Community Collaborations:
Advancing Arabidopsis Research and Training (ART-21) and the International Arabidopsis Informatics Consortium (IAIC)

Plant and Animal Genomes Conference, XXIV
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https://www.araport.org/community/group/naasc
Rationale for ART-21 RCN

*Arabidopsis Research and Training for the 21st Century*

A Research Coordinated Network (RCN) to enable research and training activities for the Arabidopsis and broader plant science communities

**Key Objectives**

1. Identify emerging technologies where using Arabidopsis as a model organism will provide fundamental discoveries and enable translational research in crop species

2. Enhance interdisciplinary training of scientists for academia and extra-academic careers

3. Increase diversity of Arabidopsis research scientists using targeted mechanisms
Community discussion- changing bioinformatics needs- ICAR 2009

- Arabidopsis informatics needs are growing quickly, with new data types and a rapidly increasing rate of data generation.
- Individual investigators are devising new data handling and visualization tools that have broad utility.
- The Arabidopsis community is global, yet most of the current informatics support is funded on a national level.

Community workshops in 2010 led to IAIC establishment- 2011

- Blake Meyers, PI, IAIC RCN NSF Award

Design Workshop-2011- spurred Arabidopsis portal funding- 2013

- Chris Town, PI, Araport NSF Award

First modules for Araport were produced- 2013

- From Arabidopsis community members in Canada, UK, Germany

July 2014: NAASC engaged the international Arabidopsis community at ICAR 2014 to discuss ‘next steps’ in plant biology

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Genesis of ART-21 RCN

ICAR 2014- Vancouver, Canada was the 25th meeting which inspired reflection by keynote speakers:

1. How Arabidopsis impacted their field
2. How continued focus on a deeply developed model will contribute to answering key questions in biology
3. How their research will impact food security in a changing climate

This led to community discussion and challenges:

1. What is the role of Arabidopsis research and its community in the next 10 years?
2. What are the key strengths of this reference organism?
Genesis of ART-21 RCN, cont.

Key strengths of Arabidopsis and its closely-knit community:

• The development of emerging genomics technologies
• Management of increasingly available and complex bioinformatic datasets
• The creation of novel resources and tools

How to leverage, and build on, these strengths to address 21st century challenges in biology?
Genesis of ART-21 RCN, cont.

21st Century Biology Challenge: *an example*

**Food Challenge:** Generate Food Plants to Adapt and Grow Sustainably in Changing Environments

**Goal:** Understand Plant Growth and Development

**Fundamental understanding requires:**

1. Fully-characterized reference plant genome as knowledge base
2. Development of predictive models
3. New technologies to test on reference and crop plants in parallel
   - *E.g. live visualization of growing plants, computational growth modeling at molecular and cellular levels, large-scale phenotyping, ‘omics data...*
4. Quantitative, computational and statistical analysis and skills including to manage and interpret large datasets

→ Allows ‘genetically informed plant breeding’ where genetic changes are made in a targeted way that will predictably result in novel crops and crops adapted to their growth conditions

*Reference: A New Biology for the 21st Century, NAS, 2009*
Several key reports were considered while developing ART-21

ART-21

1. Key training areas:
   • Computational and Quantitative Knowledge and Skills
   • Emerging Genomic Technologies and Techniques

2. Enhance interdisciplinary training for multiple careers

3. Increase diversity of Arabidopsis researchers

Several Key Recommendations:
• Combine biology with breeding, engineering, computational application
• Integrate data with statistical models
• Expand training beyond traditional PhD programs

Priorities:
• Information technologies
• Cross-disciplinary collaborations
• Integrate physical sciences into biology

NEW BIOLOGY FOR THE 21ST CENTURY (2009)

PLANT SCIENCES DECADAL VISION (2013)

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ART-21 Approach- Five Year Plan

• Annual ICAR community workshops
• Focus Groups to address specific topics in research and training for 21st Century Plant Biology
• Enabling participation and increasing diversity in science
• Year 3 pre-ICAR 2017 ‘Hands On’ week-long workshop combining computational, bioinformatic, and experimental/ wet-lab research
• White papers, publications, newsletters, webpage, outreach
• Regular community surveys for input, recalibration
Focus Groups and ICAR Community Workshops Feed into Final Wrap-Up, Assessment and Recommendations Publication
ICAR 2015: Interactive Panel Discussion (... survey)

– What are the bioinformatics and computational skills needed by plant scientists of the 21st century to deal with more complex datasets (predictive, quantitative and theory-driven)?

– Technology changes rapidly...
  • are there core marketable skills?
  • core techniques?

– What are the bottlenecks to providing students (or PDs or faculty) with the needed skills?
Preliminary survey data
(Responses from 75 North American Arabidopsis faculty, about 50:50 male:female)

[Ranked] Bioinformatic, Quantitative, or Computational skills you want to gain/learn:
1. Data Analysis
2. Statistical Analysis
3. Computer Programming
4. Computer Modeling
5. How to integrate biology w/computational and quantitative approaches
6. Imaging Techniques
7. Fundamental/foundational knowledge (e.g. advanced mathematics, physics)
Preliminary survey data, continued, 75 faculty responses

[Ranked] Biggest obstacles to obtaining those skills:

1. **Lack of time:** work focused primarily on wet lab experiments

2. **Lack of fundamental knowledge:** undergraduate or graduate education did not include programming, modeling, advanced math or statistical analysis

3. **Rapidly changing field:** makes it hard to learn and keep up with new techniques, approaches.

4. **Lack of access:** to relevant coursework or training at my institute, or to flexibly-scheduled courses (including online course availability)
Preliminary survey data

(Responses from 50 students and postdocs, majority European- @ICAR 2015)

[in order of frequency in responses]

Bioinformatic, Quantitative, or Computational skills you want to gain/learn:
1. Computer Programming
2. Statistical Analysis
3. Modeling
4. Data Analysis
5. Fundamental Mathematics
Preliminary survey data, continued about 50 students/postdoc responses

(Unranked) Biggest obstacles to obtaining those skills

1. Lack of time: work focused primarily on wet lab experiments
2. Lack of fundamental knowledge: undergraduate or graduate education did not include programming, modeling, advanced math or statistical analysis
3. Rapidly changing field: makes it hard to learn and keep up with new techniques, approaches.
4. Lack of access: to relevant coursework or training at their institute, or to flexibly-scheduled courses (including online course availability)
5. PI-based barriers (PI says to focus on wet-lab work)
Computational training and education of plant biologists for 21st century careers

Overarching Framework:
1. Bioinformatics, computational skills for 21st century biology and bottlenecks, obstacles to getting those skills
2. What employers need/want from employees, marketable skills

Specific Discussion Topics:
1. Training and Education
   • Skills needed for Industry and Faculty positions
   • Undergraduate, Graduate and Postdoc Education
2. Collaborations
   • Working with a biologist: a quantitative expert’s perspective
   • Working with a quantitative expert: a biologist’s perspective
   • Retraining yourself
3. Training Arabidopsis Biologists for High-Throughput Phenotyping
4. Translating from Arabidopsis to Crop Species, and Vice Versa
Arabidopsis Research Review in *The New Phytologist* including network analysis of 54,033 pubs (October 2015)

**Tansley review**

50 years of Arabidopsis research: highlights and future directions

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**Summary**

The year 2014 marked the 25ᵗʰ International Conference on Arabidopsis Research. In the 50 yr since the first International Conference on Arabidopsis Research, held in 1965 in Gottingen, Germany, > 54 000 papers that mention *Arabidopsis thaliana* in the title, abstract or keywords have been published. We present herein a citational network analysis of these papers, and touch on some of the important discoveries in plant biology that have been made in this powerful model system, and highlight how these discoveries have then had an impact in crop species. We also look to the future, highlighting some outstanding questions that can be readily addressed in Arabidopsis. Topics that are discussed include Arabidopsis reverse genetic resources, stock centers, databases and online tools, cell biology, development, hormones, plant immunity, signaling in response to abiotic stress, transporters, biosynthesis of cells walls and macromolecules such as starch and lipids, epigenetics and epigenomics, genome-wide association studies and natural variation, gene regulatory networks, modeling and systems biology, and synthetic biology.
ART-21 Leadership and Steering Committee

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