

## A unique web resource for physiology, ecology and the environmental sciences: *PrometheusWiki*

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**Abstract.** PROtocols, METHods, Explanations and Updated Standards Wiki (*PrometheusWiki*, <http://www.publish.csiro.au/prometheuswiki/>) is a new open access, fully searchable web resource that contains protocols and methods for plant physiology, ecology and environmental sciences. Contributions can be uploaded by anyone in the community, with attributed authorship, and are open for wiki-style comment. This resource allows the gathering in one place of methods, links to published methods and detailed protocols used by leading laboratories around the world, with annotation. As a web resource, *PrometheusWiki* is continually evolving and updatable, easily and rapidly searchable and highly accessible. It will also enhance communication, allowing multimedia description of protocols and techniques, with spreadsheet tools, slide shows and video files easily integrated into the text. This resource is anticipated to lead to strong benefits in standardising methods, improving access to training for students and professionals, promoting collaborations and expanding the cutting edge of research.

**Additional keywords:** methods, protocols, standardisation, web publishing, wiki.

### Universal access to protocols and standard methods

Science moves most rapidly when the majority of researchers use standardised methods and can easily and rapidly repeat and build upon each other's discoveries. A strong need for standardising in physiological ecology and environmental biology exists, as currently many groups utilise different methods and protocols for specialised as well as common measurements. Because of space constraints, the materials and methods sections in published papers typically do not contain enough information for a newcomer to repeat a technique reliably; for this, detailed protocols are needed. However, thus far, there has been no easy resource to access and compare these protocols or to determine the opinions of experts on the different practices. This has created a bottleneck in research and student education. Such a bottleneck also applies at a larger scale across numerous fields of science. For any given measurement technique, there is a natural progression from exploratory methods through a period of methodological debate to eventual canonisation of best practice. To date, this process has involved significant inefficiency because measurements taken in different laboratories could not

be directly compared, and the problem grew as the scale of scientific inquiry in plant biology increased globally. In recent years, there has been progress in proposing standard measurements of 'key functional traits' that can be determined with simple equipment, such as leaf mass per area and wood density (e.g. Cornelissen *et al.* 2003; Williamson and Wiemann 2010). Physiology and environmental measures, which in many cases require intensive training and specialised equipment, have proven more resistant to standardisation (Pratt *et al.* 2008). Speeding the dissemination and standardisation of methods will especially aid the research community in progressing towards integrative goals, such as elucidating genetic loci for physiological function, and predicting responses of plants and ecosystems to climate change (cf. Denny and Helmuth 2009).

### The creation of a new resource: *PrometheusWiki* (<http://www.publish.csiro.au/prometheuswiki/>)

*PrometheusWiki* is a web-based, free-access resource project with content generated by volunteer contributions. The resource contains mini-reviews of methods for each section of the field

(Table 1) written by Editors, and indexed methods and protocols that can be uploaded by anyone in the community, with attributed authorship. The protocols are open for comment by the community in wiki style. This resource is a central location for methods, links to published methods papers and, most meaningfully, detailed, updated and annotated protocols used by leading laboratories around the world. Any kind of document can be uploaded and accessed easily, including text documents, spreadsheets, images, and video and other web links.

We view the development of this resource as essential to the standardisation and rapid advance of research in the field of plant physiological ecology. In the past, resources have taken the form of widely used textbooks and methods books, such as *Plant Physiological Ecology: Field Methods and Instrumentation* (the 'pink book'; Pearcy *et al.* 1989). That particular book is now out of print, with a used price of US\$250, and although it is now partly out of date, it is still valuable. That book covered the then-current methods in photosynthesis, water relations, root physiology, and environmental and canopy measurements. However, a new resource would need to expand in breadth to include additional topics (Table 1). Scientific communication is very different today from what it was in 1989. We have seen the development of peer-reviewed methods journals (e.g. *Methods in Ecology and Evolution*, *Methods in Enzymology* and *Plant Methods*) emphasising the importance of the dissemination of methods. We see a need to complement these journals, capitalising on web technology available for accessibility, searchability, community involvement and continual updating of rapidly developing fields. With no space limitation, the web wiki resource can contain step-by-step protocols that have previously been unavailable. With its constant capacity for editing, the protocols posted here can be the most up-to-date available anywhere. *PrometheusWiki* builds on the recent movement towards voluntary web sharing of knowledge (e.g. OpenWetWare, [www.openwetware.org](http://www.openwetware.org); wikigenes, [www.wikigenes.org](http://www.wikigenes.org); Hoffmann 2008). *PrometheusWiki* is designed to enable a comprehensive

coverage of methods and protocols, to which any individual can contribute, via a process that enables standardisation of methods when this is practical.

We named this web resource, **PRO**TOCOLS, **METH**ODS, **EX**PLANATIONS and **UP**DATED STANDARDS WIKI (*PrometheusWiki*). Prometheus of Greek mythology was the Titan who bestowed fire to the earth, at the time the most advanced technology. Notably, Prometheus was punished for this action by being chained to a cliff with a vulture eating out his liver each day, only to have it regenerate for the next day's torture, but was eventually rescued by the hero Heracles (Hercules), in a sign of the gratitude of humanity (Morford and Lendardon 2006).

The wiki was designed during a Working Group in October 2009 hosted by the Australian Network for Vegetation Function, by the authors of this article, in collaboration with CSIRO Publishing. Since then, the wiki has increased its international editorial board to include expertise across fields including soil science, plant anatomy, physiology, ecology, biochemistry, whole-plant growth, environmental measures and statistics, with additional editors to be invited on an ongoing basis when protocols are uploaded for new topics, with an aim to including expertise from around the world. The current Editorial Board includes Margaret Barbour (University of Sydney), Brendan Choat (Australian National University), Will Cornwell (University of California, Berkeley), John Evans (Australian National University), Jennifer Funk (Chapman University, CA), Robert Furbank (CSIRO Plant Industry, Australia), Hans Lambers (University of Western Australia), Rana Munns (CSIRO Plant Industry), Adrienne Nicotra (Australian National University), Lawren Sack (University of California, Los Angeles) and Louis Santiago (University of California, Riverside).

The wiki interface is designed to maximise its accessibility. Initially we contacted experts for content, to encourage them to send protocols and to write short 'reviews' of methods. From July 2010 the resource will be open to the community for expanded use. The first priority is to encourage laboratories around the world to make use of this resource and, in particular, to upload protocols and tools to allow users to share in expertise and expand areas of research. *PrometheusWiki* includes templates for uploading protocols to make this simple, easy and fast. The template includes an overview of the method, background (including materials, units, terms and descriptions, preparation needs), procedures, other resources, references and health and safety considerations as well as search terms and classification tags (Table 2).

### The equal importance of innovation and of standardisation: from new methods to the *Gold Leaf*

The trend towards standardising units and methods increased strongly after the French Revolution across fields of science and has hastened progress, especially in physics and chemistry (Taylor and Thompson 2008). Recent work to standardise protocols, analyses and data presentation has contributed to rapid strides in molecular biology databasing (Benson *et al.* 2008). However, in physiology, ecology and environmental measures, despite various textbooks containing a unified nomenclature and sets of symbols and units (e.g. Pearcy *et al.*

**Table 1. List of topics currently covered on *PrometheusWiki* (with additional topics to be added on an ongoing basis)**

Sensing and environment
Atmosphere
Soils
Plant-level microclimate
Sensor technology and data logging
Soils and rhizosphere
Structure
Anatomy and microscopy
Architecture
Morphology
Function
Gas exchange
Growth
Imaging technologies
Isotope methods
Tissue chemistry
Water relations
Experimental design and analysis
Experimental treatments
Statistics

**Table 2. Electronic template for uploading protocols to *PrometheusWiki***


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Protocol title
Initiate author name.
Overview
Please enter some basic detail about your protocol below.
Explain to a novice user why you'd do this, what it's for (~50 words).
Background
Provide additional information relevant to the protocol, in particular its application and value, and possibly other details about how it was developed and the nature of the techniques involved.
Materials/equipment
List
Units, terms, definitions
List terms, define units, etc. here for the glossary.
Procedure
=== Step 1 ===
=== Step 2 ===
Please feel free to include pictures, audio files and video here. Also include links to related protocols, statistical and analytical resources. Please break your procedure into useful steps with subheadings.
Other resources
Notes and trouble shooting tips
Include extra details or minor modifications that are not critical to above protocol but are likely to assist users. Example: Estimates of preparation time.
Anecdotal observations can also be posted here.
Links to resources and suppliers
Literature references
Health, safety and hazardous waste disposal considerations
Search terms and classifications
List species on which this protocol has been used: Family____ Genus____ Species____.
Growth forms: Herb, Woody, Vine, Succulent, Tree, Aquatic Setting in which protocol has been tested.

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1989; Jones 1992), many subfields have remained resistant to consensus usage. There is now an overwhelmingly clear need to standardise methods in plant and environmental physiology as these topics have become increasingly important given the expansion of the fields at the same time as a hastened requirement to understand and mitigate global change, to increase agricultural productivity and sustainability, and to preserve rare species and ecosystems.

In particular, standardising of methods will allow research from around the world to improve by being **directly comparable** and thus increasing confidence when comparing results. Further, directly comparable data will facilitate **system-level analyses** of physiological and ecological data. This is especially important given current efforts to collect data at multiple sites in parallel by networks such as the National Ecological Observatory Network (NEON) in the USA and the international long-term ecological research (I-LTER) system. These organisations interested in monitoring the impacts of global climate change have a need for plant physiological measurements to be made accurately on a global scale for dynamic global vegetation models.

Additional practical benefits of *PrometheusWiki* will be to facilitate standardisation of not only methods, but also units and nomenclature. The development of a glossary and the use of the same symbols and units across the site is intended to contribute to standardisation in the field as a whole, with long-term benefits for rapid understanding of the future literature.

While *PrometheusWiki* is a tool to achieve updated and standard protocols, implicit in the very nature of physiology and environmental biology is the need to develop new methodologies on an ongoing basis. Some of the most creative

scientists find their homes in these fields. *PrometheusWiki* can achieve the best of both worlds. New methods can be posted on the site along with bench-top protocols, immediately and without peer-review, but can include links to papers in which they have been used, and will be open to community comment. Indeed, papers may refer to the website for additional detail (Fig. 1). This will promote the use and dissemination of new methods.

Equally, when methods or protocols are already, or become, well established, editors can propose these for peer review as '*Gold Leaf*' consensus protocols. *Gold Leaf* protocols are peer-reviewed, after being found by a subject editor to have received sufficient editing, positive feedback and usage to warrant endorsement. The Editorial Board will meet regularly (electronically) to discuss nominations. All nominations will be sent to all board members, and then at least three Editorial Board members will be involved in discussion to promote a protocol to *Gold Leaf* status. *Gold Leaf* protocols will be formatted as PDFs with initiating author, contributing author(s) and subject editor names included, and stamped with the *PrometheusWiki* logo, version and the correct citation of the protocol. A disclaimer will explain what the *Gold Leaf* standard means and will direct the user to look for updates periodically. There will be a comment section to allow continued posting of responses or additional suggestions. Of course, *Gold Leaf* protocols can be updated if the consensus view in the measurement community shifts. Multiple *Gold Leaf* protocols for a given procedure can be submitted and published, reflecting different approaches. This editorial work will rely on the involvement and expertise of committed members of the scientific community in many fields, and we are very grateful to

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# PrometheusWiki

PROtocols, METHods, Explanations and Updated Standards for ecological and environmental plant physiology

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Feel free to wander through our site:

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- register to upload or edit protocols,
- add comments, questions, and post requests for protocols too

As you'll see, *PrometheusWiki* uniquely combines the open communication of the www with the traditions of peer review to ensure quality and deliver a useful resource for the entire field.

See [About PrometheusWiki](#) for more information.

We welcome contributions from all members of the research community - from newcomers to established practitioners around the globe. Your contributions and feedback will make this endeavor a success!

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Fig. 1. *PrometheusWiki* homepage (<http://www.publish.csiro.au/prometheuswiki/tiki-index.php>).

the many that have already devoted time and effort to bringing this functionality to *PrometheusWiki*.

In some cases, there may be a high level of disagreement as to which methods are best. The goal of *PrometheusWiki* in these cases is to provide a forum for constructive and ongoing debate leading to synthesis and technical improvement. In some cases, this discussion would lead to **subsequent discoveries** as well as quickly and efficiently **determining best practices**.

During the design of this resource, several concerns were raised. We briefly discuss these here and how the *PrometheusWiki* infrastructure was built to address these issues. One particular concern was that published standard methods and protocols cannot guarantee actual standard quality. This is true. However, the unlimited length of protocols in *PrometheusWiki* may be advantageous here. As protocols grow in sophistication, they can include approaches to quantify measurement error and to provide quality assurance/quality control.

A second concern was raised about the ability of standard methods to provide the best information. Isn't it true that a great recipe only takes you so far, and a great cook learns to modify this to his own purpose? Wouldn't this be one reason for developing individual variations on given methods, to modify these to be

optimal to the plant material, climate and supplies at hand? Perhaps the highest quality data collection would then depend on idiosyncratic, rather than standard methodology? This concern is ideally addressed by *PrometheusWiki*. We have already had a test case for this issue – the protocols for the response of photosynthetic rate to irradiance (the 'light response curve'). We found that there was no common protocol for measuring this fundamental dynamic at the core of many processes of plant physiology and ecology, and that several of our editorial team had their own distinct protocols. There was skepticism that these could be integrated fruitfully, given that they were specialised for different situations. However, this exercise led to our first consensus protocol ('Gas Exchange using LI-COR 6400'; <http://www.publish.csiro.au/prometheuswiki/tiki-index.php?page=GAS+EXCHANGE+PROTOCOL+FOR+LI-COR+6400>), including in the end several alternative versions of given steps. Thus, the tension among various methods creates fertile ground for the development of consensus best practices based on the available options. The online format allows space for many variations on a given method that are optimal for different conditions, such as laboratory, greenhouse and field, and different climates and vegetation types. Such variations will

include alterations of a given method to better cope with different conditions without compromising the data.

### The *PrometheusWiki* publication process

Anyone can register as a **member** of *PrometheusWiki* without any cost, simply by providing their name, institution and contact details, and from then will have permission to upload and edit, and to provide feedback on any posted protocol. Any user can become an **initiating author** by uploading a protocol using the template form, which sets out the fields to be filled, and standards for organisation and for units (Table 2). On uploading the protocol, the author will be notified that the protocol has been sent to the appropriate editor and they will receive feedback usually within 2 weeks. The **editor** will then review the protocol to determine whether it duplicates existing protocols or is a novel addition. When a protocol meets all criteria including adherence to rules and format, the author will receive an email saying the protocol is live. The protocol will then be open to wiki editing by members. The Editorial Board will also monitor use and activity on individual protocols, and nominate protocols for consideration for *Gold Leaf* format. Editors also write and manage summary articles introducing topic sections, to which the protocols are linked. Protocols can also be found by searching from any page and are also categorised according into relevant section areas alongside related protocols.

### *PrometheusWiki* as a tool for student training and learning

This innovative resource will provide an exciting tool for teaching and learning. It will allow **student learning of up-to-date methods** used by researchers at the cutting edge. Presently, students lack a resource for finding current protocols, and the complexity of many methods in our fields makes such a resource especially critical. Certainly this resource could have a very high impact in capacity-building for undergraduate and graduate students equally in both large universities and in remote field sites, allowing anyone with access to the internet to study the methodologies. Further, because students themselves can become members of the *PrometheusWiki* community, they can engage in live discussion with practitioners in the field.

The *PrometheusWiki* website could be used by students to self-train. Indeed, the resource will have reached maturity when there is sufficient information to allow that to happen. The amount of quality science in our fields will multiply many-fold. In turn, the points of difficulty that students highlight will motivate improving the web resource, leading to specific improvements and elevating the whole field of inquiry.

### Increased collaborations and expanding the cutting edge of research

As it was intended, *PrometheusWiki* can be used as an introduction to many fields of environmental science and thus can be used as a tool to develop collaborations. We invite you to browse the website (<http://www.publish.csiro.au/prometheuswiki/tiki-index.php>; Fig. 1) and to imagine collaborating with scientists with skills to implement these measurements, or to train students on these new methods. If scientists across fields are willing to do this, our fields will cross-

link increasingly, and we will all gain a greater breadth and confidence in answering our questions, with easy access to the best methods available. Most of the feedback we have received from scientists has been positive and indicated a keenness to contribute to this initiative despite all contributions being voluntary and additional to existing research, teaching and publishing commitments. Traditionally, information about protocols has been communicated either through conventional peer-reviewed publications, or through knowledge-sharing between specific laboratory-groups. The former is slow and formal while the latter is inefficient in what is now a global field. The impetus for this project arose from a desire to provide an up-to-date, centralised resource, using new technology to facilitate contributions and collaborations among research groups across the globe.

### A new direction for science publishing

*PrometheusWiki* is a novel hybrid of scientific and internet publishing, combining formal and informal components, and emphasising content written collaboratively by an international group of scientists. Visitors do not need specialised qualifications to contribute. The intent is to create a flow of expertise among groups that (1) moves the field towards standardisation using 'best practices' and (2) improves efficiency in the general research effort by promoting open communication of methods and protocols. These aspects move beyond traditional publishing in peer-reviewed journals and have potential to revolutionise the way that science is performed.

Because *PrometheusWiki* is an ongoing work to which, in principle, anybody can contribute, it differs from a paper-based reference source in important ways. On the positive side, publication and editing on *PrometheusWiki* are close to immediate. Thus, lengthy delays in reviewing and revising are avoided. Direct peer-to-peer review on *PrometheusWiki* will enable much more rapid progress than traditional publishing methods do. However, users must also be aware that older postings on *PrometheusWiki* will tend to be more comprehensive and balanced, reflecting community editing and debate, while newer articles on *PrometheusWiki* will, by virtue of being recent posts, be relatively less tested and edited and may more frequently contain significant misinformation and even vandalism (like *Wikipedia*; Giles 2005; Thompson 2005). While *PrometheusWiki* protocols will generally attain a good standard after editing, especially after *Gold Leaf* review, it is important to note that fledgling protocols and those less well-monitored may include low-quality information. However, unlike a paper reference source, *PrometheusWiki* is continually updated, with the creation or revision of protocols on novel research areas within seconds, minutes, or hours, rather than months or years for the traditional scientific publication process. The open approach tremendously increases the chances that any particular factual error or misleading method will be relatively promptly corrected. We also encourage the posting of links to peer-reviewed scientific papers that utilise the protocols.

The software that runs *PrometheusWiki* retains a history of all edits and changes; thus, information added to *PrometheusWiki* never vanishes. Discussion pages also provide an important resource especially for contentious topics. Therefore, serious

researchers will find a variety of viewpoints not present in the consensus protocol. Like any source, information should be evaluated. We believe that these advances in publishing, used carefully, will strongly benefit our research and education. In designing *PrometheusWiki* and providing a range of content, including commentary by members, minimally checked newer protocols, consensus *Gold Leaf* protocols and considered pieces by editors, we aim to provide the whole range of possibilities for maximum usage and information transfer. We seek to maintain the openness of a wiki while ensuring that the site still maintains the credibility and reliability of a professional journal through the use of ratings systems, community review and the involvement of an Editorial Board to approve new protocols and to designate *Gold Leaf* protocol status.

### A new form of attribution in a new-media world

When colleagues ask, 'What recognition will I receive for publishing in *PrometheusWiki*?', we have four suggestions. First, we anticipate that initiating and editing protocols on *PrometheusWiki* will in time become something seen as a noteworthy achievement in itself. New media provide opportunities for innovative approaches to publishing and peer review. While 'publish or perish' currently refers to publication in ISI-listed journals and the citations that arise from these, the need for rapid dissemination of knowledge and the opportunity for more thorough peer-to-peer review provided by web resources will eventually shift the relative value of a paper citation and a web citation; online journals and pre-publication citations have become commonplace in recent years. Second, while *PrometheusWiki* is a wiki first and foremost, by virtue of its international Editorial Board and highly regarded publisher, its editorial policies and *Gold Leaf* protocols, it is also a new form of journal. To that end, we have made the most of available technology to incorporate an automatic citation system that provides each page's bibliographic details in several common reference styles for the user to copy directly. Third, we recommend that initiating authors include references to papers in which they have used their protocols. This will no doubt lead to increased exposure for those papers with potential follow-on citations. Finally, publication of a protocol on *PrometheusWiki* does not preclude publication of another version in a traditional print or online journal. For example, a more thoroughly referenced but less detailed version might ideally be published in a methods journal, with cross referencing to the wiki. The *PrometheusWiki* version will have the benefit of being more detailed and incorporating a wide array of community comments and edits.

In all cases, it is the author's responsibility to ensure his or her right to publish the protocol. If rights are held by a publisher or other body, the author will need to seek permission before posting the material. *PrometheusWiki* uses a Creative Commons, Attribution Share Alike Licence (<http://creativecommons.org/licenses/by-sa/2.5/au/>). This means that people are free to share, copy, distribute and remix material, but must attribute the work in the manner specified by *PrometheusWiki*. Further, if the user alters, transforms or builds upon the work, they may distribute the resulting work only under the same or similar licence to this one.

Successful scientific publishing relies on publicity, trustworthiness and access (Kling and McKim 1999). *PrometheusWiki* will gain publicity via the publisher and launches and displays at international meetings, but equally importantly by word of mouth transmission. As laboratory leaders around the world contribute and refer students to the site, its reputation will grow. The site's trustworthiness will follow from the valuable contributions of recognised experts as well as newcomers to the field, and the open commentary. Finally, access to the site will be open to all and any registered member can edit the site. *PrometheusWiki* is thus intended to develop into a centralised repository of ecological and environmental plant physiology protocols, a novel resource to replace previous hard copy publications of standardised methods and an important reference site for long into the future. **CSIRO PUBLISHING** will archive *PrometheusWiki* so that ongoing access to the content is ensured.

We are pleased to introduce *PrometheusWiki* and hope you join us in this project to enable a significant positive impact on our field. The future should assure universal access to the best methodology, the development of consensus best practices, increased student training and collaboration across fields, to elevate research to the highest level that these steps allow. For these results, *PrometheusWiki* will depend on your contributions and feedback on an ongoing basis. We thank you in advance for your contribution to this new resource.

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