# THE MANIFOLD WONDERS OF THE GUT

**Nicolas Chevalier** – I remember the first time that I dissected an embryo seemed so complicated, everything was white and milky, the liquid in which we did the dissection was murky because of the yolk and then there were membranes enveloping organ after organ. And so after having extracted a first embryonic intestine in an advanced state of decay, I went to see my Laboratory Head at the time, Vincent Fleury, and suggested to him rather vaguely that "perhaps we could work on a dummy intestine, a piece of rubber or something like that". He raised his eyes to heaven, and I knew that I was on the wrong track. I had precisely joined this research group at the Matter & Complex System Laboratory, to confront myself with a real 'biological system', that is to say with nature, nothing less, and all the complexity that it entails. For once I was being asked to work neither on a model of an embryo, nor on a dummy, but actually on the embryo itself whose mystery can be summed up in the question 'how can the union of an egg and a sperm give rise to the birth of a being with legs and arms and a mouth etc.'

The subject promised to be gory: farewell crystals, surfaces with finely controlled chemical properties, now I would have to remove and gut the beast in order to study it. And a whole world opens up, the sloppy pipework of organs, the scratchiness of their surface when magnified enough to see the layout of bumps on cells, some viscous and adhesive, others as slippery as Teflon, and such movement! Everything is moving in an embryo, blood, the white cells as big as the vessels that carry them, the beating heart that can be kept in culture for several weeks – an astonishing fact, and indeed one can preserve all the organs in culture, kidneys, lungs, eyes and intestines included! And in less time than it might seem, the repellent, intimidating aspect of the organ fades to be replaced in the eye of the scientist by a tiny biological machine that is remarkably well put together with its hydraulics and chemistry easily isolated hence easily studied and whose mysteries turn out to be very much ones that we want to penetrate.

The intestine is a fascinating organ in many respects: it is ancient and its layout is nearly the same in species that are extremely distant from one another. A colleague visited us recently who studies a marine worm shaped like a tube that is akin to a jellyfish. Now this tube has a layer of muscle laid lengthwise, a layer of nerves, a layer of circular muscle, then internal papillae for digestion, in short, all is as if it were an intestine that swims around the ocean or else as if our body contained an independent albeit symbiotic sea creature. To be able to extract the intestine of an organism and develop it in culture is a major asset to the experimenter because it allows us to observe and intervene and we don't pass by such an opportunity.

The aim of my research is to understand how the form and the tissues of the intestine assemble themselves – their morphogenesis. Physics plays a central rôle in the chain of events that leads from the early embryo to foetal organs, through cellular and muscular forces to stretch, deform and align: one cannot change the form of a material – no matter if it is embryonic and miraculous – without at some point applying forces to it! In parallel with this slow morphogenesis, we are interested in how the function of the organ emerges – this what I call 'the ergogenesis'. In the case of the intestine, it functions as an intelligent peristaltic pump that propels the food bolus in a way appropriate to its consistency and chemical composition. To this end, the intestine has a unique network of neurons that is intrinsic to the organ, called the enteric nervous system which controls 'clock' or 'pacemaker' cells that in their turn control muscles which cover the entire length of the intestine. And all this in tissue that is scarcely 0.2 mm thick, talk about microfabrication!

**3 min 43 sec**