- Genetics

What can we learn from our DNA?

Did we really inherit that singing voice? What about our maths brain? Some of the answers are in our DNA but how much can scientists actually tell? Jackson Graham reports.

The Timaru Herald · 19 Jun 2023 · 1

Acopy of Jeffrey Craig's genetic sequence sits on his laptop, a file mapping variations of genes unique to him. The professor has the sequence for safekeeping; it once helped him learn that a blood clot he suffered after a flight wasn't from an inherited condition.

But as for what else it might predict, for now he doesn't want to know. ''It's a Pandora's box,'' Craig says. ''If you get your gene sequence you need to be thinking about, really, what do you want to know?''

Genetic testing is becoming increasingly powerful. It can pinpoint whether someone has a rare disease or whether they carry a gene that could result in their offspring having a lifethreatening condition.

It is also now being used to score someone's risk of contracting more common ailments such as heart disease or depression. Some people use the tests to inform their choices about lifestyle or starting a family.

Meanwhile, the traits we inherit, for better or worse, are becoming clearer with genetic testing too. Our genes never fully determine who we are, but it seems the aptitudes and characteristics we love to attribute to them – the singing ability we share with our sister, the maths brain we ''inherited'' from our mother, the gift of the gab our grandpa was famous for – are influenced by our biology.

So, what can our genes really tell us about ourselves? Is how we act – as well as how healthy we are – coded in our DNA? And what can't our genes tell us?

What are our genes, genome and DNA?

When a sperm and egg meet they form a single cell, tying together DNA from each parent. As the cell multiplies trillions of times to make up a human body, each new cell contains a complete copy of our DNA. Magnified a million times, DNA is arranged on a double helix, two long strings that twist.

''The sequence of that string carries information that your cells can use to make things,'' says Centre for Population Genomics director Daniel MacArthur. Along this string are 3.2 billion locations where information is set out.

Our genome is the entire information sequence on the string. Despite its microscopic size, if unwound it would extend for about two metres. In all of our cells, this string is divided into stretches called chromosomes – most of us carry 23 of these inherited from our mother, and a matching set inherited from our father – wound tightly into orderly structures that keep it safe and stop the string from tangling.

Genes make up yet smaller sections of the string. Many genes are simply involved in regulating cells, but 23,000 lay down instructions for cells to make proteins.

''Proteins are mostly the doing molecules in the cell,'' MacArthur says. ''They do things such as helping your cells move, or make energy, or clean toxins from your blood.''

What's genetic variation?

Humans are far more genetically alike than we are different.

The genes between any two people are 99.9% the same. But if any two people are 99.9% similar to one another, what of the remaining .1%? These genetic variations make each of us different from one another, influencing anything from our physical characteristics and health and (to some extent) our talents. In producing each of us, our parents were capable of having trillions of genetically unique offspring.

Just a few genetic variations determine the colour of our eyes, hair and skin but more often, hundreds or thousands are involved. More than 12,000 influence height, for example, yet many add less than a centimetre to someone's stature.

''If you have many of these different kinds of [genetic variations], each contributing even just a few millimetres, then the combination of them can make you 10 centimetres or 20 centimetres taller,'' says forensic genetics professor Dennis McNevin of the University of Technology Sydney.

McNevin has processed DNA samples of suspects for police investigations and helped identify bodies. His testing can reveal a person's sex, whether their ancestors are from eight broad regions, and their hair and eye colour.

''It becomes too difficult and it's too inaccurate after that to predict other traits,'' McNevin says, although he foresees ''the holy grail'' of predicting someone's face might be feasible one day.

Not all genetic variations are traits we're born with. You might have heard that certain variations influence diseases such as cancer. As humans grow and age, cells turn over. ''We're always making new cells and replacing the ones that we've got rid of,'' MacArthur says. Every time a cell replicates, it makes a near-perfect copy of our DNA. ''It's astonishing that this process happens so accurately.''

Errors can occur, although they are usually benign. But a genetic change that falls in the wrong place could lead to cancer. ''It can result in a cell that no longer knows how to stop dividing,'' MacArthur says. ''It just keeps on making more and more copies of itself.''

What can our genes tell us about our health?

When genetic research was first emerging, scientists wanted to find single genes that influenced diseases. They found several thousand monogenic (single gene) disorders, which cause rare conditions such as muscular dystrophy.

But for more common diseases such as cancer and heart attacks, they found multiple genes (polygenic)
influencing a person's risk.

Several genetic variations that cause disease are so dominant it takes just one parent to pass them on. Children of a parent with the mutation for Huntington's disease, for instance – which gradually shuts down the brain – have a 50% chance of inheriting the condition.

While blue eyes or red hair are famously passed down in recessive genes – traits that skip generations – we can also carry a genetic disease without knowing it.

We have two copies of every gene, inheriting one from each parent, giving many damaged genes a back-up. But if we partner with somebody with the same genetic error, our offspring can inherit both damaged genes, causing conditions such as cystic fibrosis to surface.

''These are what we call silent diseases that can just suddenly appear apparently out of nowhere,'' MacArthur says. ''[They] can pass down within a family for many generations

without anyone ever actually being sick.'' Would-be parents can screen for their risk of passing on serious conditions to a child. ''This isn't Gattaca,'' MacArthur says of the sci-fi film about genetic perfectionism. ''It's providing future parents with information about whether the children may be at risk of really awful diseases.''

In diseases involving multiple genes, particular variations can cause more havoc than others. The BRCA1 and BRCA2 mutations, for example, can put women at up to 70% risk of developing breast cancer and an increased risk of ovarian cancer.

Similarly, changes in several genes involved in cholesterol put women at a 30% risk of having a heart attack by age 60, and men at a 50% risk by age 50.

Identifying genetic risks (more on that later) can encourage susceptible people to screen for diseases more regularly, to make lifestyle changes, and to receive medication or preventative surgery earlier.

But what can genes tell you about behaviour?

Four weeks after entering the world in 1939, identical twins James Springer and James Lewis were adopted into separate Ohio homes.

They lived in different towns until reuniting 39 years later. What they discovered still stuns Nancy Segal, a developmental psychology professor at California State University, who met the twins twice. They both had a habit of biting their nails, suffered similar headaches and had worked part-time in law enforcement and at McDonald's.

Their first wives' names were Linda, they remarried women named Betty, and they named their first sons James. They even holidayed within blocks of each other in Florida.

A coincidence, surely? Perhaps in some instances, Segal says, but too many similarities popped up to ignore. The Jims inspired a landmark study of 137 twins reared apart, which Segal was involved in for a decade, finding shared traits across intelligence, leisure activity preferences and social attitudes.

She says chance can't explain why some twins who've never met can share rare traits. ''When you see these things in identical twins raised apart, it tells you something, especially when you don't see them in fraternal twins raised apart or together.''

Unlike with some physical traits, genes do not share links as strongly with behaviour. Still, twins offer a unique opportunity for researchers to peel apart nature and nurture, and when they do it's hard to find a trait where genetics isn't at play.

But 50 years of twin studies, mostly in those raised together, have landed on genes influencing just shy of half of any given trait.

Our attitudes towards religion and politics, desire to play sport, or even our zest for life fit this trend, Segal says. ''We showed in our study that interests have a genetic component; interests in reading, even twins who had interests and never did anything [with it], both said they always wanted to be an actor.''

Most people can't tell which sister is singing when identical twins Paula and Lee Bowman perform in their country rock band, Jetty Road. In high school, their ability to harmonise stunned a music teacher so much that they made a trio and began touring country Victoria.

‘‘We could always hold a tune to start off with,’’ Lee says. ‘‘We have these instincts when we sing that are the same . . . it feels like an extension of us.’’

They were among more than 500 twins in a study published in 2022 that concluded that genetics wields a 40% influence over singing talent. Using an online tool, twins from all around Australia recorded themselves singing Happy Birthday, then hitting a single note and picking up an unfamiliar tune. The study measured how well they reached notes and intervals.

Performance, of course, didn’t just come down to genetics. Shared experiences with music, such as families singing together in the car, influenced 37% of the twins’ talent.

Then maybe one twin took music lessons and the other didn’t – differences the remaining 23% accounts for.

Nature and nurture work together to influence most traits.

‘‘Having both sets you up for success,’’ explains Sarah Wilson, a professor of clinical neuropsychology at the University of Melbourne, who led the singing study.

What about IQ or mental health?

Nick Martin was at uni in Adelaide in the early 1970s when he conducted his first study into intelligence in twins. He used the state’s school exams roll, contacting everyone with the same surname, birthdate and address.

Identical twins logged far more similar academic results than non-identical twins, suggesting genetics were at play. ‘‘I thought, wow, that’s right on your doorstep.’’

Martin, now a behavioural geneticist at QIMR Berghofer Medical Research Institute, says IQ is up to 80% genetically influenced, even taking into account education and socioeconomic status.

Separate studies have found genetics has a 20% influence on IQ during infancy and increases as we age. ‘‘IQ is the main driver of cognitive ability. But you can get genes that influence specialisation in maths, literature, or art or music,’’ Martin says.

‘‘These abilities, including, say, football ability, do often run in families at a much higher probability than one would expect by chance, but . . . we can also find striking contrasts within families.’’

From his perspective, education policies that assume everyone is equally malleable are unhelpful, and he advocates for non-academic pathways to have equal standing.

Martin now uses genomewide association studies offering ‘‘waterfalls’’ of information, scanning hundreds of thousands of genetic variations across huge databases.

The results show the many genes that together influence mental health. He found a high genetic association for schizophrenia, for example, and around 37% for depression (again, having these variations doesn’t mean you will develop the condition).

Martin says awareness that genes can affect mental health can be helpful. Opportunities for people to test – keeping in mind their risk doesn’t equal predestination – can help them take steps, such as exercising or nurturing friendships, as a first line of defence. – Nine