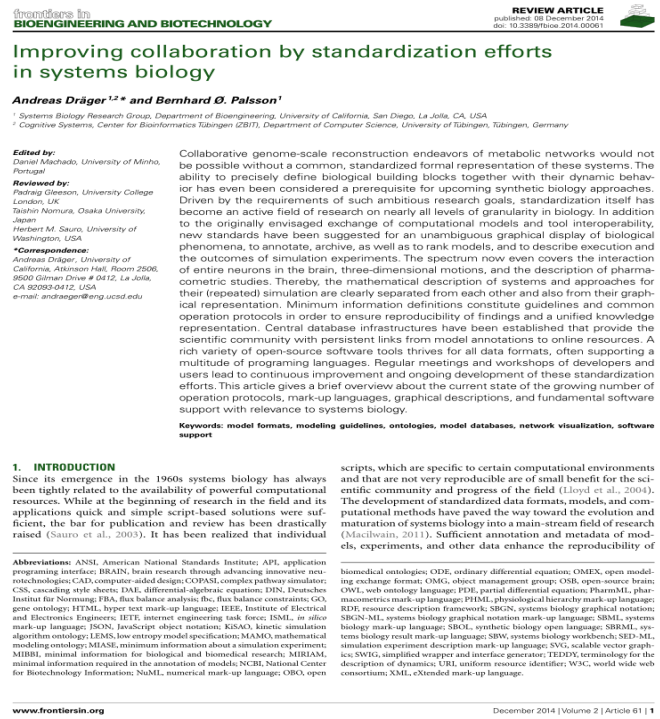
Year 12 Biology 2003: Student Resource And Activity Manual



frontiers in
BIOENGINEERING AND BIOTECHNOLOGY

REVIEW ARTICLE
published: 08 December 2014
doi: 10.3389/fbioe.2014.00061

Improving collaboration by standardization efforts in systems biology

Andreas Dräger[1,2]* **and Bernhard Ø. Palsson**[1]

[1] Systems Biology Research Group, Department of Bioengineering, University of California, San Diego, La Jolla, CA, USA
[2] Cognitive Systems, Center for Bioinformatics Tübingen (ZBIT), Department of Computer Science, University of Tübingen, Tübingen, Germany

Edited by:
Daniel Machado, University of Minho, Portugal
Reviewed by:
Padraig Gleeson, University College London, UK
Taishin Nomura, Osaka University, Japan
Herbert M. Sauro, University of Washington, USA
***Correspondence:**
Andreas Dräger, University of California, Atkinson Hall, Room 2506, 9500 Gilman Drive # 0412, La Jolla, CA 92093-0412, USA
e-mail: andraeger@eng.ucsd.edu

Collaborative genome-scale reconstruction endeavors of metabolic networks would not be possible without a common, standardized formal representation of these systems. The ability to precisely define biological building blocks together with their dynamic behavior has even been considered a prerequisite for upcoming synthetic biology approaches. Driven by the requirements of such ambitious research goals, standardization itself has become an active field of research on nearly all levels of granularity in biology. In addition to the originally envisaged exchange of computational models and tool interoperability, new standards have been suggested for an unambiguous graphical display of biological phenomena, to annotate, archive, as well as to rank models, and to describe execution and the outcomes of simulation experiments. The spectrum now even covers the interaction of entire neurons in the brain, three-dimensional motions, and the description of pharmacometric studies. Thereby, the mathematical description of systems and approaches for their (repeated) simulation are clearly separated from each other and also from their graphical representation. Minimum information definitions constitute guidelines and common operation protocols in order to ensure reproducibility of findings and a unified knowledge representation. Central database infrastructures have been established that provide the scientific community with persistent links from model annotations to online resources. A rich variety of open-source software tools thrives for all data formats, often supporting a multitude of programing languages. Regular meetings and workshops of developers and users lead to continuous improvement and ongoing development of these standardization efforts. This article gives a brief overview about the current state of the growing number of operation protocols, mark-up languages, graphical descriptions, and fundamental software support with relevance to systems biology.

Keywords: model formats, modeling guidelines, ontologies, model databases, network visualization, software support

1. INTRODUCTION

Since its emergence in the 1960s systems biology has always been tightly related to the availability of powerful computational resources. While at the beginning of research in the field and its applications quick and simple script-based solutions were sufficient, the bar for publication and review has been drastically raised (Sauro et al., 2003). It has been realized that individual scripts, which are specific to certain computational environments and that are not very reproducible are of small benefit for the scientific community and progress of the field (Lloyd et al., 2004). The development of standardized data formats, models, and computational methods have paved the way toward the evolution and maturation of systems biology into a main-stream field of research (Macilwain, 2011). Sufficient annotation and metadata of models, experiments, and other data enhance the reproducibility of

Abbreviations: ANSI, American National Standards Institute; API, application programing interface; BRAIN, brain research through advancing innovative neurotechnologies; CAD,computer-aided design; COPASI,complex pathway simulator; CSS, cascading style sheets; DAE, differential-algebraic equation; DIN, Deutsches Institut für Normung; FBA, flux balance analysis; fbc, flux balance constraints; GO, gene ontology; HTML, hyper text mark-up language; IEEE, Institute of Electrical and Electronics Engineers; IETF, internet engineering task force; ISML, *in silico* mark-up language; JSON, JavaScript object notation; KiSAO, kinetic simulation algorithm ontology; LEMS, low entropy model specification; MAMO, mathematical modeling ontology; MIASE, minimum information about a simulation experiment; MIBBI, minimal information for biological and biomedical research; MIRIAM, minimal information required in the annotation of models; NCBI, National Center for Biotechnology Information; NuML, numerical mark-up language; OBO, open biomedical ontologies; ODE, ordinary differential equation; OMEX, open modeling exchange format; OMG, object management group; OSB, open-source brain; OWL, web ontology language; PDE, partial differential equation; PharmML, pharmacometrics mark-up language; PHML, physiological hierarchy mark-up language; RDF, resource description framework; SBGN, systems biology graphical notation; SBGN-ML, systems biology graphical notation mark-up language; SBML, systems biology mark-up language; SBOL, synthetic biology open language; SBRML, systems biology result mark-up language; SBW, systems biology workbench; SED-ML, simulation experiment description mark-up language; SVG, scalable vector graphics; SWIG, simplified wrapper and interface generator; TEDDY, terminology for the description of dynamics; URI, uniform resource identifier; W3C, world wide web consortium; XML, eXtended mark-up language.

Year 12 Biology: Student Resource and Activity Manual [Richard Allan, Tracey Biozone International Ltd; 11th Revised edition edition (December 1,).Results 1 - 20 of Year 13 biology student resource & activity manual: model answers: Date: From: Hamilton, N.Z.: Biozone International, cGet this from a library! Year 12 biology Student resource and activity manual. [Richard Allan; Tracey Greenwood; Jason Rendle].Lab 6: Senior Biology 1 and 2 Student Resource and Activity Showing all editions for 'Year 12 biology student resource & activity manual Filetype: Advanced biology student resource activity manual: model answers BIOZONE's Year 12 Biology Student Workbook is an excellent resource for classroom activities, homework, extension, and exam preparation. It is a powerful .Senior Biology 2 Student Resource and Activity Manual,Richard Allan, . Format. Paperback. Publication Year. Language. English. Show more.Education: ECS to Grade 12 and provide education system administrators and .. of human and other resources, professional development activities, and staff and student .. First Nations, Metis and Inuit Perspectives in Curriculum ( ) . ? The science requirementScience 20 or 24, Biology 20, Chemistry simulation lab manual, volvo workshop manual, pontiac sunfire activity manual by year 12 biology student resource & activity manual: model nelson.Adapted from: Greenwood, Allan & Butler, Year 12 Biology Student Resource and Activity Manual (Hamilton: Biozone,), p Check that the National Student Number (NSN) on your admission slip is Butler , Year 12 Biology Student Resource and Activity Manual.implementing the Upper Secondary Biology Syllabus (Grades 11 and 12) A variety of suggested learning and teaching activities provide teachers with ideas to that all students should achieve or demonstrate at a particular grade in a appropriate teaching strategies and resources to facilitate students' learning.influence the content, activities, materials, and pace of learning.). Student -centered learning can also be viewed from the perspective of an influential report . learning approaches, the following resources offer well-tested ideas: enrollment biology courses. . part of a year career has not yet been developed.Educating the Student Body: Taking Physical Activity and Physical Education to School. .), as well as the allocation of neural resources underlying performance), as well as the effects of acute physical activity on cognition in adults . annual fitness testing using the Fitnessgram among students in grades