The Punnett Square - Contribution 2

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One of the applications of probability relies on a branch of biology called genetics. The Punnett Square is a tool for combining the aleles of the genotypes of two individuals. This is useful since it becomes possible to predict what is the probability of a certain characteristic to occur. For instance, suppose that we want to combine the aleles of the genotypes Gg and Gg; we may construct the following Punnett Square:

	G	g
G	GG	Gg
g	Gg	gg

By analysing the Punnett Square, we may conclude that, from the Gg×Gg combination, the probability of generating a...

- ... GG genotype is $\frac{1}{4}$;
- ... Gg genotype is $\frac{1}{2}$;
- ... gg genotype is $\frac{1}{4}$.

As asserted in reference 1, "a Punnett Square is just a visual way of representing probability calculations". If we want to combine more complicated genotypes, we will need to improve the Punnett Square. Suppose now that we want to combine the following genotypes: GgHH and ggHh. The Punnett Square of this combination will then be:

	GH	GH	gH	gH
gH	GgHH	GgHH	ggHH	ggHH
gh	GgHh	GgHh	ggHh	ggHh
gH	GgHH	GgHH	ggHH	ggHH
gh	GgHh	GgHh	ggHh	ggHh

By analysing the Punnett Square and considering independent events, we may conclude that, from the GgHH×ggHh combination, the probability of generating a...

- ... GGHH genotype is 0;
- ... GGHh genotype is 0;
- ... GGhh genotype is 0;

- ... GgHH genotype is $\frac{1}{4}$;
- ... GgHh genotype is $\frac{1}{4}$;
- ... Gghh genotype is 0;
- ... ggHH genotype is $\frac{1}{4}$;
- ... ggHh genotype is $\frac{1}{4}$;
- ... gghh genotype is 0.

We could also construct two separate Punnett Squares as follows:

	G	g
g	Gg	gg
g	Gg	gg

	H	H
H	HH	HH
h	Hh	Hh

By combining the Gg and gg genotypes, two genotypes may be generated: Gg and gg. The probabilities of generating a Gg and a gg are, respectively, $\frac{1}{2}$ and $\frac{1}{2}$. On the other hand, if we combine the HH and Hh genotypes, we may obtain HH and Hh. The probabilities of generating HH and Hh are, respectively, $\frac{1}{2}$ and $\frac{1}{2}$. Still considering independent events, we may conclude, hence, that the probability of obtaining a...

- ... GgHH genotype is $\frac{1}{2} \times \frac{1}{2} = \frac{1}{4}$;
- ... GgHh genotype is $\frac{1}{2} \times \frac{1}{2} = \frac{1}{4}$;
- ... ggHH genotype is $\frac{1}{2} \times \frac{1}{2} = \frac{1}{4}$;
- ... ggHh genotype is $\frac{1}{2} \times \frac{1}{2} = \frac{1}{4}$;
- ... GGHH genotype is 0;
- ... GGHh genotype is 0;
- ... GGhh genotype is 0;
- ... Gghh genotype is 0;
- ... gghh genotype is 0.

References

1. https://www.khanacademy.org/science/high-school-biology/hs-classical-genetics/hs-introduction-to-heredity/a/probabilities-in-genetics