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The Will to Bud

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INTRODUCTION

The separation of the somatic and germ lines in biology is a classic case of finding differences where there are none. August Weismann [1,2] can be blamed for claiming a fundamental difference between an immortal germ line and a mortal somatic line, but germ cells, like somatic cells live and die in a mortal context. The germ line is a tissue that gives rise to sex cells much like somatic lines give rise to their somatic products. Those germ cells that undergo meiosis and successful fertilization start new somatic and germ lines (i.e., the differentiation of cell lines including germ cells) and so do unfertilized eggs developing parthenogenically in plants and a variety of animals including amphibians, reptiles, and birds [3].

Similarly, somatic stem cells are said to differ from other somatic cells [4,5]. Somatic stem cells are a class of cells thought to be undifferentiated (although limited in adults to specific tissues) and the source of cells (transitional cells) that do not proliferate before differentiating and blast cells that divide before giving rise to their final cellular products.

Embryonic stem cells are distinguished among embryos by way of giving rise to adult cells, but what distinguishes adult stem cells? Hematopoietic stem cells and even striated muscle satellite (stem) cells may be "embryonic" in origin, but one can hardly argue that other adult "stem" cells such as those in hair follicles or intestinal villi have embryonic origins: There are no hair follicles or intestinal villi in embryos! If they arise from somatic adult cells, they can no longer be placed in the category of "stem."

In hydras (my specialty), "stem cells" come in two varieties. Hydra's interstitial "stem" cells divide and differentiate into cnidocytes, sex, nerve, gland, and adhesive foot cells, while hydra's epithelial "stem" cells divide and differentiate into epitheliomuscular cells of the epidermis and gastrodermis. Following their separation in embryos, nothing distinguishes interstitial stem cell from interstitial cells generally or somatic stem cells from somatic epithelial cells generally. Indeed, the "growth zone" in hydras enlarges and contracts as a function of feeding schedule and temperature [6].

A CASE IN POINT: BUDDING IN HYDRAS

Hydras raised at optimal temperatures and fed abundantly expel cells in buds rather than increase in dimensions with cellular additions [7,8]. These hydras do not cease cell division in response to superfluous feeding or accumulated cells. Rather, these hydras would seem to be at their optimal size for capturing their food, and excess cells are applied to asexual reproduction through budding. Removing excess cells produced on a hydra's body in the form of buds would certainly be a productive choice for natural selection over merely throwing off (wasting) cells.

The production of excess cells and the formation of buds seem to have been coupled in evolution when budding became a quantum event linked to the accumulation of cells in bud modules. Hydras only formed buds when modules were filled, more like the operation of an alarm clock [9] going off at preset times (a number of cells in a module required to set off budding) than an analogue watch [10] merely ticking away time (producing buds with whatever number of cells are available at the time). The regularity of budding under constant conditions of feeding and temperature is precise and consistent with the alarm clock analogy.

COMING UP SHORT: LINKING THE QUANTITATIVE AND QUALITATIVE

The larger question is, "Where else is this link between quantitation (e.g., the accumulation of cells in bud modules) and 'qualitation' (the formation of buds) found?" Are there connections between the quantifiable and qualitative in other metazoans, between reductive quantitative properties and complex qualitative ones? I am certainly not the first biologists to ask these questions. Other biologists have raised them [11-13], notably, Lynn Margulis, and philosophers have had a go at them [14,15] but answers are elusive.

The measurable is not easily sutured to the abstract, and pursuing questions linking the quantitative and qualitative may not be a productive use of one's research time. The problem may even reside at a different level: how we think-in human thought. Generally, the very idea of origins is an obstacle to tying the qualitative and quantitative together. Because an origin has no past, the origins of things are only pushed back as far as recognizable qualities. The very possibility of qualitative antecedents to origins is an oxymoron.

If origins do not come from sameness, then they must come from difference, and those differences must be quantitative. A rupture in or a consolidation of quantities would seem to be the likely source of transitions from the quantitative to the qualitative - origins. "The

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solution to the problem... is openness" [16] to the possibility of quantities (such as the number of hydra's excess cells in a bud module) triggering qualitative events (such the morphogenesis of a bud).

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