



Preface

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One contribution of 17 to a Discussion Meeting Issue 'Cellular polarity: from mechanisms to disease'.

Cell polarity

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Polarity is a moderately complex concept. Is an axe, or a pencil with a lead point at one end and a little rubber at the other, polarized? The answer is no. Polarity requires the property of having poles that are distinct and opposite. The physical definition of polarity is that there are opposite poles, and a property or characteristic that produces unequal physical effects at different points in a body or system. The axe's or pencil's ends are not opposite, just different. There also has to be an asymmetrical and ordered distribution of structures along an axis as in the direction of a magnetic or electric field. It must be possible at any point to draw an arrow pointing to one of the poles. There are no arrows or asymmetries along the axis of the axe or the pencil.

The Oxford Dictionaries definition of polarity for biology is: "the tendency of living organisms or parts to develop with distinct anterior and posterior (or uppermost and lowermost) ends, or to grow or orientate in a particular direction" [1]. A definition from Wikipedia is: "cell polarity refers to spatial differences in the shape, structure and function of cells" [2]. Neither of these definitions refers to poles or properties of the axis and raises the question as to whether polarity in biology is very different from that in physics. It is thus not surprising that many examples of polarity in biology are really references to asymmetry. In a recent review on polarity, St Johnston & Ahringer [3] emphasize its relation to asymmetry and do not refer to the physical features.

A nice example of polarity with all the necessary classical features is a simple organism, hydra. Hydra is essentially a tube with a head with tentacles at one end and a basal disc at the other. These are polar opposites as when a piece of the hydra is isolated by removing the two ends, a head always forms at the head end and a basal disc at the other. Moreover, there is a gradient down the body, with a high point at the head end. The slope of the gradient effectively provides an arrow along the axis.

An important example of polarity, illustrating the role of cells and proteins, is planar cell polarity as seen in the epidermis of the fly *Drosophila*, where all the bristles point in a posterior direction. A key protein is the Frizzled receptor, which is graded along the axis. Also, it is involved in the key interactions that maintain polarity at epidermal junctions where signalling between cells takes place.

Neurons do seem to be polarized as the electrical signal along an axon can only go in one direction, and there is a synapse at one end and the cell body at the other.

Polarity in the development of the embryo may be illustrated by the early development of the nematode embryo. Before fertilization there is no evidence of asymmetry, but sperm entry is considered to set up antero-posterior polarity and the first cleavage, which is asymmetric and unequal. Even before first cleavage, there is movement that leads to P granules at the posterior end and actin filaments at the anterior end.

It is widely accepted that epithelia are polarized as they are split into two different regions, apical and basal. Moreover, the plasma membranes are different and can transport molecules in different directions. While there is very good evidence for these differences, there is no evidence for polarity between the two regions in the form, for example, of a gradient or molecular orientation. This is a case of asymmetry rather than classical polarity.

Migrating cells are regarded as being polarized as they have a clear front and back, and this defines an arrow along the cell. But are there similar asymmetries along that axis in the cell? Probably not. Yeast cells proliferate by budding, which involves specialization of a small patch of the mother cell

cortex and movement of many cell constituents towards that patch, promoting growth of the bud. Asymmetry or polarity?

Polar body formation gives rise to a small cell at meiosis. It is thought to involve polarity as the spindle takes a position that can be considered to be an axis, and the small cell is at one end of it with the other cell at the other end. It seems to be another example of asymmetry.

There are papers in this issue on budding yeast, epithelial polarity, cell migration and early nematode development, and several papers on meiosis and spindle asymmetry and cell shape changes. Even though their link to polarity is, in a few cases, not very clear, they provide important results and concepts of basic cell biological processes, such as cell behaviour and function in epithelia, including cancer.

References

1. Oxford Dictionaries. *Definition of polarity in English*. See <http://oxforddictionaries.com/definition/english/polarity?q=polarity>.
2. Wikipedia. *Cell polarity*. See http://en.wikipedia.org/wiki/Cell_polarity.
3. St Johnston D, Ahringer J. 2010 Cell polarity in eggs and epithelia: parallels and diversity. *Cell* **141**, 757–774. (doi:10.1016/j.cell.2010.05.011)