Available online at www.sciencedirect.com
ScienceDirect
C. R. Biologies 332 (2009) 935–936
COMPTES RENDUS BIOLOGIES

Foreword

Integrative animal, microbial and plant biology: Dialogue between experiment and modelling

Although there are earlier references to integrative biology (Bullock [1], Ng et al. [2]), it is only since the 1990s, and especially since the early 2000s, that this approach has been spreading (Charrier et al. [3]; Fig. 1: left). Certainly, biology is, or should be, essentially integrative, but the tremendous increase in analytical and investigative capabilities has contributed to focusing research on molecular and cellular mechanisms.

This reductionist and, in many respects, fruitful trend relies primarily on ever higher throughput production of data in structural and functional genomics and on the development of new imaging techniques that are essential for exploring the organization and functioning of cells or tissues. A first challenge deals therefore with data integration, from their storage and organization to their access, analysis and traceability. Hence, the fact that recent technologies tend toward providing global and exhaustive molecular datasets, raises questions in terms of volume of information. These technologies also generate data that are increasingly diverse (e.g. from molecular data about small RNAs, genes and proteins to cellular images and integrated phenotypic traits), which raises needs for linking different types of information acquired on the same organisms. Finally, these technologies are gaining in spatial and temporal resolution, thereby addressing the spatiotemporal tracking and reconstruction of biological events, topics that are critical in developmental biology.

A second scientific challenge of integration is to combine experimental and modelling approaches to reconstruct an overall picture of the whole organism, or of some major functions. This challenge addresses the understanding and prediction of phenomena at nested levels of organization (from the finer subcellular levels to tissues, organs, and organisms considered in their biotic or abiotic environment, or even to populations and communities) and of the spatiotemporal coordination of events within the organism. The study of the functioning and dynamics of networks (e.g., networks of genes or metabolic networks within the cell, communication between cells in a tissue, or signalling pathways) is therefore seen as a central theme in biology. The analysis and prediction of the emergent properties of these networks are thus major topics of systems biology, a scientific domain that has been growing very quickly since the early 2000s (Fig. 1: centre).

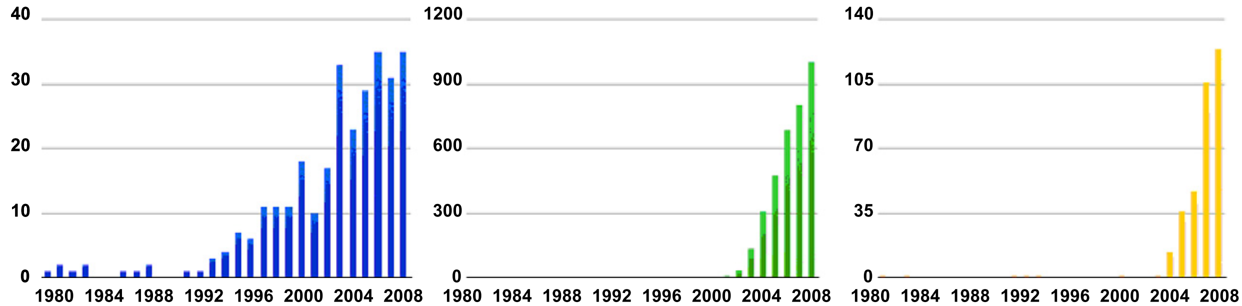

Fig. 1. Evolution of the number of publications, between 1980 and 2008, listed by the Web of Sciences, as of 2009 October 21st. Left: publications where the topics refer to 'integrative biology' or 'integrative physiology'. Centre: publications where the topics refer to 'systems biology'. Right: publications where the topics refer to 'synthetic biology'.

1631-0691/$ – see front matter
doi:10.1016/j.crvi.2009.10.006

Mass production of data also renews comparative approaches. A third scientific challenge of integration refers therefore to the study of the diversity of individuals and species, to the analysis of phenotypic plasticity and of the genotype–environment interactions, as well as to evolutionary approaches, such as phylogenomics. This challenge leads naturally to a particular reflection on the choice of species and systems that are studied. After a period where some model systems benefited from huge scientific investments, there is a strong development of structural and functional genomics in other biological systems, e.g. in species that are critical in agriculture and for food production, for chemical, energetic and other non-food uses of biomass, or in natural ecosystems. The concept of model species is thus evolving under the joint effect of the accelerated renewal of technology, and of comparative and translational approaches.

Whatever the challenge, integrative biology involves the ability to articulate experimental approaches, large scale data acquisition, and formal or quantitative data analysis and modelling approaches. This issue of the C. R. Biologies illustrates this movement towards a more predictive biology that should finally result not only in a better understanding of living organisms, but also in a greater capability to control and engineer them (Fig. 1: right). They also illustrate the diversity of approaches in animal, microbe and plant integrative biology, as well as the traits and species that are important in agronomy. To a large extent, these approaches could be transposed to higher levels of organization, populations and communities (Thellier [4]). Here, the choice was, however, made to focus on levels of organization that range from the gene to the organism, and to present approaches at the intra-cellular level or involving systems biology, approaches in developmental biology, mainly at the level of tissues and organs, and approaches of systems where organisms interact with their environment.

Catherine Christophe
INRA DSPPV, Direction Scientifique,
Plantes et Produits du Végétal,
147, rue de l'Université,
75338 Paris cedex 07, France
E-mail address: cchristophe@paris.inra.fr

François Houllier
INRA DSPPV, Direction Scientifique,
Plantes et Produits du Végétal,
147, rue de l'Université,
75338 Paris cedex 07, France
E-mail address: houllier@paris.inra.fr

References

[1] T. Bullock, In search of principles in integrative biology, American Zoologist 5 (4) (1965) 745–755.
[2] E. Ng, R.S. Loomis, W.F. Hunt, Integrative physiology of sugar beet. Developmental control of partitioning, Plant Physiology 56 (2) (1975) 77.
[3] A. Charrier (coordinator), La biologie intégrative végétale, INRA, Conseil scientifique, Paris, 2005, 43 pages.
[4] M. Thellier, Modelling of complex systems in agronomy and environment, C. R. Biologies 329 (2006) 1–2.