Heredity and Genetics

1. Genetic crosses and inheritance

Suppose these were the results of an individual investigation of the phenotype of your future partner.

Table 1: Your partner

Traits	Thumb	Chin cleft	Middle digit hair	Handedness	Earlobes	Hand clasp
Phenotype	Normal	No	None	Right	Free	Left
Genotype	hh	dd	mm	Rr or RR	Ff or FF	Cc or CC

Which genotype and phenotype would our offspring have?

To predict the genotype and phenotype of your offspring you have to consider your personal results and those of your partner and determine the alleles you and your partner can pass on to the next generation. Then you have to recombine these alleles in the appropriate way.

Which alleles can be passed on to the next generation?

When gametes (e.g. egg- or sperm-cells in animals and egg-cells and pollen in higher plants) are produced, they only carry a single allele of the two alleles carried by body cells. This reduction in the number of alleles is achieved through a process called "meiosis" taking place in the ovaries and testes, respectively. Geneticists call this "the number of genes or alleles is reduced from 2n (= diploid state = two alleles) in the body cells to 1n (= haploid state = one allele) in the gametes. Thus, a person with the genotype "Rr" can produce sperm or egg cells with either the allele "R" or the allele "r". A person with the genotype "RR" only produces gametes with the allele "R".

How are alleles recombined in genetic crosses and how can I follow this process on paper?

The answer is: "Don't think you're smart, use a Punnett square"!

2. Punnett squares

A Punnet square is a table that allows for a systematic recombination of alleles in genetic crosses. It tells us which genotypes and, hence, phenotypes we can expect from genetic crosses and even which chance (probability) exists to obtain a particular genotype and phenotype among individuals of the next generation.

In a first step you determine the possible gametes (sperm or egg cells) that are produced from the genotype of your body cells and those of your partner. E.g. in the case of the genotype "Rr" this is "R" and "r".

Parental generation	Female partner	Male partner
	Phenotype: right-handed	Phenotype: right-handed
	Genotype: RR	Genotype: Rr
Possible gametes	R, R	R, r

A Punnett square looks like this:

1st Generation Offspring	♂ Male gametes (sperm cells)→	R	r
♀ Female gametes (egg cells) ↓	R	?	?
	R	?	?

In the Punnett square you write down all different alleles from the male partner (= possible sperm cells) in the horizontal line of the square (see "Male gametes (sperm cells) →)" as well as all different alleles from the female partner (= possible egg cells) in the column on the left (see "Female gametes (egg cells) ↓)". Then you have to recombine all male and female gametes with each other, which is simply done by filling the cells of the table with the respective lower- or upper-case symbols for the alleles. This resembles what accidentally takes place when a sperm-cell or pollen and an egg-cell unite upon fertilisation in animals or plants, respectively.

1st Generation Offspring	♂ Male gametes (sperm cells)→	R	r
♀ Female gametes (egg cells) ↓	R	RR	Rr
	R	RR	Rr

So, what do the results tell us?

As can be deduced from the Punnett square in the case above the offspring's genotypes would be either "RR" or "Rr" in a 1:1 ratio or 50% each. The probability to inherit the homozygous or the heterozygous genotype would be 50% each. The phenotype, however, would be right-handed in all cases, 100%.

Your task:

1. Take your own results and fill in all missing symbols in Table 2 and 3, respectively.
2. Mate yourself with the (imaginary) partner whose phenotype and genotype are shown in Table 1.
3. When doing the imaginary mating stick to the sentence: "Don't think you're smart, use a Punnett square"! You have to use one Punnett square for each trait (see next page)! There is no "cross-combination of alleles" coding for different traits!
4. To make it easier for you and to reduce the number of Punnett squares to fill in, in case of dominant traits only use the heterozygous genotype, not the homozygous one. This reduces the number of Punnett squares you have to fill in to six (see next page).
5. Finally, use Table 4 to fill in the phenotype and the genotype of your offspring.

Table 2: Your partner

Traits	Thumb	Chin cleft	Middle digit hair	Handedness	Earlobes	Hand clasp
Phenotype						
Genotype						
Gametes (sperm- or egg-cells)						

Table 3: You

Traits	Thumb	Chin cleft	Middle digit hair	Handedness	Earlobes	Hand clasp
Phenotype						
Genotype						
Gametes (sperm- or egg-cells)						

Punnett squares for imaginary mating

Thumb

1st Generation Offspring	♂		
♀			

Chin cleft

1st Generation Offspring	♂		
♀			

Middle hair digit

1st Generation Offspring	♂		
♀			

Handedness

1st Generation Offspring	♂		
♀			

Earlobe

1st Generation Offspring	♂		
♀			

Hand clasp

1st Generation Offspring	♂		
♀			

Table 4: Phenotype and genotype of your offspring

1st Generation Offspring	Thumb	Chin cleft	Middle digit hair	Handedness	Earlobes	Hand clasp
Phenotype (including probability)						
Genotype (including probability)						