

## TEACHING EVOLUTION

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Last year, the first draft of the Human Genome was finally published. At long last, we had penetrated the inner sanctum of human biology. Equipped with this scientific unearthing, we were in the unique position to understand the workings of the brain, predict how people behave and treat debilitating disorders. But what does the Human Genome Project mean for us? Is there anything we can learn from it that is relevant to us as we now embark on the High Holidays?

One supposed implication is that science will now show us how dependent we are on our genes. Rarely a day goes by without a scientist, using misleading shorthand, finding 'a gene for' aggression, xenophobia, obesity or whatever the case may be. We are inundated with claims to the effect that, like enlightened computers, humans are hostages to their genetically determined hormone systems and prisoners of their brains.

The dictum that says that genes determine behaviour is a perilous one. Fortunately, it is also untrue. It is erroneous because the same genes that determine our brains also enable us to learn, to be creative and to make a mess of our lives if we so choose. It is our freedom that makes us unique among the animals. Human beings are to a large extent – two world wars and multifarious genocides notwithstanding – morally sensitive beings. Or so we like to think. Given a fair choice, we think of ourselves as free to choose the better course of action. But is human freedom reconcilable with ordinary genetic determinism, which says that genes determine brains that determine behaviour?

It may be tempting to suppose that we simply have more genes than other animals. Perhaps this guarantees our higher mental abilities? However, closer analysis of other genomes has rendered this explanation untenable. Humans have 3.1 billion base pairs of genetic code. A base pair is a joining of two nucleotides – known by the letters A, C, T and G. These repeat over and over in various combinations to make amino acids, which in turn combine to make proteins. The size of the genome, the number of base pairs, is practically speaking irrelevant to biology. Corn has the same number of genes as humans. The lily plant has 91 billion pairs of genetic code.

So if human freedom has nothing to do with the number of genes that we have, can it be caused by the size of our brains? Unfortunately, this too does not seem to correspond to our vain determination to construct a classification scheme that will place us triumphantly atop the cognitive cabal. Whales and elephants have bigger brains than we do. Even if we take animal's body weight into account and measure the brain-to-body ratio, we are still beaten by the small gregarious porpoise with its gigantic cerebellum. So bigger is not necessarily better. Like the blunt-snouted whale, we also have a massively disproportional cerebellum, which enable us to walk around on two legs without falling over (though alcohol has been shown to cause momentary cerebellar paralysis).

Moreover, it cannot be the number of brain cells because, as the brain weight goes up, the density of neurons tends to decrease. To solve this embarrassing conundrum, industrious scientists have proposed to use a concept called the encephalisation quotient (EQ). It compares the relation of the brain size of each species to the size expected for an average mammal of the same body weight. Using this method of comparison, human beings have brains about three times as large as one would expect for a primate of our build. Yasher koach to us!

Human beings are unlike the rest of the animal kingdom because we possess a unique mental character endowed by our genes, which gives us freedom of action. Of course, it is vital to remember that there is nothing unique about being unique. All animals are unique in their own way. If chimpanzees were to acquire the skills that humans possess they would need to expand their brains so that they would be able to think with the aid of language, develop advanced tools and remember complex relationships. Of course, it is

possible that, when faced with the option of becoming human, a rational chimp would take one look at human society and turn down the offer.

Human beings share some 98.5 percent of their genes with the (other) apes. Could it be that this one and a half percent constitutes the entire difference? To answer this we need to look at what these genes do. What divides the apes and us is that we have the ability to learn languages, effectively communicate our thoughts and remember a wealth of crucial information about our favourite Premiership team. In human beings, the proportionally more developed areas include the neocortex and the association cortices. These brain regions are responsible for these higher cognitive abilities, including memory, creativity and conscience. And it turns out that this is exactly what these additional one and a half percent code for. These human genes govern our neocortical development and brain structure. As well as hairlessness. Not to mention an unwise penchant for hors d'oeuvres.

In addition, human brains are lateralised, that is to say that the left and right halves of the brain are functionally asymmetrical. Each half does something different. For example, neurological data indicate that lesions on the left side of the brain cause verbal deficits whereas right side lesions affect performance on tasks that require spatial and pictorial skills. This lateral specialisation makes it possible for humans to learn crucial skills in areas such as abstract thought and language. These attributes are owed to the singular development of the human brain. Like Japanese cars, human brains are built smaller but smarter.

The range of human behavioural choices far outstrips that of any other primate. We are able to learn, change and adapt. This point was driven home to the American scientist couple Winthrop and Luella Kellogg in the 1930s. They brought a young female chimpanzee called Gua into their home with the noble intention of teaching it language. It lived with the family for several months. Not only did the poor animal not learn to string together a single sentence, but the real-life experiment had to be terminated because their son Donald started grunting "uhuh-uhuh" whenever he saw his parents.

The cameo grows more interesting still. The most remarkable fact of the human brain is its potential for plasticity. At birth, our brains are as big as one would expect from our body weight. It is approximately comparable to other mammals. But that's not the end of the story. In primates, the brain grows only modestly in the first years of life and then stops. In humans, on the other hand, the brain continues to grow. In fact, it develops and changes in light of experience all the way until the mid-teens. During this period, abilities such as sociality and language are laid down.

The brain of a newborn human has a large number of superfluous synaptic connections. The cortical neurons are wired together in elaborate networks mainly without a pre-set pattern. In the first few years of life, the period that psychoanalysts call the 'the crucial years', neurons that are activated at the same time, strengthen their interconnections. In this way, impressions and experiences shape the brain. Conversely, connections between neurons that are not co-activated wither away. This process is called 'synaptic pruning'.

Parenting is nothing less than an act of mind sculpting. Paradoxically, this plastic character of the brain is genetically hardwired. The human genome predisposes us to have a remarkable degree of freedom.

As the famous French philosopher Jean-Paul Sartre observed: "We are condemned to be free."

Even after the brain is fully developed it is capable of extraordinary change. To halt brain atrophy in old age, for example, the best remedy is to learn new skills. This activates the brain and causes it reorganise and repair itself. Who could have guessed that woodcarving, knitting or learning a second language was neuroprotective! It is interesting to speculate whether this health benefit might have been a causal factor in the development of habits that elderly people are supposedly wont to engage in. Sometimes the body just knows best.

Where does this leave the Human Genome and the creeping spectre of genetic determinism? Our unique mental profile owes its nature to our brains, which, in turn, are built by proteins according to instructions laid down in our DNA. Incidentally, DNA itself does not make anything whatsoever. Without proteins, DNA is completely inactive; it is as useless as a recipe forgotten in a dusty kitchen drawer. To propagate itself, the DNA has to make use of an organism. The common evolutionary strategy is to equip the animal with ready-made instructions in the form of unalterable instincts. These traits enable the animal to survive at least until reproduction – preferably until the offspring is reared.

An alternative evolutionary strategy, or ‘strategy’ if you object to the misleading shorthand, is to allow for a great degree of adaptability. This has most likely been the favoured strategy of evolution of humans. We survived on the Pleistocene savannahs and we are able to adapt to our fast-paced post-industrial society – just. Our adaptability in the face of changing circumstances has made us an evolutionary success story.

Thus the passage of the years, in crude neurobiological parlance, is an opportunity for synaptic and behavioural re-wiring. The lessons from genetics can sustain our belief in our potential for change. What you do moulds you as a person. As Ludwig Feuerbach concluded, “We are what we eat.” And not merely in terms of which amino acids we consume. Also in terms of how we treat our sources of food. Or whom we share it with.

Through heightened self-awareness and effort, ingrained behavioural patterns can be changed. And this is the flip side of adaptability: we have to take responsibility for our actions. We cannot merely sit back and rely on our instincts. We are required to learn and re-learn – all through the life span. The ancient rabbis understood this a long time ago.

As children, perhaps the hardest thing of all is to believe that we can contribute something unique and valuable to the world. This thought - this flight of fancy! - is not easy to espouse with confidence. Yet uncertainty and feelings of failure tug at our sleeves even in adulthood. We need to implant in our children – and tell ourselves year upon year – that we are capable of great things. Should we fail we are also capable of change. Our genes do not hem us in. Instead, they serve to empower us.

So when we face up to our constraints, it is relevant to remind ourselves that cognitive and emotional change is achievable. Not only is it achievable, it is built into our system.