

A major breakthrough in human origin research

The question of the origin of humans remains largely a mystery. In a paper published today in Scientific Reports [1], French physicist Vincent Fleury, working in Paris at University of Paris-Cité, reveals the intrinsic built-in constraints which canalize the evolution of vertebrates, and leads to animals with a big brain, a less prognathous face, and a head flexed forward.

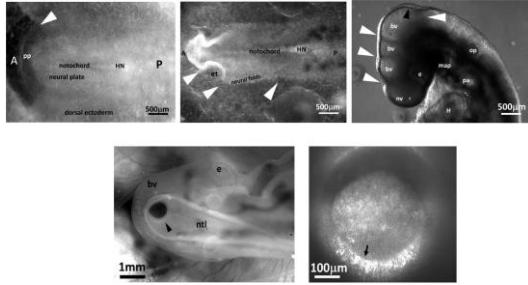
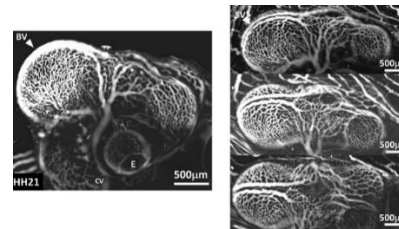


Figure 1 Top: mechanism of embryo neural tube roll-up. Left: a blastodisc stage (the embryo is flat). Middle: during neural tube roll-up (kinks already appear in the folds). Right, the neural tube exhibit belts of cells, and brain vesicles (bv) separated by valleys (arrowheads). Bottom, the circular belts of cells can be imaged directly inside the brain vesicle (which is transparent), the belts form perfect rings (arrow) with cells stacked in a radial order along the perimeter (from Ref. 1).

At early stages of development vertebrate embryos exhibit a pattern of rings and rays, similar to tree rings and fruit wedges (Fig. 1). As in plants, this is inherited from the mechanism of cell division. But tissue is more active in animals, because of the presence of muscle-like molecules. Animal formation proceeds by rolling up of this pattern. This creates a hollow tube. The pressure inside the tube dilates the brain until it forms vesicles ballooning like hernias. Vincent Fleury has shown that the rays or wedges become belts of cells which strangle the tube, after the roll-up (arrowheads in Fig. 1 Right, Fig. 1 Bottom). This is why the early brain appears as a clutch of balloons separated by cables. Blood vessels mirror this specific structure, or texture, of the embryo (Fig. 2).

Figure 2 The pattern of blood vessels mirrors the embryonic texture (small capillaries in the brain vesicles, and larger vessels in the valleys, from Ref. 1).



By studying experimentally and theoretically the biomechanical behavior of an inflated tube, which is coiled with a few cables, Vincent Fleury was able to show that the brain automatically curls, when it dilates. The origin of this phenomenon lies in the fact that a tube covered with cables, such as the early brain, is a hybrid physical object which both dilates, by ballooning, and flexes, like a ruler (Fig.3). The balloons behave as if they were pushing each-other, which induces a flexure of the entire head. And since the texture is imposed also on the blood vessels, the circulation enhances the correlation between dilation and flexure, after the onset of heart beat.

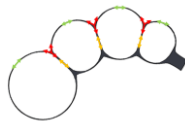


Figure 3 Numerical modelling shows that the brain automatically curls when it dilates (from Ref. 1).

A spectacular experiment of electric stimulation of the head confirms these results. Indeed, the experiment is able to change embryo development both in the physiological direction, which gives embryos with bigger and more curled heads, as if the chicken was becoming more human-like, or to hinder development, which gives embryos with flatter heads and a more anterior mouth, as if the chicken was reverting to a lizard.

These experiments and models explain why hominins can be ordered in a morphological diagram such that, as the brain expands, the head rocks more forward and face features become less prognathous. This gives support to the idea that there exists a deterministic self-organized latent dynamic pattern for the observed paleontological trends in craniates towards *homo*, a concept known as *Inside story*.

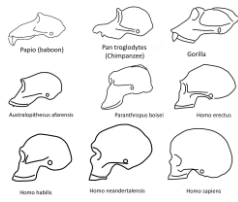


Figure 4 Hominins can be ordered in a morphology diagram, in which animals with bigger brain tend to have a head which rocks over the palate, as the face recedes. This suggests that human evolution contains some determinism.

References

1. V. Fleury, Electrical stimulation of chicken embryo development supports the inside story scenario of human development and origin, Scientific Reports, March 27th 2024, <https://rdcu.be/dCC1H>
 Contacts : Vincent Fleury Research Director CNRS vincent.fleury@u-paris.fr