

## Regeneration and scientific terminology

Sir,

In her otherwise excellent review article, *Signaling molecules in regenerating hydra*<sup>(1)</sup>, Brigitte Galliot tells us that 'the hydra regeneration process is epimorphic', and mentions the 'contradictory usages in the literature' of that term. She then cites Goss' definition<sup>(2)</sup> of epimorphic regeneration as follows: 'Epimorphic regeneration refers to the regrowth of amputated structures from an anatomical (sic) complex stump. This may involve either (the) replacement of parts of appendages or (the) regeneration of fractions of organisms into new complete individuals after their bisection.' We are then informed that 'in contrast to other cases of epimorphic regeneration, hydra regeneration mostly follows a morphallactic process, meaning that it does not depend on cell proliferation'<sup>(1)</sup>.

If we examine Goss' article, as well the origins of the terms 'epimorphic' and 'morphallactic', we find that Galliot's use of terminology has only served to confuse matters further. After the sentences quoted by Galliot, Goss goes on to state: 'Whatever it is that must be regenerated, the sequence of events by which its replacement is achieved is essentially the same. The first event in epimorphic regeneration is the development of a blastema, or regeneration bud, derived from dedifferentiated cells, out of which the new structure will take shape.'<sup>(2)</sup> Galliot, however, makes it clear that hydra does not form a blastema during regeneration, thus contradicting the very definition of epimorphic regeneration she cites.

T. H. Morgan coined the term 'morpholaxis' in an 1898 paper on regeneration in the planarian, *Planaria maculata* (now referred to as *Girardia tigrina*): 'Thus, the relative proportions of the planarian are attained by a remodelling of the old tissue. I would suggest that this process of transforma-

tion be called a process of morpholaxis.'<sup>(3)</sup> In his 1901 monograph, *Regeneration*, Morgan further clarified his definitions (and changed the spelling of 'morpholaxis' to the etymologically more correct 'morphallaxis'): 'At present there are known two general ways in which regeneration may take place, although the two processes are not sharply separated, and may even appear combined in the same form. In order to distinguish broadly these two modes I propose to call those cases of regeneration in which a proliferation of material precedes the development of the new part, 'epimorphosis'. The other mode, in which a part is transformed directly into a new organism, or part of an organism without proliferation at the cut surfaces, 'morphallaxis.'<sup>(4)</sup>

Morgan's definitions are, therefore, quite clear: epimorphosis requires cell proliferation, whereas morphallaxis does not. Given the fact that these definitions remain useful for describing different modalities of regeneration, we see no reason to abandon them. Galliot, herself, accepts the original definition of morphallaxis, but inexplicably rejects the historical definition of epimorphosis. All regenerating organisms live by Bert Lance's statement, 'If it ain't broke, don't fix it.' We recommend that scientists studying regeneration also follow this rule with respect to scientific terminology.

### References

- 1 Galliot, B. (1997). Signaling molecules in regenerating hydra. *BioEssays* **19**, 37-46.
- 2 Goss, R.J. (1991). The natural history (and mystery) of regeneration. In *A History of Regeneration Research* (ed. C. E. Dinsmore), pp. 7-23. Cambridge University Press, Cambridge.
- 3 Morgan, T.H. (1898). Experimental studies of the regeneration of *Planaria maculata*. *Arch. Entw. Mech. Org.* **7**, 364-397.
- 4 Morgan, T.H. (1901). *Regeneration*. Macmillan Co., New York.

**Phillip A. Newmark and Alejandro Sánchez,**

Department of Embryology,  
Carnegie Institution of Washington,  
115 W University Parkway,  
Baltimore, MD 21210,  
USA.

E-mail: newmark@mail1.ciwemb.edu

### Authors' Correction

In our article 'It's the genes! EST access to human genome content', *BioEssays* (1996) **18**, 973-981, we failed to credit the origin of the 'Expressed Sequence Tags' approach to Adams *et al.* (1991). We apologize for the error. The reference is given in full below.

**Adams, M. D., Kelley, J. M., Gocayne, J. D., Dubnick, M., Polymeropoulos, M. H., Xiao, H., Merril, C. R., Wu, A., Olde, B., Moreno, R. F., Kerlavage, A. R., McCombie, W. R. and Venter, J. C.** (1991). Complementary DNA sequencing: Expressed sequence tags and Human Genome Project. *Science* **252**, 1651-1656.

**David L. Gerhold and C. Thomas Caskey**