

## Editorial to my Article in Open Biology Journal

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It is hard to believe, but it is true: some facts in modern cell biology are ignored and disregarded, still. One example is the driving forces in the early embryonic development and morphogenesis in general. Recently, a very well compiled commentary summed up the history of the physical (mostly mechanical) forces in early embryogenesis [1] but one physical force was left out completely: the electric force or the charges of molecules and ions and their gradients. Another example is left – right pattern formation in early embryogenesis where most theories set the starting point at the asymmetric beat of cilia moving the flow of growth factors or other signaling molecules into one preferred direction [2].

In both examples many well documented experiments could show gradients in endogenously generated electric fields produced by ion pumps and charges molecules which build pre-formative patterns. These patterns are imprinted subsequently into genes via signaling pathways and then these patterns arise morphologically and can be observed as distinctive folding, proliferation and migration of different cell groups.

The review by FUNK in this issue demonstrates by many well published studies that such ion gradients generate electric fields and direct currents, which are able to form patterns within cell membranes (e.g. in the early embryo), cell arrays (e.g. in the developing lens) and tissues (e.g. neural tube formation). Furthermore, not only small ions like sodium or potassium can be involved in this field patterning but also larger biomolecules (which possess nearly all electrical charges) like tissue factors, growth hormones, transmitters and signaling molecules like serotonin and others. By the activity of ion pumps and channels as well as via charged transmitter molecules these electric phenomena are coupled to canonical molecular pathways and thus intrinsic elements of biological processes.

### References

1. Keller R (2012) Developmental biology-Physical biology returns to morphogenesis. *Science* 338: 201-203.
2. Norris DP, Grimes DT (2012) Developmental biology: Cilia discern left from right. *Science* 338: 206-207.

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