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LETTER TO THE EDITOR

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KNOWLEDGE OF EVOLUTION ASSISTS IN UNDERSTANDING BRAIN VARIATIONS IN NEUROSURGERY

Anatomical structures are considered to be "ideal" types remaining unchanged over extended time. This is far from the truth. For example, neuroanatomical structures such as Circulus Arteriosus Cerebri (CAC) exhibit considerable variation up to 45%, (Qiu *et al.* 2015, Forgo *et al.* 2018) with some variants linked to risk for aneurysms and stroke (Tarulli *et al.* 2014, van Seeters *et al.* 2015). Why do such variants, among others, exist at all? Biological variation is the source and the result of evolution (Saniotis, Hennenberg 2020).

Neurological pathologies are related to evolutionary origins of brain parts. For example, Pick's disease has a predilection to primate-specific structures (i.e., the frontal and temporal lobes), and spares the primary sensory and motor cortices. The subcortical white matter (of the isocortex) is involved in Krabbe's leukodystrophy but allocortical fibers, such as the olfactory tracts, fornix, and mammillothalamic tract are spared (Basma *et al.* 2020).

Importantly, even though natural selection has been relaxed in extant *Homo*, neuroanatomical structures are still undergoing microevolution. Certain heritable traits which can be observed now are a consequence of relaxed natural selection (Rűhli, Henneberg 2013). Some evolutionary scientists have speculated that improved living conditions have led to altered embryonic developmental processes leading to an increased prevalence in the median artery, left vertebral artery origin from the aortic arch, tarsal coalitions and accessory renal arteries (Saniotis, Henneberg 2020, Rűhli, Henneberg 2013). Of relevance to neurosurgeons is the rise in spina bifida occulta during the 20th century, which reflects a decline in differential mortality and fertility that has provided less chance for natural

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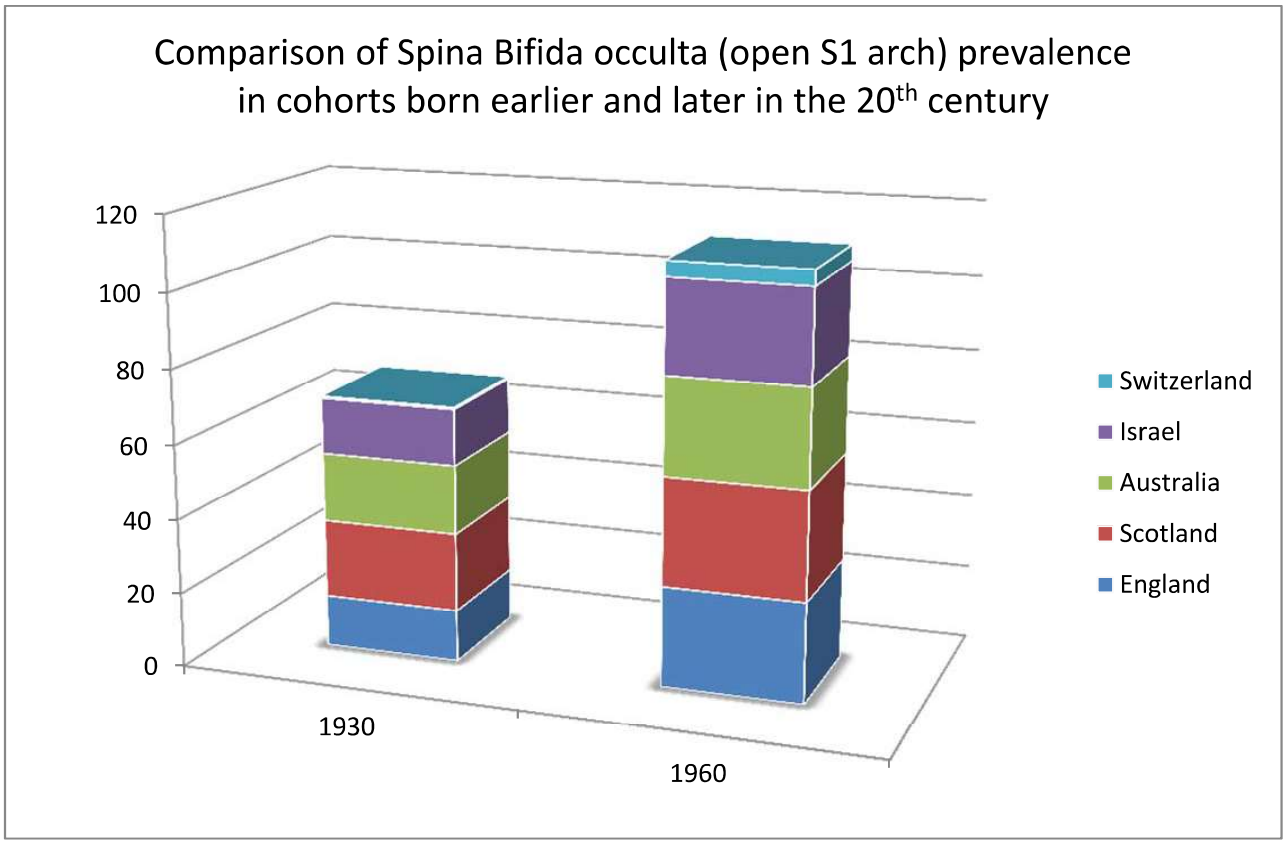

FIGURE 1: The prevalence of the spina bifida occulta (open S1 arch) increased in the 20th century. Data from Henneberg 2011.

selection to remove harmful mutations from the human gene pool (Saniotis *et al*. 2020).

Tumors are effects of evolution since neoplastic processes involve mutations. Tumors tend to grow in specific regions of the brain. Such preferential growth may be related to distinct cytoarchitectonic properties of phylogenetic origins. Glial tumors occur in phylogenetically "recent" systems (i.e., the association cortex) or "older constantly active" regions (i.e., in memory, or limbic system).

In a recent study, Hindenes *et al*. (2020) identify a trend in missing segments in CAC. Based on previous studies on increasing anatomical variations, we may speculate that this increase of missing segments in CAC reflects relaxed selection. This should certainly be brought to the attention of neurosurgeons since it identifies changes to brain hemodynamics and their implications for strokes. Therefore, increasing awareness of the evolutionary basis of neuroanatomical structures and their ongoing microevolution may provide neurosurgeons important information on human development and possible anomalies.

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