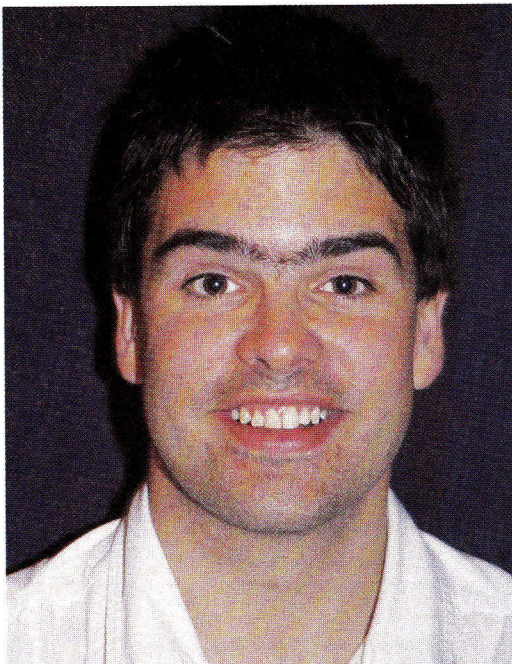


F1

Introducing heredity

Why are we like our parents, and why do we differ from them? This is the science of heredity.



Picture 1 How did John get his brown eyes?

How John got his brown eyes

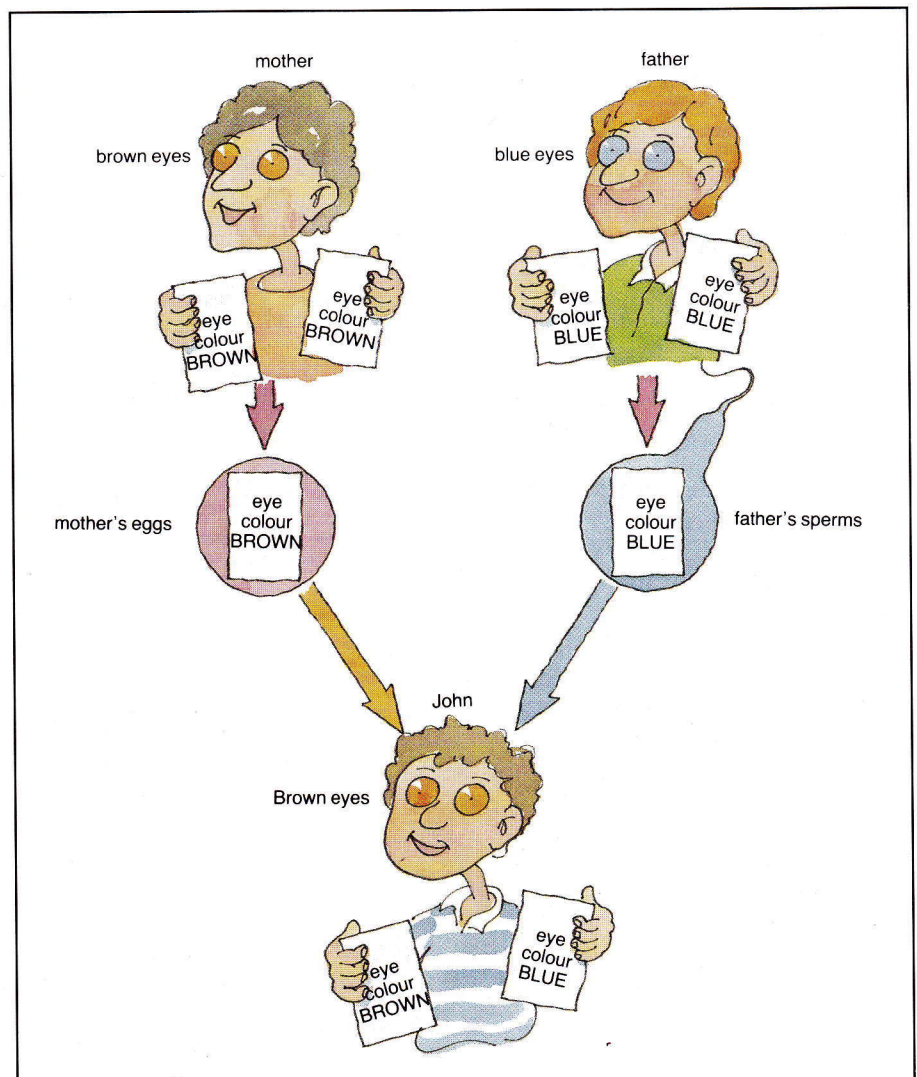
John has brown eyes. His mother has brown eyes too, but his father has blue eyes. How can we explain how John got brown eyes?

Let's suppose that people are born with **instruction cards** telling them what sort of eyes to have. John's mother has two eye-colour instruction cards which make her have brown eyes. John's father has two eye-colour instruction cards which make him have blue eyes. For convenience, we'll call mother's cards 'brown cards', and father's cards 'blue cards'. John's parents and their cards are shown at the top of picture 2.

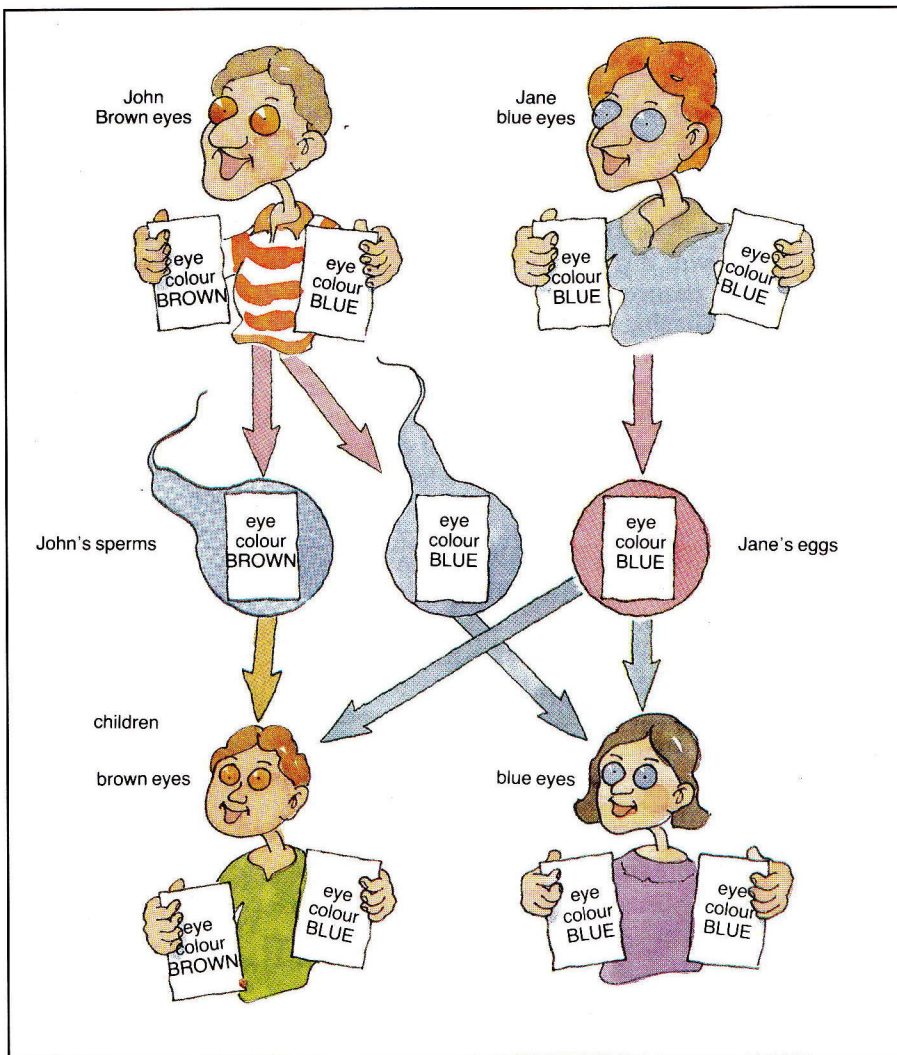
First of all, notice the eggs and sperms. Mother's eggs each contain one brown card, and father's sperms each contain one blue card. This is one of the most important things about heredity: *a person has two cards for controlling a particular feature, whereas the sperms and eggs have only one.*

John was conceived when one of his father's sperms fertilised one of his mother's eggs. When this happened, one of father's blue cards was combined with one of mother's brown cards. So John has two cards, a brown one from his mother and a blue one from his father.

John has a blue card as well as a brown card. Why, then, does he have brown eyes? The reason is that the brown card *overrides* the blue card. Putting it another way, the brown card is **dominant** to the blue card. So although John carries the blue card, it has no effect on his eyes.



Picture 2 How John got his brown eyes.



Picture 3 How John and Jane pass their eye colours on to their children..

John marries Jane

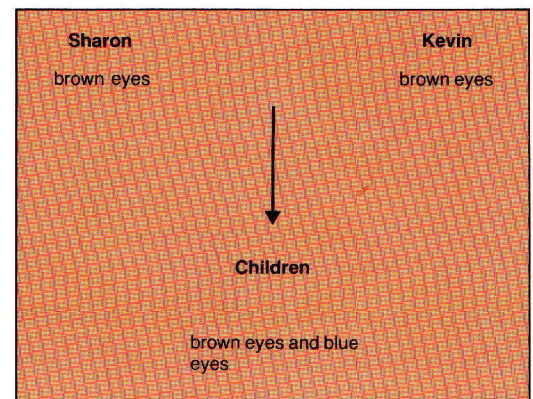
John marries Jane who has blue eyes. They have two children: one has brown eyes and the other has blue eyes. How can we explain this?

The explanation is given in picture 3. John has a brown card and a blue card, as we've already seen. Now half John's sperm contain one brown card, and the other half contain one blue card. This is because the two types of card are equally distributed amongst the sperm, rather like dealing cards. All Jane's eggs contain a blue card.

When fertilisation takes place, Jane's egg may receive one of John's brown cards or one of his blue cards. Fertilisation is random — it's pure chance as to which kind of sperm fertilises the egg. So there's an equal chance of a brown card or a blue card combining with the egg's blue card. This means that there's a 50:50 chance (one in two) of any of the children being brown-eyed or blue-eyed. It happens that one of the children has brown eyes, and the other blue eyes. But both could have had brown eyes, or both blue eyes — it's just like tossing coins.

John has a sister

John has a sister called Sharon. Sharon has brown eyes, like John's. Sharon marries Kevin who also has brown eyes. They have lots of children: most of them have brown eyes, but to their surprise one has blue eyes, as shown on the right. How can we explain this? Think about it before you turn over the page.

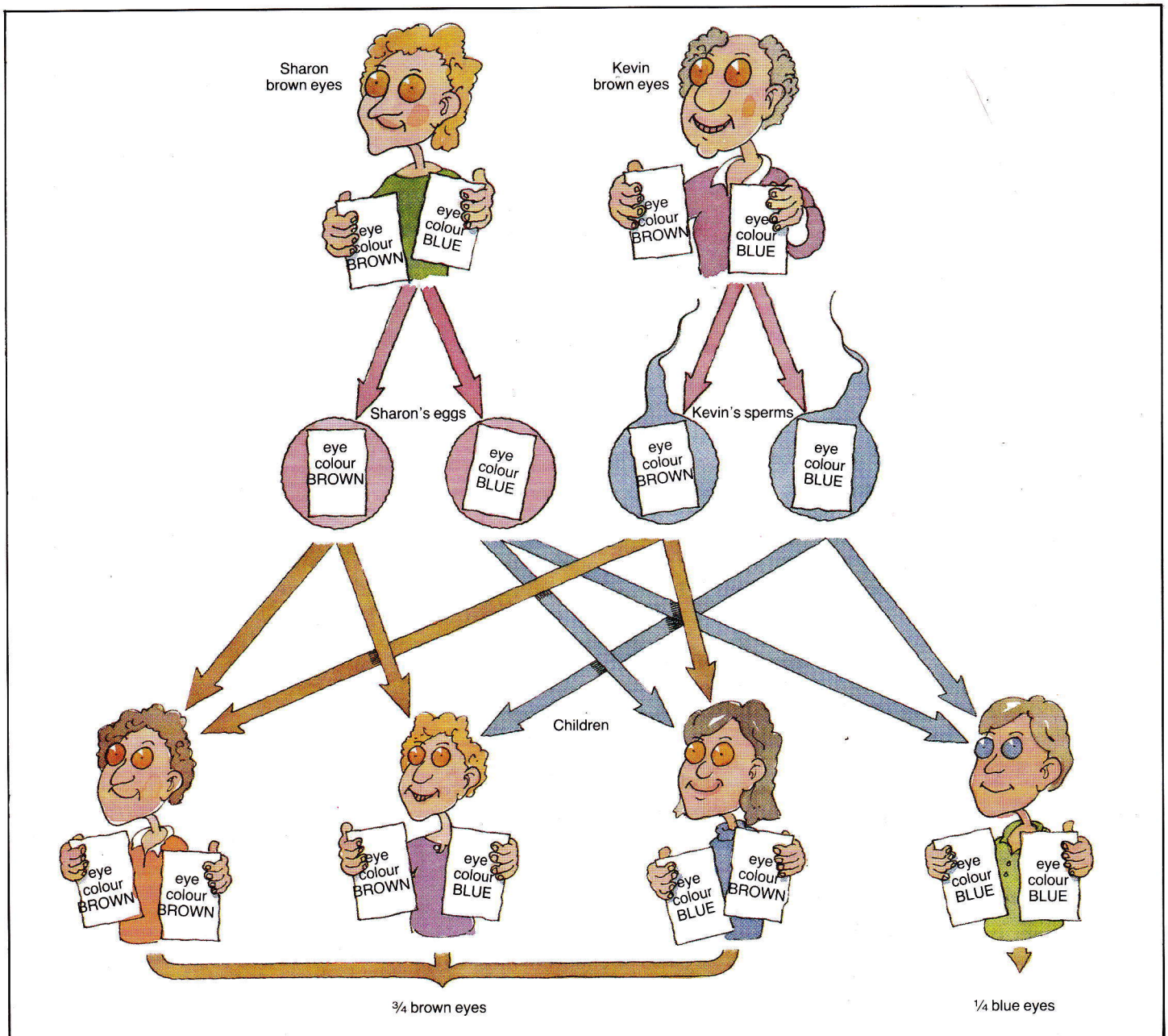


The explanation is given in picture 4. Half of Sharon's eggs contain the brown card, and half contain the blue card. Half of Kevin's sperms contain the brown card, and half contain the blue card. The different ways the cards may combine when fertilisation takes place is shown at the bottom of the picture. Fertilisation is random, so there's an equal chance of each combination taking place.

What colours are the children's eyes? Remember that the brown card is dominant to the blue card: as long as a child has at least one brown card, the eyes will be brown. If you look at the bottom of picture 4 you will see that there is a 3 in 4 chance of a child having brown eyes. And there is a 1 in 4 chance of a child having two blue cards, and thus having blue eyes.

Another way of looking at it is like this. If Sharon and Kevin had hundreds of children, approximately $\frac{3}{4}$ of them would have brown eyes, and $\frac{1}{4}$ would have blue eyes. This is hardly likely to happen in practice, because humans don't produce large numbers of offspring. But it does happen with certain other organisms, as we shall see later.

Picture 4 How Sharon and Kevin pass their eye colours to their children.



What are the instruction cards?

What we have been calling *instruction* cards are really our **genes**. Genes are found in all our cells and they control the way we develop, causing us to have certain features. Later we shall see what genes are made of. For the moment let's use the idea of instruction cards to illustrate some important things about genes.

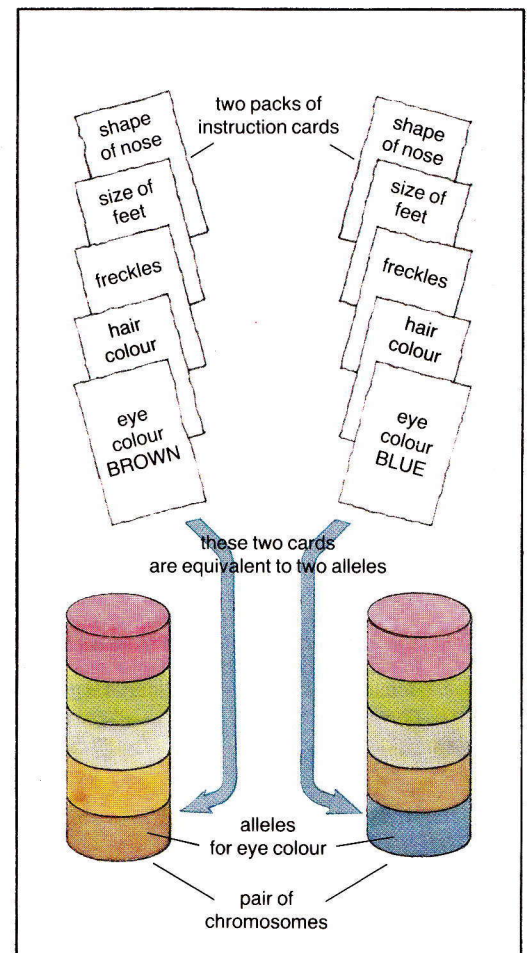
There are different versions of the instruction card for eye-colour. One version says 'have brown eyes', another version says 'have blue eyes'. In the same way the gene that controls eye colour may exist in different forms, each one telling the person to develop a particular eye colour. These different forms of a gene are called **alleles**.

The cards are in packs

We don't just have instruction cards for eye-colour. We have cards for hundreds of other features as well. These cards are arranged in 'packs':

In the same way, our genes are grouped together into **chromosomes**. Chromosomes occur in the nuclei of all living cells (see page 236). They are like pieces of thread. The genes are strung out along the chromosomes, like strings of beads. Each gene controls a particular feature such as eye-colour, hair-colour, the length of the nose and so on (picture 5).

The card that says 'have brown eyes' is in a separate pack from the card that says 'have blue eyes'. But these two cards are in exactly the same position within each pack. In the same way, the alleles that call for brown or blue eyes are in the same positions within two separate chromosomes. These two chromosomes look exactly alike: they belong to a *pair*. And just as the chromosomes are in pairs, so too are the alleles which they carry.



Picture 5 Genes in a chromosome can be likened to instructions cards in a pack.

Life is full of surprises!

From this topic you may have got the idea that blue-eyed parents can only produce blue-eyed children. This isn't always the case. Sometimes one or more of the children have brown eyes! The reason is that the inheritance of eye colour is complicated — in fact it's not fully understood. Eye colour is controlled not just by a single gene, but by a *group* of genes acting together. Sometimes the group of genes produces an effect which we may not be expecting. And of course there are other eye colours besides blue and brown — green and hazel, for example. The author of this book breaks all the simple rules by having eyes of two different colours — one green and one brown.

Questions

- The blue-eyed child in picture 3 thinks she got her blue eyes from her mother. Is this true? Explain your answer.
- John's sister has brown eyes. Could she have had blue eyes? Explain your answer.
- Suppose Kevin in picture 4 had two brown cards instead of a brown card and a blue card. What difference would this make to the colour of the children's eyes? Explain your answer.
- Human features sometimes 'skip a generation'. What does this mean, and why does it happen? Use the pictures in this topic to illustrate your answer.
- In picture 3 both children *might* have had brown eyes, or both *might* have had blue eyes. Explain this. (Hint: when you toss a coin, what decides whether you get heads or tails?)
- A black mouse mates with a brown mouse, and all the offspring are black.
 - Why are no brown offspring produced? Use instruction cards to illustrate your answer.
 - If two of the black offspring mate with each other, what kind of offspring would you expect and in what proportions? Draw a diagram to show what happens.