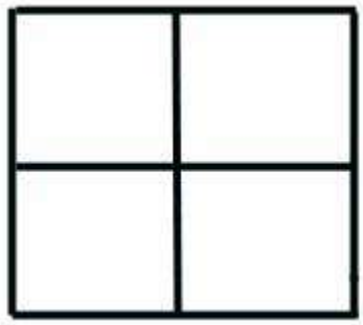
Baby Steps Through the PUNNETT SQUARE

The basic naked p-square looks like a window pane:



When given enough info about two parent organisms, we can use this window pane to predict the genotypes & phenotypes of their offspring.

Very quick rehash (review):

- **genotype = the genes of an organism; for one specific trait we use two letters to represent the genotype. A capital letter represents the dominant form of a gene (allele), and a lowercase letter is the abbreviation for the recessive form of the gene (allele).**
- **phenotype = the physical appearance of a trait in an organism**

For example, let's say that for the red booby bird (I am making this up), red throat is the dominant trait and white throat is recessive.

Since the "red-throat code" and the" white-throat code" are alleles (*two forms of the same gene)*, we abbreviate them with two forms of the same letter. So we use "R" for the dominant allele/trait (red throat) and "r" for the recessive allele/trait (white throat).

Our possible genotypes & phenotypes would be like this:

Symbol	Genotype Name	Phenotype
RR	homozygous (pure) dominant	red thoat
Rr	heterozygous (hybrid)	red throat
rr	homozygous (pure) recessive	white throat

One more note: A very helpful thing to memorize is that the ONLY way for a recessive trait to show up in an organism is if that organism's genotype is homozygous recessive (two little letters, like "rr").

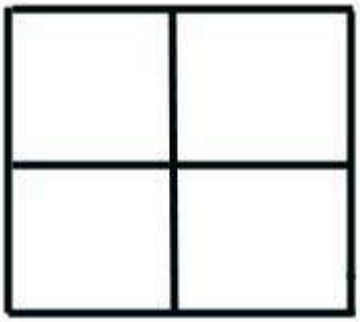
Here are the basic steps to using a Punnett Square when solving a genetics question. After you get good at this you should never miss a genetic question involving the cross of two organisms.

BABY STEPS:
1. determine the genotypes of the parent organisms
2. write down your "cross" (mating)
3. draw a p-square
4. "split" the letters of the genotype for each parent & put them "outside" the p-square
5. determine the possible genotypes of the offspring by filling in the p-square
6. summarize results (genotypes & phenotypes of offspring)
7. bask in the glow of your accomplishment !

Step #1: *Determine the genotypes of the parent organisms*.

- **Sometimes this already done in the question for you. If the question says "Cross two organisms with the following genotype: Tt & tt", it's all right there in the question already.**
- **More likely is a question like this: "Cross a short pea plant with one that is heterozygous for tallness". Here, you have to use your understanding of the vocab to figure out what letters to use in the genotypes of the parents. Heterozygous always means one of each letter, so we'd use "Tt" (where "T" = tall, & "t" = short). The only way for a pea plant to be short is when it has 2 lowercase "t's", so that short parent is "tt". So the cross ends-up the same as in my first example: Tt x tt.**
- **Now, we (us mean teachers) can make things just a little more tricky. Let's use hamsters in this example. Brown is dominant (B), and white is recessive (b). What if a question read like this: "Predict the offspring from the cross of a white hamster and a brown hamster if the brown hamster's mother was white". Oooooh, is this a toughy? First things first: the only way for the white hamster to be white (the recessive trait) is if it's genotype is homozygous recessive (2 little letters), so the white hamster is "bb". Now, the brown hamster's genotype could be either "BB" or "Bb". If its mommy was white (bb), then this brown hamster MUST have inherited a little "b" from its mommy. So the brown one in our cross is "Bb" (not "BB"), and our hamster cross is: Bb x bb.**

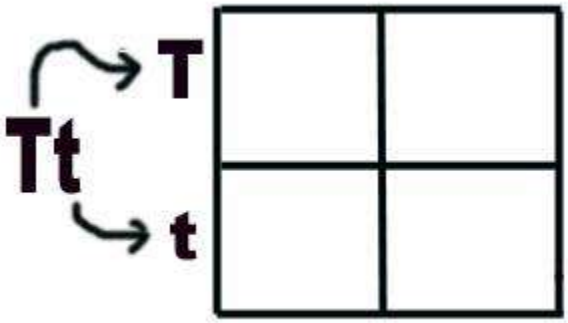
Step #2: W*rite down your "cross" (mating)*. Write the genotypes of the parents in the form of letters (ex: Tt x tt).



<u>Step #3</u>: ***Draw a p-square.***

<u>Step #4</u>: ***"Split" the letters of the genotype for each parent & put them "outside" the p-square.***

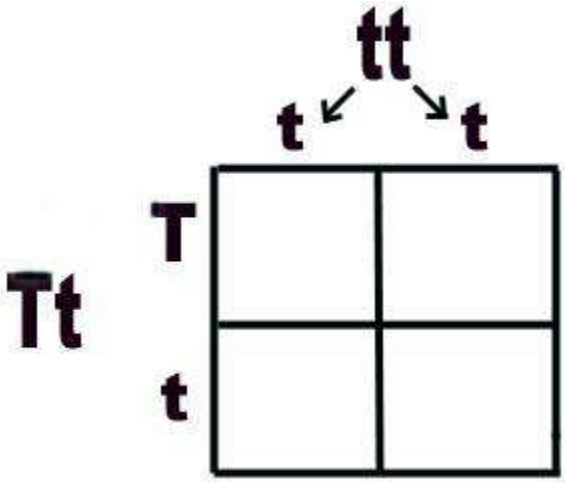
- **For an example cross we'll use these parental genotypes: Tt x tt.**
- **Take the genotype letters of one parent, split them and put them on the left, outside the rows of the p-square.**



What we've done is taken the heterozygous tall plant (Tt) and put its big "T" out in front of the top row, and the little "t" out in front of the bottom row. When we fill-in the p-square, we will copy these "tees" into each of the empty boxes to their right. So the big "T" will be in each of the boxes of the top row, and the lowercase "t" will be in the two boxes of the bottom row.

Isn't this exciting?

Now take the two letters of the second parent's genotype, split 'em up, and place them above each of the two columns of the p-square.

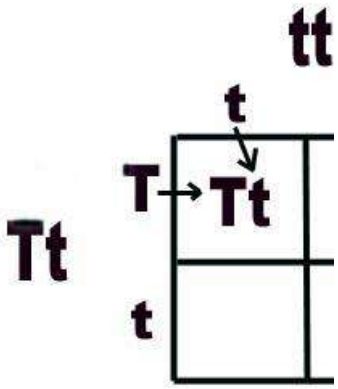


Now, when it comes time to filling things in, those lowercase "t's" will each be copied into the two boxes directly below them. So after the next step, each little box will have two letters in it (one "tee" from the left & one "tee" from the top). These new 2 letter combos represent possible genotypes of the offspring. Exciting, ain't it?

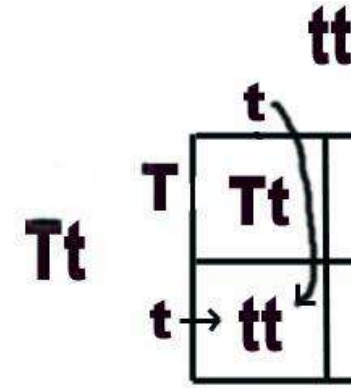
Step #5: ***Determine the possible genotypes of the offspring by filling in the p-square.***

- **I kinda gave this away already, but to "determine the genotypes of the offspring" all we gotta do is fill-in the the boxes of the p-square. Again we do this be taking a letter from the left & matching it with a letter from the top. Like so:**

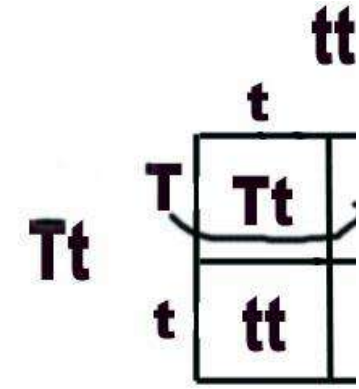
Filling in the top-left box:



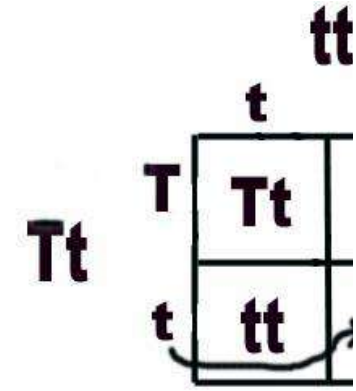
Filling in the bottom-left box:



Filling in the top-right box:



Filling in the bottom-right box:



One from the left, one from the top... one from the left, one from the top...one from the left, one from the top...one from the left, one from the top.

Step #6: ***Summarize the results (genotypes & phenotypes of offspring).***

- **Simply report what you came up with. You should always have two letters in each of the four boxes.**
- **In this example, where our parent pea plants were Tt (tall) x tt (short), we get 2 of our 4 boxes with "Tt", and 2 of our 4 with "tt". The offspring that are "Tt" would end up with tall stems (the dominant trait) and the "tt" pea plants would have short stems (the recessive trait).**
- **So our summary would be something like this:**

Parent Pea Plants ("P" Generation)		Offspring ("F1" Generation)	
Genotypes: Tt x tt	Phenotypes: tall x short	Genotypes: 50% (2/4) Tt 50% (2/4) tt	Phenotypes: 50% tall 50% short

Step #7: ***Bask in the glow of your accomplishment !***

- **We are so good I can't stand it.**
- **We are genetics *MONSTERS* !**

A little scientific side-note:

You know how, in Step #4, when we "split" the letters of the genotype & put them outside the p-square? What that step illustrates is the process of gametogenesis (the production of sex cells, egg & sperm). Gametogenesis is a cell division thing (also called meiosis) that divides an organism's chromosome number in half. For example, in humans, body cells have 46 chromosomes a piece. However, when sperm or eggs are produced (by gametogenesis/meiosis) they get only 23 chromosomes each. This makes sense (believe it or not), because now, when the sperm & egg fuse at fertilization, the new cell formed (called a zygote) will have 23 + 23 = 46 chromosomes. Cool, huh?

So, when the chromosome number is split in half, all of the two letter genotypes for every trait of that person (or organism) get separated. Which is why we do what we do in Step #4.