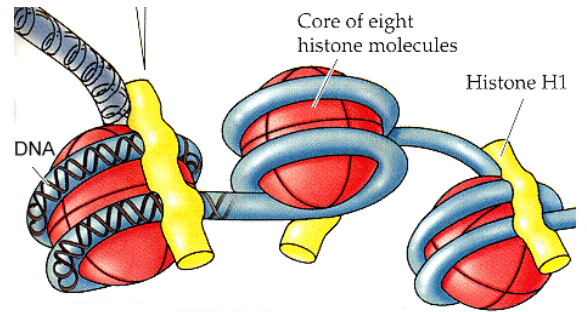
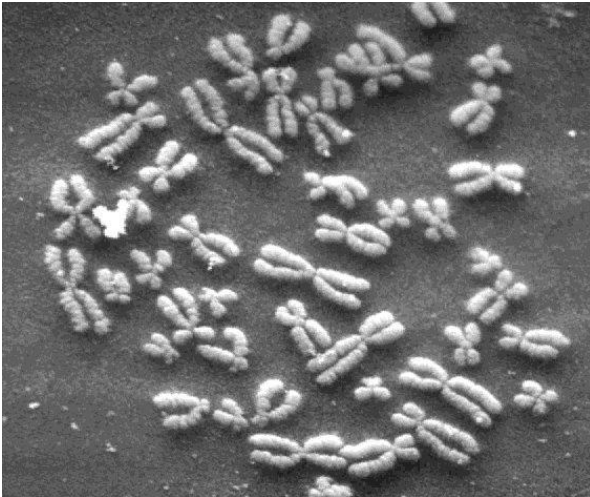
A. Factors Responsible for Biological Character Traits



- a) What are character traits?
- b) What is responsible for those traits?
- c) **Distinguish between the following:**
 - a) Chromatin material:
 - b) Chromosome:
 - c) Chromosome pair:
 - d) DNA:
 - e) Gene:

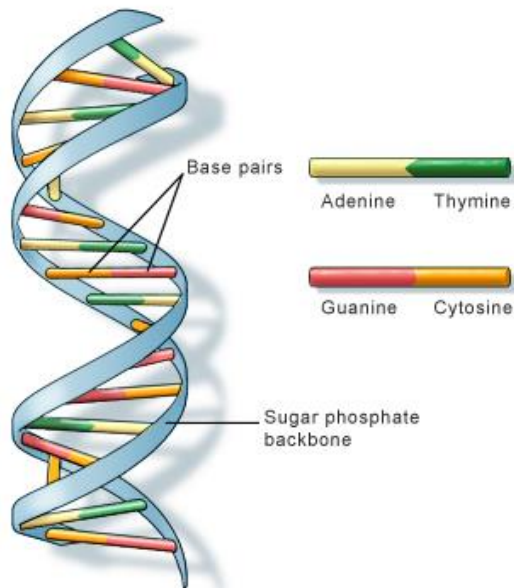
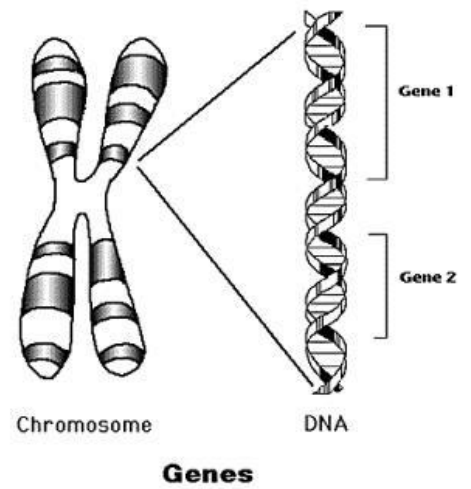


d) How many human genes are there?

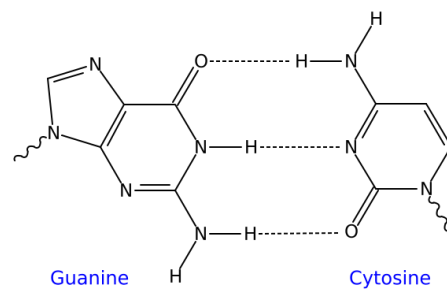
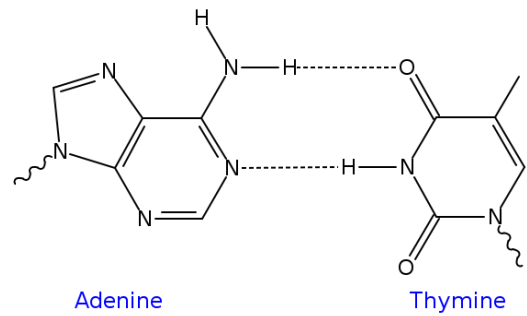


e) DNA

What is DNA?

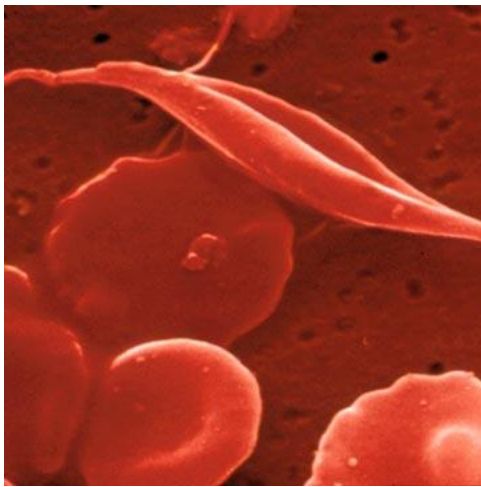
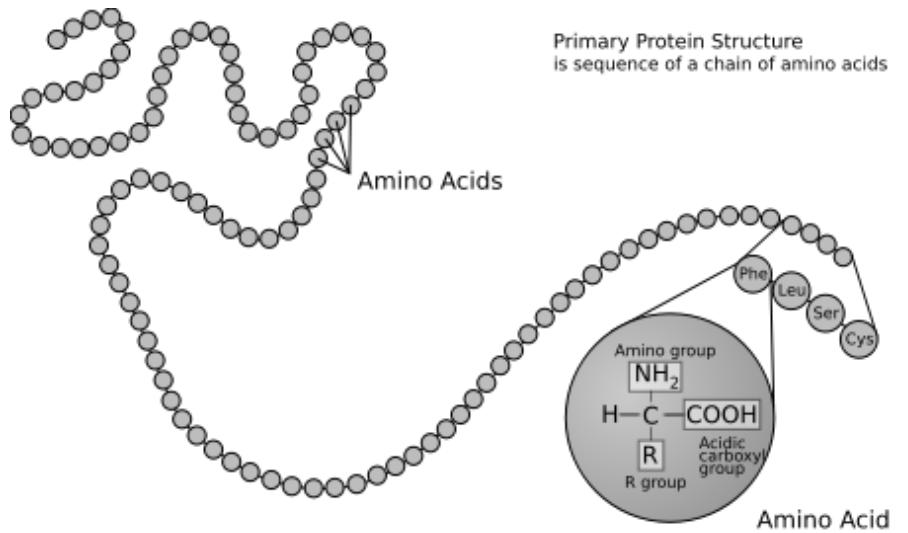


U.S. National Library of Medicine



f) **Protein**

What is a protein?

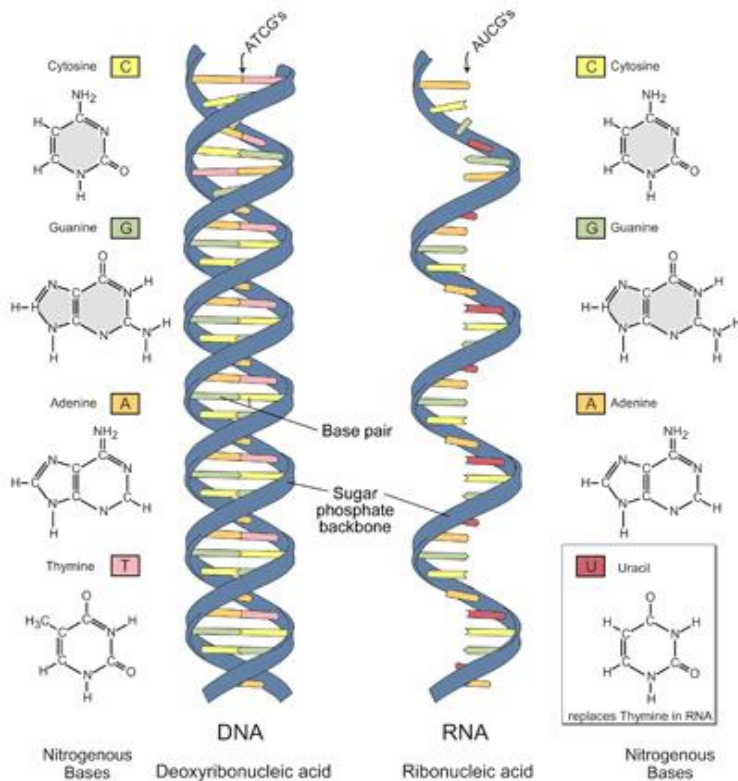


Normal blood cells and sickled cells are pictured to the left.

The latter have hemoglobin (a protein) with one wrong amino acid in the sequence. What went wrong?

g) **RNA**

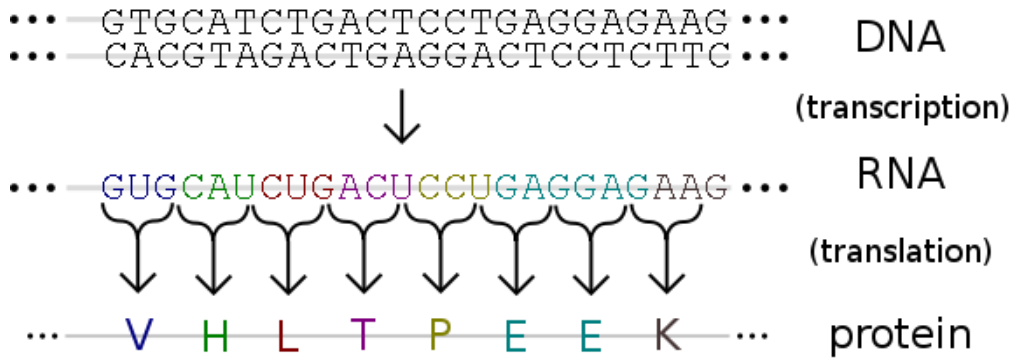
What is RNA? How does it differ from DNA from the point of view of structure, location and function?



Exercises

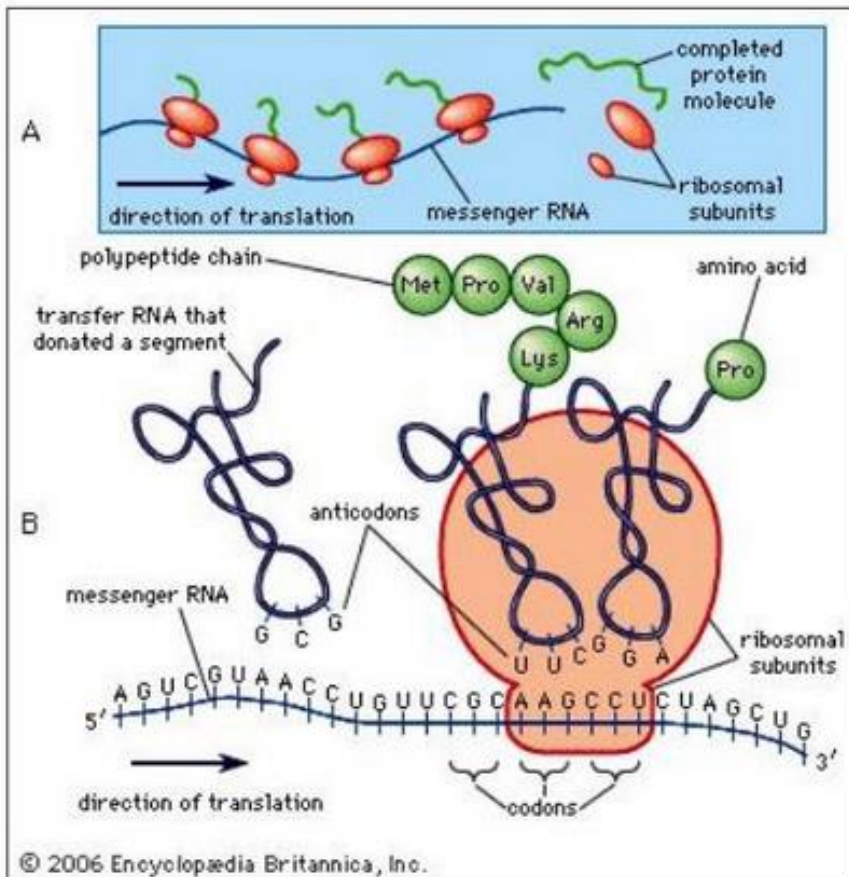
1. Draw a chromosome. Show what it looks like when a cell has 46 chromosomes.
2. Draw a chromosome. Show what it looks like when a cell has 92 chromosomes during cell division.
3. Are chromosome pair members identical?
4. What is the difference between a gene and DNA?
5. What is the difference between an amino acid and a DNA base(adenine, thymine, guanine, cytosine)?
6. Why does adenine match with thymine and not with cytosine?
7. Why are proteins so important? Describe at least three roles played by protein molecules in the human body.

B. Protein Synthesis



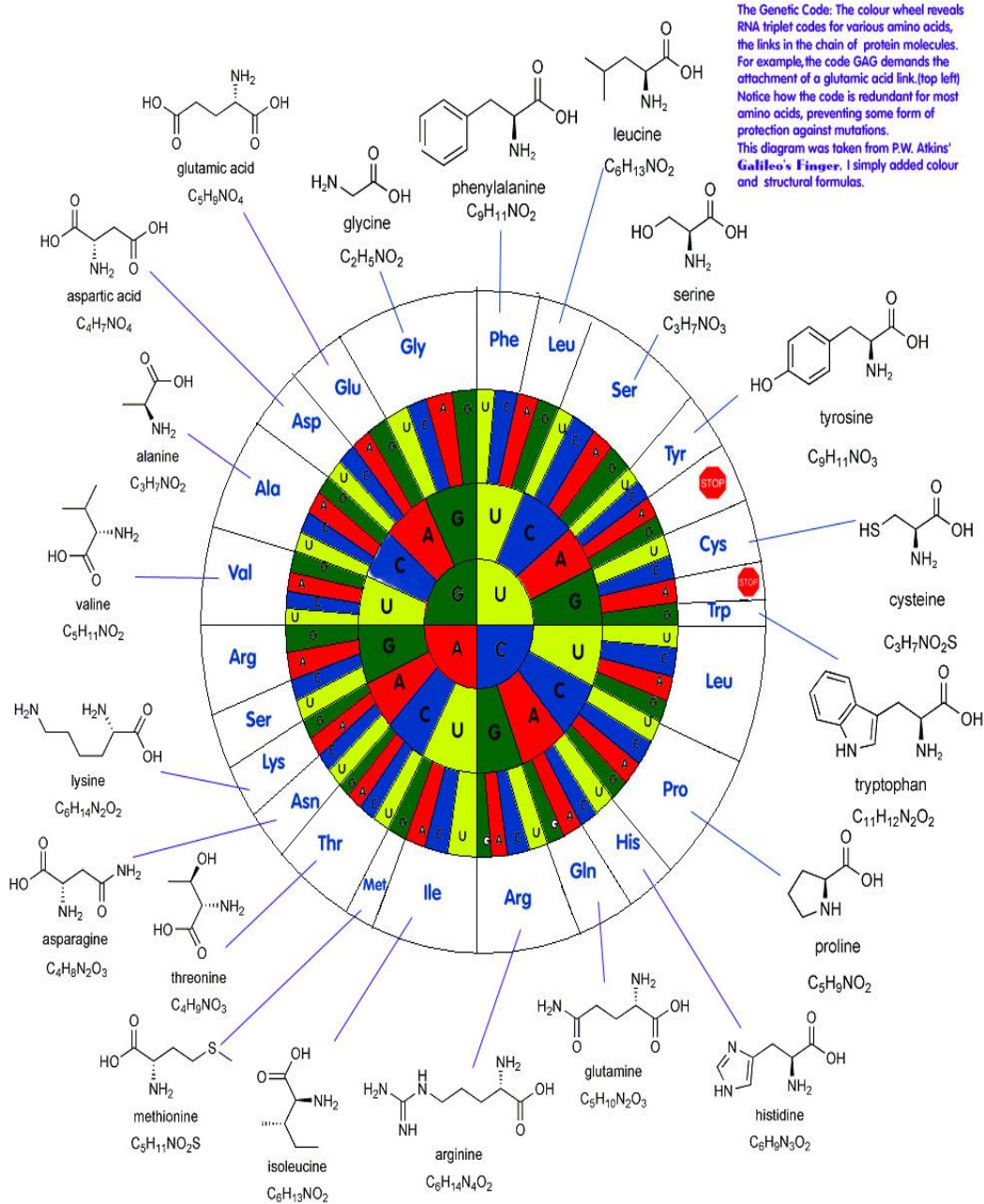
a) Use the architect-foreman analogy to explain protein synthesis.

b) Label each structure or molecule and describe its role



c) The Genetic Code

Notice that for most amino acids there are more than 3 triplets that code for the same amino acid. Why?



In Class Exercise

- a) Use the messenger-RNA codes on p158 to obtain the amino acids that would be assembled if the m-RNA code was the following:

UUUACUCGC

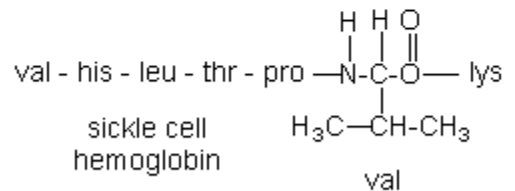
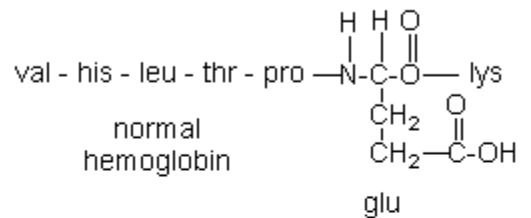
- b) What would be the DNA codes corresponding to the above messenger RNA codes?
- c) **Transfer RNA codes?**

Exercise: Protein Synthesis

1. Choose from column2(matching)	Column 2: Possible answers
a) Enzymes (make important reactions occur faster)	1. Mostly or exclusively protein
b) Chromosomes	2. Mostly or exclusively DNA
c) Ribosomes	3. Mostly or exclusively RNA
d) dried muscle	
e) a string of amino acids	
f) transfer RNA	
g) uracil, adenine, guanine, cytosine	
h) genes	

2. Shown are the tail ends of two proteins: one is part of normal hemoglobin and the other is part of sickle-cell anemia.

- a) Instead of the amino acid "glu"= glutamic acid, which amino acid does the sickle cell anemia hemoglobin have? (see diagram)



b) Consult the genetic code table on the next page and complete the following:

Amino acid	corresponding t-RNA codes	Possible m -RNA codes (start here: see chart)	Corresponding DNA codes
Valine(val)			
	Possible t-RNA codes	Corresponding m-RNA codes	Corresponding DNA codes
Glutamic acid(glu)			

		Second letter					
		U	C	A	G		
First letter	U	UUU } Phe UUC } UUA } Leu UUG }	UCU } UCC } Ser UCA } UCG }	UAU } Tyr UAC } UAA Stop UAG Stop	UGU } Cys UGC } UGA Stop UGG Trp	U C A G	
	C	CUU } CUC } Leu CUA } CUG }	CCU } CCC } Pro CCA } CCG }	CAU } His CAC } CAA } Gln CAG }	CGU } CGC } Arg CGA } CGG }	U C A G	
	A	AUU } AUC } Ile AUA } AUG Met	ACU } ACC } Thr ACA } ACG }	AAU } Asn AAC } AAA } Lys AAG }	AGU } Ser AGC } AGA } Arg AGG }	U C A G	
	G	GUU } GUC } Val GUA } GUG }	GCU } GCC } Ala GCA } GCG }	GAU } Asp GAC } GAA } Glu GAG }	GGU } GGC } Gly GGA } GGG }	U C A G	

3. What name is given for all the triplets needed to code for the entire haemoglobin molecule? (It's a part of a chromosome!)
4. If you go back to the original transfer RNA codes, which codes resemble each other when you compare those of valine to those of glutamic acid?
5. This substitution of valine for glutamic acid creates a hydrophobic(water-avoiding) spot on the outside of the protein structure that sticks to the hydrophobic region of an adjacent hemoglobin molecule's beta chain. This clumping together (polymerization) into rigid fibers causes the "sickling" of red blood cells.

What caused the wrong code and therefore the wrong amino acid that leads to this molecular disease known as sickle-cell anemia?

C. Principles of Heredity

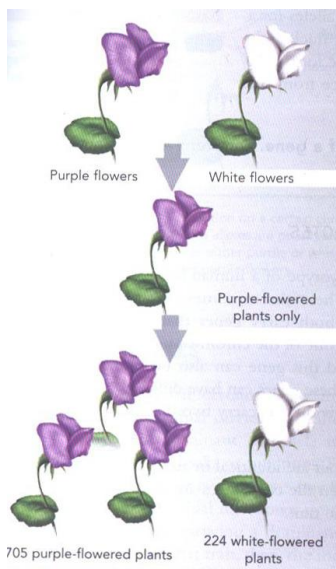
a) Mendelian Traits: What are Mendelian traits?

b) Where on chromosomes are Mendelian genes?

Ability to taste phenylthiocarbamide (PTC, a bitter compound)	Face freckles (dominant)
Albinism (recessive)	Hitchhiker's thumb (recessive)
Blood type	Sextdactyly (Six fingers/toes)
Brachydactyly (Shortness of fingers and toes)	Sickle-cell trait (also considered co-dominant)
Cleft chin (dominant)	Widow's peak (dominant)
Cheek dimples (dominant)	Wet (dominant) or dry (recessive) earwax
Free (dominant) or attached (recessive) earlobes	

c) Examples of Crossbreeding

Crossbreeding is the exchange of gametes (sex cells and their DNA) between two different individuals during sexual reproduction.



Example 1









How do you explain the results of Mendel's experiments with pea plants?

Example 2

If a pea plant that is heterozygous for stem length is crossed with a short-stemmed one, what % of the offspring will be short when fully grown?

Example 3

- a) If you grow pea plants from green seeds for several plant generations, will you ever get yellow-seeded plants, assuming no mutations?
- b) What is meant by “assuming no mutations”?

Dominant allele	Recessive allele	Phenotypes	Genotypes
P	p	Purple flowers 	PP or Pp
		White flowers 	pp
Y	y	Yellow seeds 	YY or Yy
		Green seeds 	yy
R	r	Round shape 	RR or Rr
		Wrinkled shape 	rr
L	l	Long stem (about 3 m) 	LL or Ll
		Short stem (about 30 cm) 	ll



Blue American lobster (*Homarus americanus*).
Taken at the New England Aquarium
(Boston, MA, December 2006. Copyright © 2006

C Dihybrid Cross

In summer squash, white fruit color (W) is dominant over yellow fruit color (w) and disk-shaped fruit (D) is dominant over sphere-shaped fruit (d). If a squash plant true-breeding for white, disk-shaped fruit is crossed with a plant true-breeding for yellow, sphere-shaped fruit, what will the phenotypic and genotypic ratios be for the 1st and 2nd generations?

a) First generation

b) 2nd generation

c) Give the phenotypic and genotypic ratios for the 2nd generation cross.

Exercises for Mendelian Genetics

Use the following tables to answer questions 1 to 6.

	Dominant Trait in Animals	Recessive Trait in Animals
Cats	Tabby coat(T)	Black coat(t)
cattle	Horned(H)	Hornless (h)
Sheep	White fleece(W)	Black fleece(w)
swine	Uncleft hoof (U)	Normal hoof(u)

- Show that if two black cats mate their litter will always be black.
- Suppose that a homozygous white sheep mates with a black sheep. What is the probability that they will have white sheep?
- If a hornless cow gave birth to one horned calf and a hornless one, what was the genotype of the bull?
 - If the horned calf from part (a) went to college and met a nice heterozygous cow who gave him babies, what are the chances that they had a horned calf? A hornless calf?

Dominant Trait in Humans	Recessive Trait in Humans
Pigmented skin(P)	Albinism(p)
Detached Earlobes(D)	Attached earlobes(d)
Short fingers (S)	Normal fingers (s)
Widow's Peak (W)	Straight hairline(w)
Freckled skin (F)	Unfreckled skin (f)
Straight thumb(T)	Hitchhiker's thumb(t)



4. Two unfreckled sisters love milk. Both parents have freckles and argue a lot. Is the unfreckled milkman, who is the only unfreckled man in the neighbourhood, necessarily the real father of the sisters?

5. a) A widow with a widow's peak marries a straight-hairlined man. If her father's hair looked like her husband's, what is the likelihood that her son will have a widow's peak?
b) Is the widow's mother someone with a straight hairline?

6. If a short-fingered woman marries a long-fingered man, what are the possible genotypes and phenotypes of the children? Draw two separate squares.

7. Assume that the genes for albinism and attached earlobes are on separate chromosomes. What are the chances that a man whose genotype is $DdPp$ and a $Ddpp$ woman will have an albino child with attached earlobes?

In class examples

Example 1: a) Show why the possibility of getting a baby girl is 50%.



b) If you already have three girls, is the possibility of giving birth to another girl still 50%?

c) Which of a man's grandparents could not be the source of any of the genes on his **Y**-chromosome?

Example 2: Some human traits are sex-linked, usually meaning that only the X chromosome can carry the gene. Hemophilia in humans is due to an X-chromosome mutation. What will be the results of mating between a normal (non-carrier) female and a hemophilic male?

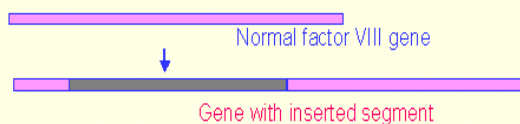


Fig 5.6. Insertion of a 3.8 Kilo base segment in the factor VIII gene is the most common mutation in haemophilia A

Example 3 A human female "carrier" who is heterozygous for the recessive, sex-linked trait causing red-green color blindness, marries a normal male. What proportion of their male progeny will have red-green color blindness?

Genetics Vocabulary

Allele — alternative forms of a gene for each variation of a trait of an organism

Dominant — observed trait of an organism that hides the recessive form of a trait

Recessive — trait of an organism that can be masked by the dominant form of a trait

Trait — characteristic that is inherited; can be either dominant or recessive

Genotype — combination of genes in an organism

Phenotype — outward appearance of an organism, regardless of its genes

Heterozygous — when there are two different alleles for a trait

Homozygous — when there are two identical alleles for a trait

Cross- mate a female with a male

Exercises

1. Women have sex chromosomes of **XX**, and men have sex chromosomes of **XY**.

Which of a woman's grandparents could not be the source of any of the genes on either of her **X**-chromosomes?

2. A human female "carrier" who is heterozygous for the recessive, sex-linked trait red color blindness, marries a normal male. Draw a Punnett square.

3. In pea plants, spherical seeds (S) are dominant to dented seeds (s). In a genetic cross of two plants that are heterozygous for the seed shape trait, what fraction of the offspring should have spherical seeds?

4. Is a phenotypic ratio of 3:1 in the offspring of a mating of two heterozygous organisms for a single trait expected if one gene is dominant over an allelic gene? Show why or why not.
5. a) When true-breeding tall stem pea plants are crossed with true-breeding short stem pea plants, if all offspring are tall, then the tall-pea gene is dominant over the short one. True?
- b) Show what happens when the 2nd generation tall peas are crossed.
6. Two unlinked genes affect mouse hair color. **CC** or **Cc** mice are streaked. Mice with genotype **cc** are albino because all pigment production and deposition of pigment in hair is blocked. At the second location on a different chromosome, the **B** allele (black streaked coat) is dominant to the **b** allele (brown streaked coat). A mouse with a black streaked coat is mated with an albino mouse of genotype **bbcc**. Half of the offspring are albino, one quarter are black-streaked, and one quarter are brown-streaked. What is the genotype of the black streaked parent?
(Hint: first list all four combinations, and then figure out which of the four will give the listed results)

More Protein Synthesis

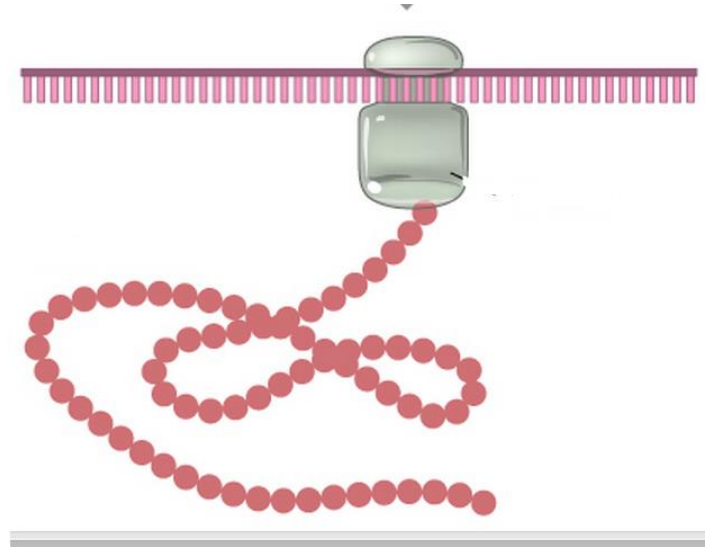
7. In Huntington's disease (which impairs coordination, reasoning and emotions), the responsible and dominant gene is longer than the normal one. Specifically, the DNA-sequence **GTC** is repeated about 40 times, about 23 more than what normally occurs.

After translation, the protein produced has too many of the same amino acid in its sequence.

- What amino acid is being repeated?
 - What three bases would be found on the transfer RNA molecule fetching the above amino acid?
8. Give two different DNA sequences that signal the end of a particular protein mole.

mRNA codes					
First Letter	Second Letter				Third Letter
	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
	(start) methionine	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

9. Label the protein, ribosome and mRNA in the following:



10. On average, every day, an adult produces 1.3 g of protein per kg of body weight. If the average molar mass of human protein is 53 000 g/mole, how many molecules of protein are produced per second in a 100 kg adult?

11. For each amino acid, use the molecular formula and skeleton structure to draw the missing atoms and bonds.

<p>a)</p>	<p>b)</p>	<p>c)</p>
<p>Glutamic acid(Glu)</p> <p><u>$C_5H_9NO_4$</u></p>	<p>Glutamine(Gln)</p> <p><u>$C_5H_{10}N_2O_3$</u></p>	<p>Proline (Pro)</p> <p><u>$C_5H_9NO_2$</u></p>

D- Biotechnology: CLONING

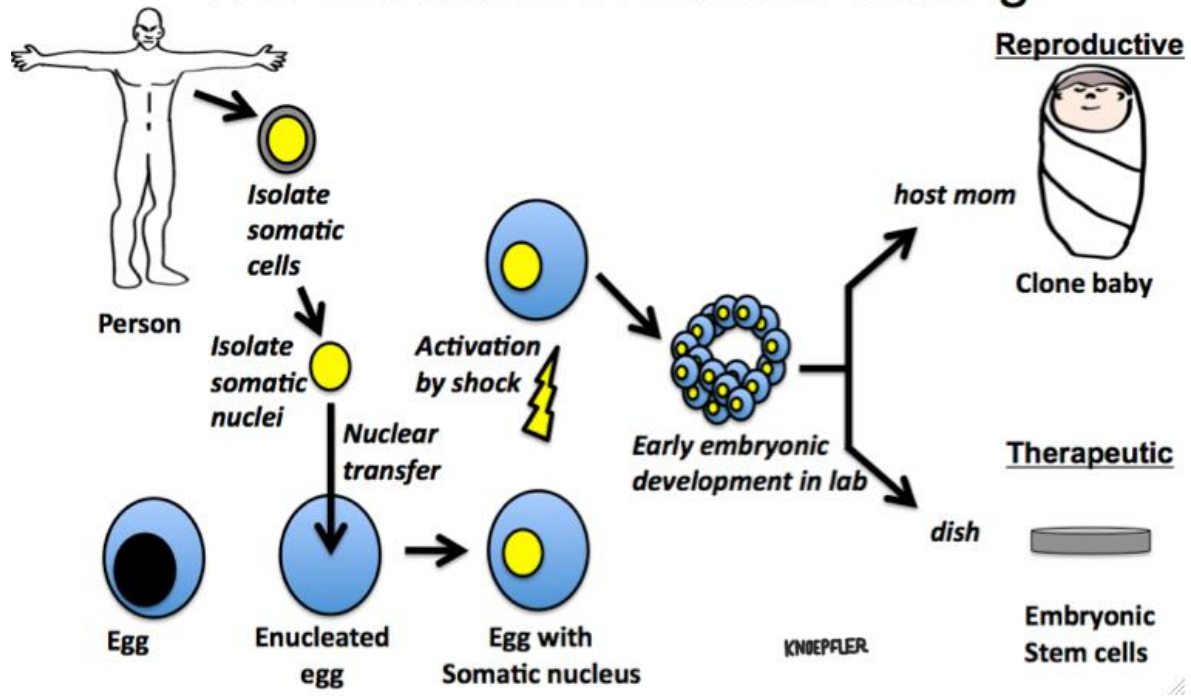
1. What is cloning?
2. What are some natural examples of plant cloning?



3. What are some artificial examples of plant cloning? Mention both traditional and modern techniques.

4. How are animals cloned? Use a diagram which shows an egg from which the nucleus has been removed.

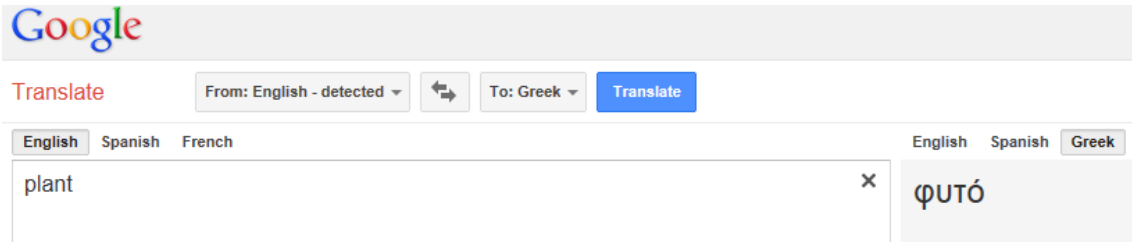
The two kinds of human cloning



Recopied with permission from Paul Knoepfler

23. Biotechnology: Water Treatment

1. A) What is phytoremediation? Mention the role of cabbage or algae.



b)

SUMMARY

Cabbage plants were grown for 55 days with a nutrient solution containing 1 and 10 ppm of V, Cr(III), Cr(VI), Mn, Fe, Co, Ni, Cu, Zn, Cd, Hg(I), or Hg(II). A comparison of the plant growth and chemical analysis revealed that Cr(VI), Cu, Cd, and Hg(II) in the solution are most toxic to the plant growth (hence detrimental to the cabbage-head formation) and Mn, Fe, and Zn are less toxic than other heavy metals, and that Mn, Zn, Co, Ni, and Cd are translocated into all the plant organs while V, Cr(III), Cr(VI), Fe, Cu, Hg(I), and Hg(II) are accumulated in the roots.

Read the above.

- a) How many metallic elements do the roots filter out of the soil? What are Cr(III) and Cr(VI)? What is the difference between them?
-
2. What is the difference between a septic tank and a water treatment plant, and what is "lagooning"?

Exercises

1. Read the following:

This study assessed heavy metals (lead, cadmium, arsenic, nickel, copper, iron and zinc) concentration in lettuce, cabbage and spring onions grown along River Subin and its tributaries; Rivers Wiwi, Oda and Sisa which are extensively used by urban vegetable farmers in Kumasi to irrigate their vegetables. Atomic Absorption Spectrophotometry was used to evaluate the levels of heavy metals in the vegetable samples at four places along the river banks. There were no well defined trends in heavy metals concentration in all the vegetable samples. However, heavy metals in vegetables at the KNUST and Ayeduase sites were relatively higher compared to the Sepetimpon and Ofoase sites.

Levels of nickel, zinc, copper and iron in all three vegetable samples (lettuce, cabbage and spring onion) at the four sites were below the WHO/FAO recommended guideline levels of 67.90 mg/kg for nickel, 99.40 mg/kg for zinc, 73.3 mg/kg for copper and 425 mg/kg for iron.

However, comparing the three vegetables in terms of levels of heavy metals accumulation, averagely-nickel was highest (0.192mg/kg) in spring onion, zinc- (2.85mg/kg) in spring onions, copper (0.355mg/kg) in spring onion and iron (13.91 mg/kg) in cabbage.

Levels of cadmium, lead and arsenic in all three vegetable samples were above the WHO/FAO recommended guideline levels of 0.2 mg/kg, 0.3 mg/kg and 0.43 mg/kg, respectively. Cadmium was highest (1.06mg/kg) in spring onion, lead (1.57mg/kg) in spring onion and arsenic (4.14mg/kg) in lettuce. The presence of cadmium, lead and arsenic above the recommended WHO/FAO guidelines levels presents a potential hazard to the health of consumers.

- a) How many moles of cadmium(Cd) would you expect to find in 10 kg of spring onion?
 - b) Was the arsenic in lettuce a problem?
 - c) Is this an example of unintentional phytoremediation? Why?
2. In what kind of community is a septic tank practical? When is sewage better?
 3. What must be done to an egg during the cloning process?
 4. Can two females be used to clone a sheep? Why? or why not?
 5. Explain the difference between traditional and more modern techniques of plant cloning.
 6. If a strawberry plant sends a runner (looks like a long root) to a spot in the soil that's 1.0 m away, is it cloning itself, if a new plant grows from that runner?
 7. Why do you think it is illegal in Canada to clone humans? (What's wrong with cloning a few Malkov's and giving them to a talent-challenged team like the Montreal Canadiens?)

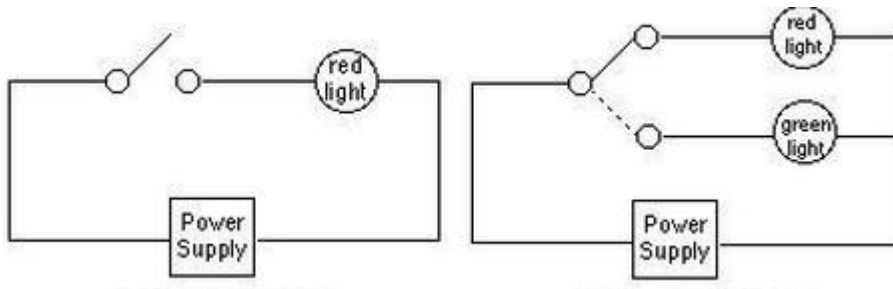
24. Types of Switches

A **pole** is the number of circuits controlled by a switch. A **throw** is the number of contacts made by a switch.

We'll consider four types:

- (1) Single pole-single throw
- (2) Single pole-double throw
- (3) Double pole-single throw
- (4) Double pole-double throw

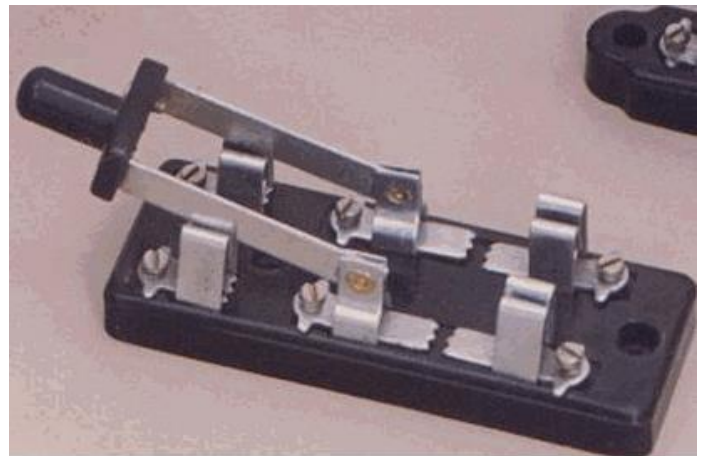
Example 1 a) Match two of the above with the following



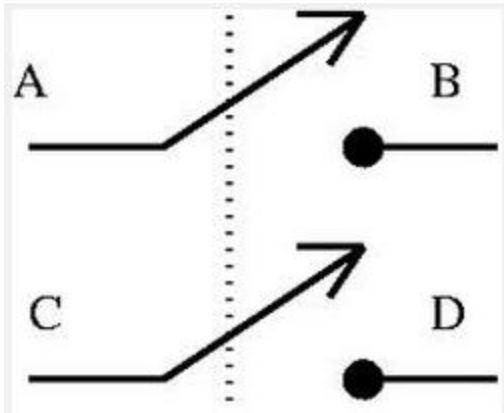
b) What advantage does the second switch have over the first one?

c) If the red and green lights have the same resistance, what's the power consumption of the red light, if a current of 50 mA flows through the green light when the voltage is 500mV?

Example 2 a) What kind of switch is this?



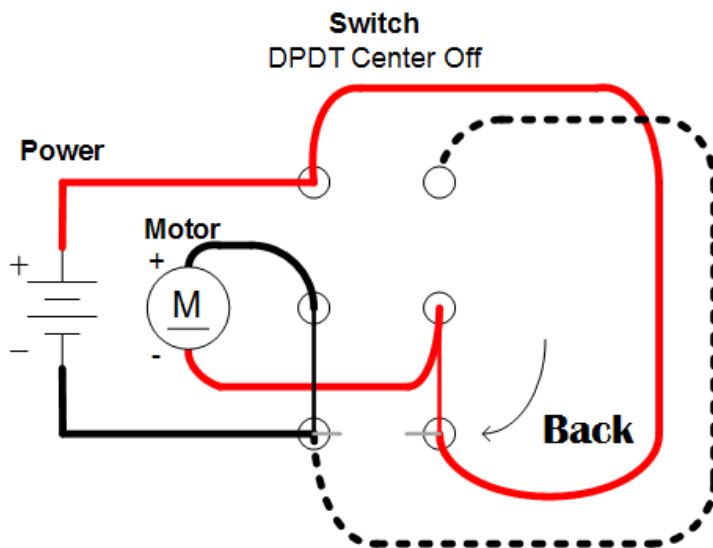
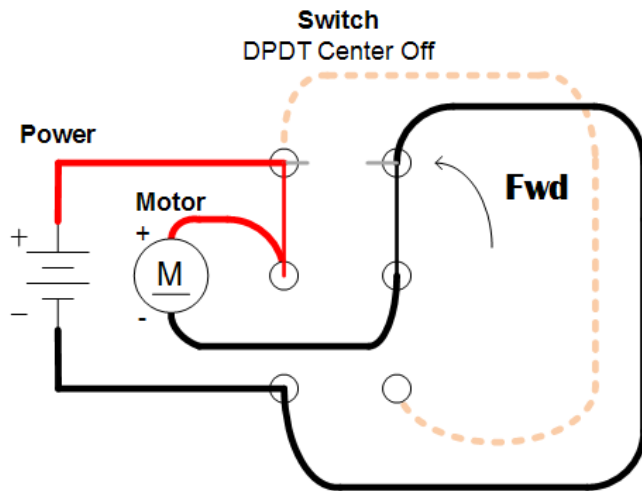
b) Draw a circuit diagram that has a double-pole single throw switch.



Example 3 Draw a circuit with a double pole, double-throw switch.

Example 4 a) What is the switch doing to the motor?

b) How is it tied in to magnetism?



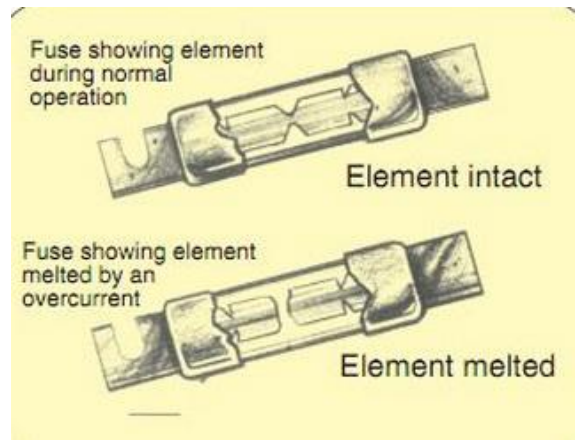
Switches in Breakers

a) Why does total current sometimes get too high in your home?

b) What was the old-fashioned solution to this problem?

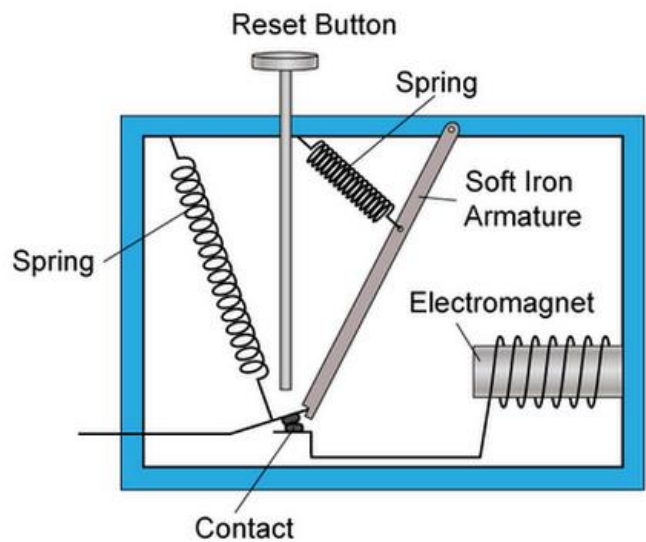
c) How did they work?

d) What was their disadvantage?



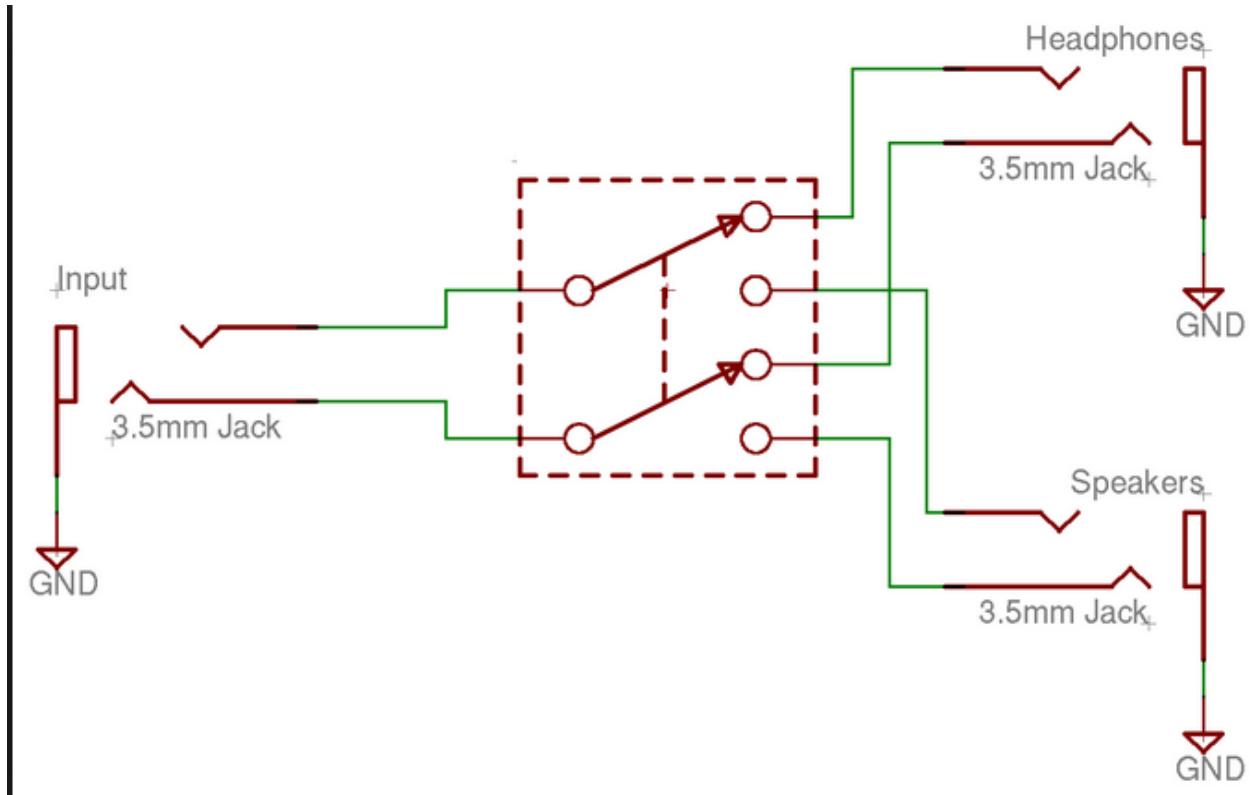
e) **The Modern Solution**---read the following and identify what is being described:

“Increasing current boosts the electromagnet's magnetic force, and decreasing current lowers the magnetism. When the current jumps to unsafe levels, the electromagnet is strong enough to pull down a metal lever connected to the switch linkage. The entire linkage shifts, tilting the moving contact away from the stationary contact to break the circuit. The electricity shuts off.”



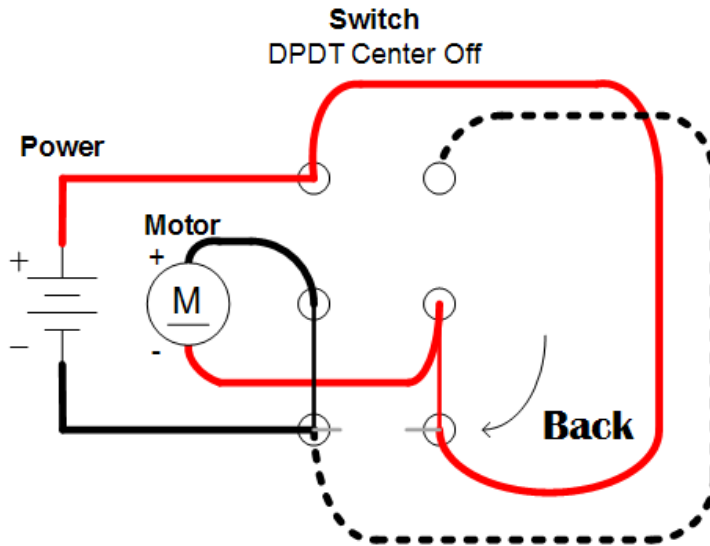
Exercises

- What kind of switch is shown below?
 - What purpose does it serve?



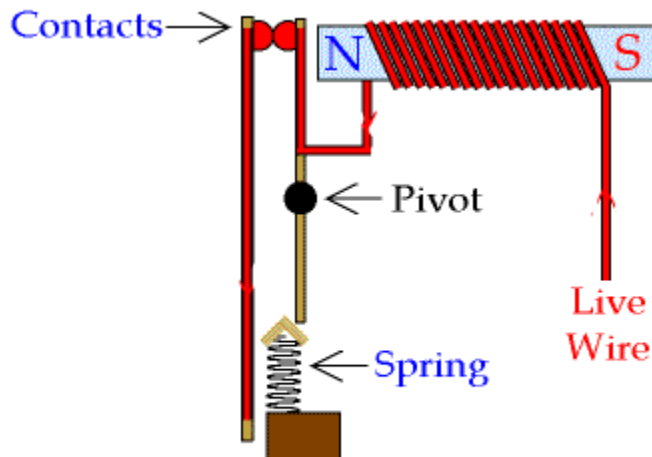
- Draw a circuit with a single pole-double throw switch. In one of the connections two $10\ \Omega$ resistors lead to a total resistance of $5\ \Omega$. In the other "throw", three $5\ \Omega$ resistors have a total resistance of $7.5\ \Omega$.

3. Examine the diagram:



Why does the broken-line option shut the motor?

4. a) What is shown below?
 b) Which part will break contact? Indicate on diagram.
 c) In which direction is electricity flowing?



- d) What adjustments did the manufacturers make to ensure that a dangerous current would indeed lead the electromagnet to break contact?

Periodic Table of the Elements

1 H 1.00794	2 He 4.002602																																						
3 Li 6.941	4 Be 9.012182	5 B 10.811	6 C 12.0107	7 N 14.00674	8 O 15.9994	9 F 18.9984032	10 Ne 20.1797																																
11 Na 22.989770	12 Mg 24.3050	13 Al 26.981538	14 Si 28.0855	15 P 30.973761	16 S 32.066	17 Cl 35.4527	18 Ar 39.948																																
19 K 39.0983	20 Ca 40.078	21 Sc 44.955910	22 Ti 47.867	23 V 50.9415	24 Cr 51.9961	25 Mn 54.938049	26 Fe 55.845	27 Co 58.933200	28 Ni 58.6934	29 Cu 63.546	30 Zn 65.39	31 Ga 69.723	32 Ge 72.61	33 As 74.92160	34 Se 78.96	35 Br 79.904	36 Kr 83.80																						
37 Rb 85.4678	38 Sr 87.62	39 Y 88.90585	40 Zr 91.224	41 Nb 92.90638	42 Mo 95.94	43 Tc (98)	44 Ru 101.07	45 Rh 102.90550	46 Pd 106.42	47 Ag 107.8682	48 Cd 112.411	49 In 114.818	50 Sn 118.710	51 Sb 121.760	52 Te 127.60	53 I 126.90447	54 Xe 131.29																						
55 Cs 132.90545	56 Ba 137.327	57 La 138.9055	72 Hf 178.49	73 Ta 180.9479	74 W 183.84	75 Re 186.207	76 Os 190.23	77 Ir 192.217	78 Pt 195.078	79 Au 196.96655	80 Hg 200.59	81 Tl 204.3833	82 Pb 207.2	83 Bi 208.98038	84 Po (209)	85 At (210)	86 Rn (222)																						
87 Fr (223)	88 Ra (226)	89 Ac (227)	104 Rf (261)	105 Db (262)	106 Sg (263)	107 Bh (262)	108 Hs (265)	109 Mt (266)	110 Mt (269)	111 Mt (272)	112 Mt (277)	114 Mt (287)	116 Mt (289)	118 Mt (293)																									
																		69 Tm 168.93421	70 Yb 173.04	71 Lu 174.967																			
																		68 Er 167.26	67 Ho 164.93032	66 Dy 162.50	65 Tb 158.92534	64 Gd 157.25	63 Eu 151.964	62 Sm 150.36	61 Pm (145)	60 Nd 144.24	59 Pr 140.90765	58 Ce 140.116	100 Fm (257)	99 Es (252)	98 Cf (251)	97 Bk (247)	96 Cm (247)	95 Am (243)	94 Pu (244)	93 Np (237)	92 U 238.0289	91 Pa 231.03588	90 Th 232.0381
																		258 Mt (258)	259 No (259)	260 Lr (262)																			