A Very Short Course in   Cattle Genetics.   By Ron Thorne

In 1860 a Czechoslovakian Monk by the name of Gregor Mendel worked out the simple patterns of inheritance that are passed on in the plant, animal and human world. Mendel decided to cross breed some common garden peas. He took peas that always bred true for the trait of smooth, round seeds and crossed them with other peas that always produced wrinkled seeds. Peas are normally self-pollinating. But Mendel pinched off the pollen producing parts on the blossoms of the plants that produced wrinkled seeds, then fertilised them with pollen from plants that bred true for round seeds. Then he did the same on the plants that produced round seeds. He tied little paper bags over the flowers so the bees wouldn't interfere. When he opened the pods he was surprised to find only round smooth seeds. The alternative trait 'wrinkled' seemed to have disappeared completely. This was what we would now call the F_1, generation. Mendel then planted the round seeds from the experiment and allowed the resulting plants to fertilize themselves as they normally do. When he opened the pods from the second generation (the 'F_2' generation), he was astounded to find both smooth and wrinkled seeds in the one pod. He grew over 7,000 peas and when he counted them he found about 25% of the seeds were wrinkled and 75% round. The trait "wrinkled" which had disappeared in the F_1, generation had once again returned in the 'F_2' generation.

In order to explain the patterns he observed, Mendel proposed that inherited traits are transmitted from parents to offspring by means of independently inherited "factors" that are known as **genes** Furthermore he found that he could predict the results of his experiments if he assumed that true breeding lines of plants contribute either a **Dominant** or **Recessive** factor to their offspring in the F_1, generation. He calculated that each member of the F_1, contained both dominant and recessive factors. He also realized that parent plants (animals or humans) always have two of these genes and always contribute one or the other to their offspring. The enterprising monk then invented a shorthand method of following his hypothetical dominant and recessive factors through various generations. He labelled the **Dominant** factor '**R**' for round seeds and the **Recessive** factor '**r**' for wrinkled (in other words not round). Scientist still use capital letters to represent dominant traits and lower case letters to represent recessive traits. The two (or more) forms of genes responsible for different traits (**R & r** in the example above) are called **Alleles**. Dominant genes will always mask recessive genes. Then Mendel devised the little box on the right called a Punnett Square

You write the symbol for the genes or individual alleles that one parent might donate across the top

Then write the possible alleles from the other parent down the side

Then you marry up the possibilities

As you can see there are four possibilities in the four boxes. And in this F_1, generation the outcome is always the same '**Rr**' This seed is round because the Dominant factor is present. But the seed also carries the allele or genetic make-up to produce wrinkled seeds.

Crossing round peas with wrinkled peas

Parent

	R	R
r	**Rr**	**Rr**
r	**Rr**	**Rr**

(side label: **Parent**)

Then remember Mendel took the F_1, generation seeds and planted them.

Parent

	R	r
R	RR	Rr
r	Rr	rr

(Left column label: **Parent**)

The results were 25% wrinkled. And this is pretty easy to calculate. The Punnett Square on the left gives the results. In the top left box we have **RR**. Then in two other boxes we have **Rr**. All three seeds will be smooth round because Dominant always masks Recessive. It is only the seed in the last box that is **rr** and will be wrinkled. So as you can see 75% of the seeds will be round and 25% will be wrinkled. And now we have another rule; Individuals in whom the two alleles of a given pair are the same (**RR** or **rr**) are **homozygous**, Individuals in whom the two alleles of a given pair are different (**Rr**) are **heterozygous**.

The homozygous round seeds **RR** will always produce round. The heterozygous seeds Rr will be round but carry the allele for wrinkled and if crossed with another heterozygous Rr seed, 25% of the offspring will be wrinkled. These genes are located on the chromosomes in the cells of plants & animals. Peas have 7 pairs of chromosomes. Each chromosome in the pair has one allele for the trait round or wrinkled. Mendel found identical results for 6 other traits in peas. Long or short stems, green or yellow pods, inflated or pinched pods etc etc.

Many of the complex traits in animals and humans come from a number of chromosomes but other traits originate from a single pair of chromosomes. Literally thousands of human traits have been identified as Dominant or Recessive traits.

Menders rules apply to all animals and even Devon cattle. You can use Mendel's Punnett Square to work out predicted traits in your herd.

Now in the case of cattle, horns are actually recessive. And the dominant trait is polled. The symbol used for poled in cattle is the capital letter **P** and the symbol for horns is lower case **p**.

Phenotype is a description of what a person or animal looks like and **Genotype** describes an individual's genetic constitution. So an example cattle of phenotype "Polled" may be either of two genotypes, **PP** or **Pp**. But homed cattle are always genotype **pp** or homozygous horned.

Now lets put a homozygous polled bull over a homozygous homed cow and see what results. If we want polled cattle we are going to be pretty happy because in each of the four possibilities the calves will be polled. We could put the same bull over 20 of our homed cows and the result will always be the same.

Bull

	P	P
p	Pp	Pp
p	Pp	Pp

(Left column label: **Cow**)

We end up with only one genotype. All are heterozygous **Pp**. All the offspring will be polled. But every calf will carry the allele for horns. This is pretty easy to work out what will be the result when these animals are bred with other heterozygous cattle.

In reality we would have been lucky to find a homozygous polled Devon bull because there is probably no more than a handful in the country. So lets see what happens when we put a heterozygous polled bull over our homozygous horned cows.

Here there are two genotypes; **Pp** and **pp** 50% of the offspring will be **Pp**. Similarly 50% will be **pp**. So half of the offspring will be polled and half will be horned. But unbeknown to you

Bull

	P	p
p	Pp	pp
p	Pp	pp

(Left column label: **Cow**)

none are homozygous. In fact it is impossible to produce a homozygous polled bull from this particular match. So all the offspring can pass on the gene for horns. ……But at least it's a start.

Now lets put Rotokawa 667, a great Kiwi polled bull, over your magnificent polled heifer that you paid $2,000 for.
        (Unfortunately both are heterozygous)
Now we end up with three genotypes; **PP**, **Pp** and **pp**

50% of the offspring will be **Pp**. Similarly about 25% will be **PP** and the remaining 25% will be **pp**. 75% of the offspring are either **Pp** or **PP** and therefore will be polled. 25% are **pp** and will be horned. But only one of the four possibilities may be homozygous polled or **PP** If you were sweating on a homozygous polled bull your chances are only one in eight. But the chances are a little better than Lotto.

	Bull	
Cow	**P**	**p**
P	PP	Pp
p	Pp	pp

There is no way of knowing whether a polled animal is homozygous or heterozygous. The Americans now have a test for homozygous polled but at this stage it has only been validated for Charolais, Gelbvieh, Hereford, Limousin, Salers and Simmental cattle. It does not work with any bos indicus cattle. Hopefully it may be validated for Devons shortly.

The only way for us to know is by producing lots of calves by a bull we hope is homozygous polled. The probability of a polled bull being homozygous if no horned calves are produced is;
        2 Calves 75%   5 Calves 96.88%   10 Calves 99.90%

So as you can see it isn't difficult to produce heterozygous polled Devon cattle. But it is difficult to produce a homozygous polled bull and then to prove it is homozygous. It is also easy to understand why there are very few homozygous polled Devons out there. Almost all of our polled cattle are heterozygous. It is also easy to understand that whether an animal has horns or is polled has nothing to do with purity. Cattle actually have 30 pairs of chromosomes with many hundreds of traits that make it a Devon or Angus or Brahman.

Lastly lets look at what happens when we have identified a homozygous polled bull which we cross with a lot of heterozygous polled cows.

All progeny are polled which is good. But we still have two genotypes; **PP** homozygous and **Pp** heterozygous. And although we have 50% homozygous polled animals we don't know which is which. But eventually it is possible to produce a homozygous polled herd.

	Bull	
Cow	**P**	**P**
P	PP	PP
p	Pp	Pp

When selling horned Devon bulls for crossbreeding to farmers with polled cattle such as Angus you can assure them that all cattle in the F_1 generation will be polled. And you can easily demonstrate this with the Punnetts Square.

Where did polled Devons originate from? Well certainly from infusion from other breeds. But this may have occurred many, many years ago and so both our homed and polled cattle are equally pure. You have probably heard of polled animal occurring naturally which are called Sports. I do not want to put a dampener on this and it can happen occasionally. But Sports are mutation and such mutations only occur in cattle once in 100,000 crosses.

Without going into the detail horns in bos-indicus cattie follow a separate set of rules. The homozygous dominant and the homozygous recessive cattle are polled or horned as in bos-Taurus, but the heterozygous bulls have horns and the heterozygous cows are polled. This is called the 'African Horn Gene'.
The Scur gene works in exactly the same way.

Coat colour in cattle comes about because of Dominant and Recessive traits. Here is a very brief overview:

There are Just three basic colours in cattle.

BB	Black is homozygous dominant and includes Angus, Brangus, Simmental, Welsh black, Limousin and Galloway.

Bb	Brownish Red is heterozygous and includes; Brown Swiss, Brahman, Longhorn and Jersey.

bb	Red is homozygous recessive and includes Devons, Gelbvieh Lincoln Red Senepol Salers Santa Gertudis etc.

Basically all cattle are of one of these three colour phenotypes and their genotype is **BB**, **Bb** or **bb**. Now you might ask about all those other colours. Well there is a simple explanation. There are also three different "**Modifying genes**". These include **White Faced** as in Hereford, **Spotted** as in Holstein and Simmental, **Dorsal** Stripe as in Longhorn, Pinzgauer and Charolais. You will now understand why you get a white face and red cow with a Devon/Hereford cross. But you could argue that you haven't seen a Charolais with a dorsal stripe. Well there is one other gene that affects colour. It is called the "**Pigment Dilution Gene**" and is found with Charolais, Simmental and British White. It usually has different levels of expression. Thus the range of light colour that occurs. Charolais does have the Dorsal Stripe but it is masked by the **Pigment Dilution Gene**. Occasionally you will see a white Charolais with a black calf from an Angus bull. The calf will have a white skunk tail or white back stripe from its mother's Dorsal Stripe gene. All of these colour combinations can also be accurately calculated with the Punnett Square. A couple of simple truths are; **Solid covets Spots - Black covers all other colours - Red is the easiest colour to maintain in a crossbreeding program**.

Well I hope you enjoyed the little session and now have an improved understanding of Polled and Horned Inheritance.

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