The X factor

A basic explanation of the link between inherited heart size and racing performance

Ron Groves 2014

**Heredity and the X Factor**

The standardbred is a hybrid animal and, as such, transmit their genetic characters in a different way than pure bred species.

Inherited characteristics are transmitted from generation to generation via a genetic code held in the DNA. This expression of different genes (plus the resulting synthesis of different proteins) is what distinguishes one cell from another, for example, muscle cell from brain cell.

Each individual in a pedigree can influence future generations depending upon dominant genes that can suppress recessive genes.

The intricate versatility of genetic influence from ancestors can be carried and transmitted without being expressed by the carriers. Every new foal inherits exactly half of its genes from each parent but some are more dominant than others in the final makeup.

DNA provides the blueprint and proteins the structure of the foal. Proteins are made up of 20 amino acids. Just like 26 letters of the alphabet may be combined to form the words that make up a variety of works such as a novel, the bible or a song, so the 20 amino acids combine to make proteins that in turn make up the horse. So, there is an astronomical number of possible combinations and the chances of identical genetic makeup for siblings is millions to one.

For more information on horse genetics you may like to follow this hyperlink.
**Siblings and the role of chance**

A simple analogy to explain the difference between siblings is to treat their make up as if it was a poker hand. Rather than the twenty amino acids discussed above, imagine their structure comprising a poker hand with one card selected from each of five different packs.

Imagine the probability of being dealt an unbeatable Royal flush. Not as high as the millions to one odds described above, but still highly improbable.

Imagine, however, if some of the packs contained only aces and court cards. This would significantly improve the likelihood of a far better hand being dealt.

Imagine now that the hand dealt includes four ‘superior’ packs being dealt by four individual horses within the pedigree and the fifth from a full pack thought of as nature. How improved would chances be if all four of these ‘superior’ horses carried reduced decks.

My suggestion is, that if a breeder could create a pedigree using four such ‘superior’ horses in the correct positions then the likelihood of success would be substantially improved.

This would not guarantee success every time however, because there would always be the full ‘nature’ pack factor plus opponents can always drawn higher cards.

The analogy does explain how full siblings can be dealt very different hands and why those foals that have fewer ‘superior’ dealers in their pedigrees are unlikely to beat those that do have them.

Granted, a simplistic analogy, but one I suggest can be used if you are prepared to look for the ‘superior’ dealers in the pedigree of your foal. So how does one select ‘superior’ ancestors?

**The X factor**

The X factor theory refers to a genetic trait that enhances performance by producing a large heart in the foal inheriting the gene. This genetic inheritance can only be passed on by the X chromosome. It is this large heart gene that many claim has proven a solid indicator of racing performance.

It is also thought that (Mitochondrial DNA or the M Factor) responsible for a more efficient cardio vascular system is similarly passed on the X chromosome.

**For a more thorough explanation of Mitochondrial DNA refer to Genetic Heritage by Ken McLean.**

Genetic influence begins with the X and Y chromosomes. The dam carries two X chromosomes, one from her sire and the other from her dam. The stallion carries a different pair, a Y from his sire and an X from his dam.

The inheritance of X and Y sex chromosomes and hence the determination of gender is illustrated in Diagram One below. The two X chromosomes carried by the female are colour coded to make the path easier to follow.

**DIAGRAM ONE: INHERITANCE OF SEX GENES**

In the case of a filly foal (XX), the stallion contributes the X chromosome he had received from his dam. But because a mare has two X chromosomes, she will contribute
either the one she received from her sire or the dominant one she received from her dam.

In the case of a colt foal (XY), the stallion contributes the Y he received from his sire, while the mare provides the X. This means it is the stallion who determines the sex of a foal. However, neither the sex of a foal nor which of the two X chromosomes the dam contributes can be pre-determined.

It is the X chromosome that carries more genetic potential (whether it is inherited from either the stallion or the mare). On the X chromosome are factors that influence build, temperament, and stamina. These are termed X-linked traits.

However, these sex-related chromosomes are not the only genetic inheritance a foal receives from its parents. There are 62 chromosomes in 31 pairs that influence everything else about the foal’s physiology, conformation, colour, temperament and racing prowess. Hence both sire and dam contribute equally.

Each pair of chromosomes is composed of inherited genetic traits from both the sire and the dam (one from the sire and the other from the dam). In other words, a foal inherits important characteristics, including speed and stamina, from each parent.

An X chromosome that carries the mutated large heart gene is symbolically designated as Xh rather than X. The possible combinations that parents carry can symbolically be shown as; Sires (XY) or (XhY) Dams (XX) or (XhX) or (XXh) or (XhXh).

This X factor descends, in a zigzag pattern, from a sire to his daughter and from that daughter to her sons. However, not all stallions have this Xh trait to pass on to their daughters. Only those who trace back to the original Xh sires along their maternal lines can accomplish this.

There are six possible mating outcomes and these are illustrated in the following six diagrams.

Diagram Two depicts the five possible combinations for sire and dam; ordinary stallion (XY), large heart stallion (XhY), ordinary mare (XX), single copy mare (XhX) and double copy mare (XhXh).

Diagram Three depicts an ordinary stallion (XY) with an ordinary mare (XX). That is, neither has an Xh factor. In this scenario there are only two possible outcomes, neither colt nor filly can inherit a large heart. In effect they reproduce in their likeness.

Diagram Four depicts the mating of this same stallion (XY) with a single copy mare (XXh). There are four possible outcomes, the only one not possible being a double copy filly. Also note- there is only a fifty percent probability of any progeny from this mating having an Xh factor.
Diagram Four: XY sire - single copy mare

Diagram Five depicts this same stallion (XY) with a double copy mare (XhXh). In this case there are three possible outcomes with all progeny inheriting the large heart factor and the possibility of a filly foal being double copy like her dam. This scenario emphasizes the powerful influence of Xh on the maternal line.

Diagram Five: XY sire - double copy mare

Diagram Six illustrates the use of a large heart sire (XhY) with an ordinary mare (XX). As you will note there is no possibility of a large heart colt from such a mating, as the sire can only pass this trait onto his daughters.

Diagram Six: Xh sire - XX mare

Diagram Seven represents the mating of a large heart sire (YXh) with a single copy mare (XXh). As depicted, there is a 25% probability for each of the four possible offspring. While any colt offspring has only a 50% chance of carrying the large heart Xh, any filly progeny must always carry at least one Xh.

Diagram Seven: XhY sire - single copy mare

Diagram Eight depicts the mating of a large heart stallion with a double copy mare. In this case there are only two possible outcomes, a large heart colt or a double copy filly, or in effect a duplication of the status quo.

Diagram Eight: XhY sire - double copy mare

As you can see, in all three of these scenarios involving a large heart stallion, the advantage rests with daughters over sons.

Diagram Nine shows the zig zag inheritance path of the Xh factor to a foal. The path of the red line from successive dams on the maternal line is crucial for both colts and fillies. (positions 2-6-14 and 30).

Also of significance when looking at a pedigree for Xh inheritance are the three broodmare sires (positions 5-13 and 29) and especially the dams of these sires (at positions 12-28 and 26). A succession of strong Xh mares in these seven maternal positions enhances the probability of inheriting the large heart factor.

For fillies there is an added bonus of inheriting an Xh factor from the sire. This means that
mares in positions (4-10-22 and 20) can be included along with the sires (positions 1 and 9). Thus filly foals can inherit from sixteen positions in the pedigree while colts can inherit from just ten positions.

If a mare inherits the Xh factor from both her sire and her dam, she is termed a **double copy mare** (XhXh). This means she will pass it on to either a son or a daughter.

Obviously, this does not mean that parents with an Xh will automatically transmit it to all foals unless the dam is a double copy mare. Also, not all foals that inherit the gene turn into champions as there are many other factors such as conformation, nature and desire to win, that are also inherited.

Beginning in the Foundation Era, certain mares have appeared frequently in the pedigrees of top standardbred performers and X factor theory appears to correlate with their occurrence in these positions in the pedigree.

The recipe for success appears to be the inheritance of speed on the Y gene from the sire, and stamina on the X gene from the dam. Those foals from an Xh carrying mare will obviously have an advantage.

**DIAGRAM NINE: LARGE HEART INHERITANCE PATH**
**A Warning on X factor**

While a lot of research has been conducted on the role of Xh in the evolution of the thoroughbred, I know of little research carried out for the standardbred. As such it is important to note the following warning.

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It is planned that American horses carrying an Xh will soon be displayed in the Classic Families program. These single copy and double copy mares or large heart sires, have not been chosen as the result of DNA testing or genetic research.

Rather, selection is based upon three subjective criteria. Firstly, their own pedigree and breeding record, secondly, the racing and breeding performance of their descendants, and thirdly, the presence of selected thoroughbred Xh horses on the inheritance lines of their pedigrees.

This is far from scientific, but does, I hope, offer some assistance to those who wish to indulge X factor theories.

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**A final comment**

As an electronic article, I have added a substantial number of hyperlinks. These allow the reader to click on them to bring up a Classic Family pedigree page relevant to what has being written. This is designed to enable the reader to more easily follow the argument by following the text with an associated pedigree.