Perception, 2000, volume 29, pages 505 – 508

DOI:10.1068/p2905ed

Editorial

Neuro-archeology

One of the most famous and most controversial statements in the history of biology is Ernst Haeckel's, "Ontogeny is the brief and rapid recapitulation of phylogeny". This sounds great but it has had a bad press—and so, it has to be said, has the German zoologist Ernst Heinrich Philip Haeckel (1834 – 1919), that for example he combined a maximum of self-expression with a minimum of self-criticism. Rightly or wrongly he is generally seen as a dodgy thinker and writer, who reinvents circular arguments and uses ten words when one would do. His main work is translated into English as *The History of Creation: or, the development of the Earth and its Inhabitants by the action of natural causes*, etc. Even the title is wordy. Worse, is Haeckel's vitalism.

He did, however, think in terms of evolution, and surely *ontogeny recapitulates phylogeny* is just what should happen, on the Darwinian paradigm. Indeed Darwin himself said in *The Origin of Species* (1859):

> "Embryology rises greatly in interest when we look at the embryo as a picture, more or less obscured, of the progenitor, either in its adult or larval state, of all the members of the same great class."

Perhaps Haeckel should not be so lightly dismissed. Let's look at phylogeny (the origin and development of species) and ontogeny (the origin and development of individuals, in particular of children) perhaps to come to a revised view.

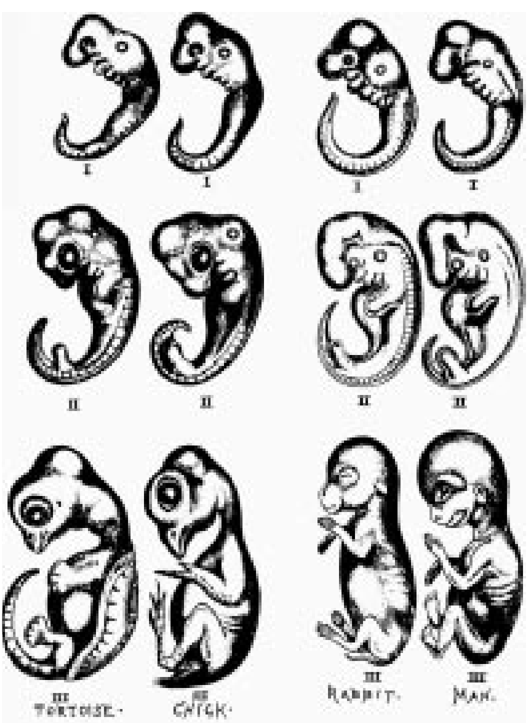

Figure 1. Haeckel pointed out that embryos of very different species look remarkably similar. [George John Romanes, after Ernst Haeckel (1892); from William Coleman, *Biology in the Nineteenth Century* (Cambridge: Cambridge University Press, 1971)]

As a student, I was impressed by Arnold Gesell's *The Embryology of Behaviour*, which appeared in 1945 (two years before I became an undergraduate at Cambridge). I still have my copy (dated 1947), which is the worse for wear, as it got into a flood when I was washing prints and the drain got blocked. (Actually there was at least an inch of water on the floor, which I bailed out with waste tins. The office below was locked; but, when its owner turned the light on next day, it was an eerie yellow, as the bulb was sitting in water entirely filling its glass bowl! He was not amused.)

This will be like an undergraduate essay, handed in over fifty years too late.

Presumably Gesell's book is out of date but it still looks interesting. In the introduction he says (page xiii): "In the biological perspective, the newborn infant is an extreme ancient for he has already traversed most of the stages of his long, racial evolution." Chapter 5—The Archaic Motor System—is a good starting point for seeing the 'archeological' time-layers of muscles and their functions. We learn that the oldest muscles are for posture, posture being the basis of all behaviour. Among the oldest are the muscles of the trunk and pelvic girdle, the broad flat overlying muscles being more recent. Ancient, also, are the six extra-ocular muscles, going back to lamprey and hagfish.

As posture changed over hundreds of millions of years from horizontal to modern human vertical, so these muscles and their neural organisation changed to accommodate new postures, with greatly revised strategies for moving around and performing new skills. The development of skills is seen in terms of innate ontogeny, as well as individual learning. Thus (page 52): "Complicated action patterns whose components were ontogenetically and physiologically developed over long reaches of time are telescoped into a single moment of behaviour." This is based on years of careful observation, though of course Gesell lacked modern techniques of ultrasonics and PET and fMRI for imaging the developing foetus. Much more must be known now.

Relating posture to behaviour, Gesell cites the classical studies of motor development for swimming behaviour, and responses to touch stimuli of salamanders by Coghill (1914, and on), which distinguished innate development from learning, and also from maturation, which may require active behaviour though it is not learning. These are beautiful experiments. Gessell quotes a less-well-known study on ontogenetic mammalian posture and behaviour, by Magnus (1925):

> "Suppose a cat standing in the middle of the room, and a mouse is running on its right side along the wall. The optic and acoustic stimuli act on telereceptors of the cat's head, and make it turn the heavy head to the right. By this the centre of gravity of the fore part of the body is displaced to the right. At the same time tonic neck reflexes are evoked, by which the vertebral column is curved and the right fore limb strongly extended so that it carries the weight of the body alone and prevents it from falling. The left fore limb has nothing to carry, and in harmony therewith this limb relaxes under the influence of the tonic neck reflex. At the same time the distribution of excitability in the motor centres of the spinal cord is rearranged by turning of the neck, so that ... the limb which has no static function will always make the first step. In this way ... the cat is focused towards the mouse and made ready for movement. The only thing the cat has to do is to jump or not to jump: all other things have been prepared beforehand reflexly under the influence of the mouse, which will be the object of the resulting jump."

Gesell comments: "Magnus demonstrated the presence of these reflexes in idiots and in patients suffering from extrapyramidal tract lesions and erroneously came to the conclusion that in man it is a pathological phenomenon." But Gesell showed—and surely this is important—that "it is a normal characteristic of foetal and early post-foetal human behaviour. It occurs in classic form as early as the 28th foetal week." So characteristics of neurological abnormalities or diseases may be *returns to ancient behaviour patterns*. Is it these that we see in cerebral palsy, in Down's syndrome?

The implication, surely, is that to understand what is happening with neurological problems we should trace back the phylogeny to find the individually upset ontogeny. Or is this just a wild idea?

Shouldn't we consider this approach for mental problems such as autism? Is it possible that here we have a return to less 'social' early brain organisation? And what of schizophrenia? If this is a good approach, surely the clinical possibilities from decoding the human genome are even greater; though we might need to know the gene sequences of our phylogenetic ancestors (as well as detailed comparative anatomy) to carry out this programme and apply the results clinically.

Do our own experiences reflect phylogeny? Most of us have innate fears—fears for example of snakes, and spiders, and heights—which were truly dangerous to our ancestors. As appropriate behaviour to these dangers increased chances of survival, so the genetic code learned lessons that we inherit. This is not Lamarckian. Stored in our nervous systems, is innate knowledge from past ancestral disasters. Though generally extremely useful—indeed necessary for every-day survival—when no longer appropriate, innate knowledge causes all sorts of problems. The other side of this coin is that, where there is no such inherited knowledge, we lack immediate skills and intuitive knowledge as of danger. So driving above the speed limit, with one hand, with the other telephoning, and eating an orange, feels safe though it is more dangerous than snakes. What makes one think that the common fear of snakes, spiders, and so on, is innate rather than learned? A strong argument is that they were dangerous, but now (except for Australia) are not—so there is nothing now to fear, or to learn.

A specific example of innate, out-of-date neural knowledge, is the Babinski reflex—where the big toe sticks up and the other toes extend and fan out, upon touch to the foot. This is present in babies up to about 18 months, but is then lost. For arboreal living, it was appropriate for the toes to grip branches of trees, but it became inappropriate for later walking on the ground—to be inhibited in infancy. Referring to *foetal* toes and fingers (illustrated with photographs on page 226), Gesell says:

> "During sleep the fluctuating tonus permits variable lackadaisical or limp posturing. When the tonus is stronger, fingers and toes alike react with patterned fanning to a sudden stimulus. Note the Babinski spread ... A mild Babinski response suggests an attempt to grasp an object; an exaggerated response suggests repulsion and release. The mobility of the great toe and the adjacent cleft recalls arboreal antecedents, when the feet as well as the hands were nimble and prehensile."

Many other infant behaviours, such as sucking, are lost by neural inhibition—sometimes to reappear with adult neurological problems. So they are not lost, but are pushed down by reversible neural inhibition—sometimes to re-emerge.

One might say this is ancient *knowledge*, remaining in our nervous systems when we are adult, though rejected by neural inhibition. This knowledge is pushed down, but not entirely forgotten as it remains dormant in our nervous system, surfacing when the inhibiting neuronal systems are impaired. Then, the individual travels back through the phylogenetic past, which literally comes alive in the released behaviour or experience, for example fear.

Could suppression by neural inhibition of ancient knowledge be a general principle, with clinical significance? If neurological problems can be caused by releasing ancient, now inappropriate, posture and behaviour, couldn't this be reversible—by controlling the neural inhibitions? This would be quite different from simple loss of functions, with perhaps more hopeful prognoses.

This clinical suggestion may be science fiction. I certainly do not wish to raise false hopes for incurable neurological problems. But sometimes ideas of fiction do become facts. Indeed, unproved possibilities drive science (and perceptions themselves are largely fictional, such as seeing colours in objects though they are generated in the brain). So it just might be worth considering these issues.

Let's take a different step. Thinking of the ethologist's concept of releasers—innate behaviour patterns triggered by specific stimuli—could we revive knowledge from the distant past, of long-gone threats and extinct life forms? Now that imaginative constructions of extinct creatures can be simulated so vividly, with computer graphics, as in the BBC programmes *Walking with Dinosaurs*, couldn't we elicit long-lost responses to supposed pasts, to see back into our phylogenetic origins? How well they work would check the accuracy of the simulations. By removing neural inhibitions to revive dramas of lost worlds, perhaps even the colours of dinosaurs could be discovered, by neuro-archeology.

Richard L Gregory

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