

History is inscribed on the body and branded in the mind.

A brief description of epigenetics within heredity by Emeritus Professor John Boulton.

I first heard of Fitzroy Crossing in October 1970 when at the beginning of my career as a specialist paediatrician at the Princess Margaret Children's Hospital in Perth. On rounds one day, after examining a boy with acute rheumatic fever, my senior asked him "What's the best place in Australia?" The boy replied "Fitzroy Crossing!" Although I must have been offended by the cheap laugh at the boy's expense to remember this trivial episode, his answer contained a truth that grew in importance to me during the years in which I regularly visited the town and the communities in its vast hinterland to conduct Paediatric clinics.

The kernel of this truth is that despite the town growing out of the terrible trauma of the refugee camps that started there in Dec 1968 after the forcible eviction of peoples from the cattle stations built on their country,¹ the people of Fitzroy Crossing have since forged a post-colonial space (the expression coined by Kowal²). In Fitzroy Crossing this space is one in which Aboriginal and Kartiya (non-Aboriginal) learn from each other's world-views and expertise in an atmosphere of respect, grounded in friendship. In this space it is possible to engage in conversations about topics that are freighted with deep hurt, and are therefore usually off-limits in the p.c. conversations of the cities. Heredity and genetics is one such topic. The deep hurt echoes to this day of the deep offense to Aboriginal people from the amplification of racism and hence the structural violence of the last decades of the nineteenth century that followed the publication of Darwin's "Origins" in 1859. This found expression in the normalisation under the guise of science of such atrocities as grave robbing by earnest British and European doctors and natural historians. This moral stain lingers not only in the human remains still kept in European museums, but in the "orphan DNA" of anonymous blood samples kept frozen in science laboratories.³

With the weight of this history on my mind, last dry season whilst having dinner on the wide verandah of the hotel in Fitzroy Crossing with Kartiya, Nyoongar, Walmajarri and Bunuba colleagues and friends, I noticed a tiny woman (she must have weighed well under 40 kg) begging for "baccy". This glimpse of the 1950s shocked me, and I mentioned this the

¹ Hawke S. 2013. A town is born. The Fitzroy Crossing Story. Broome: Magabala Books.

² Kowal, E. 2008. "The Politics of the Gap: Indigenous Australians, Liberal Multiculturalism, and the End of the Self-Determination Era." *American Anthropologist* 110 (3): 338-48.

³ Emma Kowal. Orphan DNA: Indigenous samples, ethical biovalue and postcolonial science. *Social Studies of Science*. DOI: 10.1177/0306312712471739 2013 43: 577 originally published online 28 February 2013

following day to one of the senior Aboriginal women at the child health conference. I told her that the woman's history was inscribed on her body through intergenerational malnutrition, from epigenetic mechanisms. She asked me to write a summary of this phenomenon, which is how I came to write this short piece.

Heredity is a human given. The similarity of facial features, mannerisms and temperament down the generations is a medium of family pride and pleasure. This was described eighteen centuries ago by a Roman author in the Life of St Thecla (Vitae Thecla)⁴:

“The succession of children born from us, by which the image of those who begot them is renewed in their offspring, so that it seems as if those who have passed away a long time ago still move among the living, as if risen from the dead.”

If in this beautiful quotation we catch a glimpse of the pre-Christian “Everywhen”; Stanner's characterization of the Dreaming as the circularity of time which we have long since lost, how do we reconcile this ancient knowledge of Nature (heredity) and Nurture (the effects of the environment) with contemporary science?

The conflict is over now between advocates of Nature who argued that our genetic make-up (the code written in our genome) determined our fate, and those who argued that at birth the human baby was a blank slate (*tabula rasa*) on which would be written her future from the influences of the behaviour of kin and the effects of the culture of her society (the Skinnerian psychologist and erstwhile social anthropologists' view). It is now not a question of Nature or Nurture, but how Nature, in the form of the immediate emotional, visual, auditory and intellectual environment of early childhood, as well as the nutritional and physical environment, shapes the child's inborn (genetic, heritable) potential.

The selection of genetic traits within a population through the accumulation of small advantages to reproductive success leads to measurable change. For example when the first humans arrived in what is now the peninsula of western Europe, and followed the reindeer as they moved north with the retreating ice-caps, living a way of life quite similar to the people who lived in what we now call the Kimberley region of that era, they had dark skin.

⁴ Brown P. The Body and Society. Men, Women, and Sexual Renunciation in Early Christianity. Columbia University Press. NY 1988. p7.

At that high latitude with its weak sunlight, there was an advantage to lighter skin. A lack of vitamin D prevents the bones growing strongly so the leg and pelvis bones would get deformed, and cause difficulty in childbirth. The advantage of pale skin resulted in people's skin to become progressively paler the further north they lived over the course of perhaps 10 000 to 20 000 years.

At the other end of the genetic spectrum, the major errors that occur in the process of sorting the chromosomes, and the genes which lie along them, during their separation as the ovum (egg) and sperm are formed leads to the death of the embryo (in up to one third), or birth defects with physical and / or intellectual disability in those that survive. However few common heritable diseases are caused by single defective genes. It therefore is easier to understand disorders of health through the evolutionary prism, such that natural selection acts on phenotypes, not on genes, and that people represent a series of phenotypes. Thus disease represents an outcome of traits that are influenced by genes but also by the expression of those genes. The expression of some genes is influenced by the environment, and because this process runs alongside the mechanism of Mendelian inheritance (after the monk Gregor Mendel), it is thus called "epi-genetic".

This is how epigenetics works: during the production of the ovum in the ovary the number of chromosomes is halved to 23 so that when it is fertilized by the sperm, another 23 are added to the necessary total of 46. This process is called meiosis. Each gene (allele) is paired, one from the ovum and one from the sperm, and each has the opportunity to work in partnership with its opposite number to produce its effects. In some cases only one allele is needed in which case the other one is "silenced". This happens by a small change to its chemical make-up during meiosis in which a methyl group is attached. Its effect was discovered from studying diseases which were caused by both alleles working so the baby had a double dose of the effect. This chemical process of modifying the gene occurs in the ovary of the fetus, so that the nutritional environment of the pregnant woman can alter the chemical environment in which this process takes place. In other words, the pregnant woman's nutritional status can alter how genes are expressed in the ovum of her fetus, the ovum that itself will create her grandchild.

The effect of the mother's nutritional environment on her future grandchild's health in later life was discovered from observing what happened to the children and grandchildren of women who survived the Dutch Winter Famine of 1944-45 in Amsterdam (a Nazi atrocity).

Depending on the stage when the pregnant mother suffered malnutrition and her fetus was starved, then the risk changed for the onset of diabetes, high blood pressure, heart attack, and obesity in later life.⁵ Other studies have since been done using the records of grain harvests in Sweden to document when villagers would have been well-fed or starved, and then looked at the church records to see how this affected the descendants of people who would have suffered from shortage of food when young.⁶

In India during the nineteenth century there was a series of famines from drought. Economic historians argue that these famines were made worse by the British Raj (rule) because although the network of railways allowed rice and grain to be moved across the country, its price was manipulated and so the poor starved from poverty in not having the money to buy the food. A British nutrition-research paediatrician argues that the constant state of food insecurity over many generations caused what he terms a “nutritional ghetto”.⁷ In other words, an enclave in which the political imposition of lack of sufficient food over many generations has caused a shift in the human phenotype ie what people look like as an adaptation to want of food. In comparison with people in populations in northern Europe that escaped from starvation more than two hundred years ago, people in India are in general of shorter stature, with low muscle bulk, and with a high percentage of their adipose tissue (fat) deposited in the abdomen. The outcome is a high risk of diabetes and cardiovascular disease for all who now have access to adequate food, and only the very poor remain thin.

Across northern Australia the loss of food resources amongst Aboriginal people in the colonial zone was noticeable to all sympathetic observers. Hence my argument that Aboriginal people in northern Australia are also locked into a nutritional ghetto. From those displaced by the Palmer River gold rush on Cape York in the 1870s, to those living across the vast swathe of savanna that was taken over for cattle grazing, and west to the coastal people of the Kimberley taken as slave labourers by the pearlers, all suffered generations of malnutrition.

⁵ Lumey LH et al. Prenatal Famine and Adult Health. *Annu. Rev. Public Health* 2011. 32:237–62. Heijmansa BT. Persistent epigenetic differences associated with prenatal exposure to famine in humans. *PNAS* 2008;105: 17046–49.

⁶ van den Berg GJ, Pinger PR. A Validation Study of Transgenerational Effects of Childhood Conditions on the Third Generation Offspring’s Economic and Health Outcomes Potentially Driven by Epigenetic Imprinting. IZA Discussion Paper No. 7999. February 2014

⁷ Wells JCK. 2010. *The evolutionary biology of human body fatness*. Cambridge Studies in Biological and Evolutionary Anthropology. Cambridge University Press.

This is a part of the historical story that now has no traction. It is of no interest to young Aboriginal or non-Aboriginal people; they think only of the future. The effect is that the intergenerational effects of malnutrition on life-long health from epigenetic effects remain off the health radar. The lack of improvement in the percentage of babies born of low birth weight over the past 50 years goes unremarked and un-investigated, despite low birth weight now being recognised as one of the most important makers for factors that play a part increasing the risk for early-onset diabetes, high blood pressure, and early death from heart attack and stroke. Hence my expression that the history of Aboriginal people is inscribed on their bodies.

History is branded on the mind.

A comparable process takes place in as a consequence of intergenerational stress from fear of lethal violence in the frontier zone, and during the past two generations from the effect of alcohol-induced domestic violence meted on women and children. Hence this history is branded (burnt) on the minds of children. The experimental evidence for this comes from studies of lab animals which were exposed from birth to different levels of stress from fear, and from human experiments on children who suffered emotional neglect and abuse and physical maltreatment.⁸ Child specialists had long known that such children are noticeable for their state of constant vigilance, and as described for the children of the London poor in 1913, for their “restlessness, diminutiveness, and a kind of elfin quickness”.⁹

Over the past decade or so, studies of affected children using sensitive brain scans and psychological measures have shown that they suffer from an impairment of the growth and maturation of the parts of the brain that allow the emotional self-regulation that is essential to function in a complex society. In addition, there is a disorder in the system of chemical messengers in the brain, called the neuro-endocrine axis. The outcome is a tendency to impetuous and violent behaviour, and a lack of ability to plan ahead and take into consideration the consequences of their actions. Their ability to cope with stress is impaired

⁸ Klengel T. et al. The role of DNA methylation in stress-related psychiatric disorders. <http://dx.doi.org/10.1016/j.neuropharm.2014.01.013>

McGowan P et al. Promoter-Wide Hypermethylation of the Ribosomal RNA Gene Promoter in the Suicide Brain. *PLoS ONE* 2008; 3; (5) e2085 pp1-10.

Murgatroyd C. et al. Genes learn from stress. How infantile trauma programs us for depression. *Epigenetics* 2010; 5:194-199

⁹ Reeves, Maud Pember. 2008 (1913). *Round about a pound a week.* (1913 G Bell and Sons). London: Persephone Books.

throughout life, and they are more likely to turn to alcohol as an immediate way of dealing with stress.

There is now a vast industry of bio-medical research being undertaken to clarify in greater detail the extent of these processes and how they alter people's behaviour. Of equal importance is for this dimension to be understood and taken into account by all the people concerned in making a difference to this continuing tragedy, and for it to be used in working out how this terrible vicious circle of escalating self-harm can be stopped so that the present and future generations of children can look forward to the same prospects of self-fulfillment as any other child.