

H3ABioNet: Developing Sustainable Bioinformatics Capacity in Africa

Shaun Aron^{1,2}, Kim Gurwitz^{1,3}, Sumir Panji^{1,3}, Nicola Mulder^{1,3}, H3ABioNet Education and Training working group* as member of the H3Africa Consortium

¹H3ABioNet - a pan-African Bioinformatics Network; ²Sydney Brenner Institute for Molecular Bioscience, University of the Witwatersrand, South Africa; ³Computational Biology Division, Department of Integrative Biomedical Sciences, University of Cape Town, South Africa.

* all H3ABioNet Education and Training working group members are listed on the last page of this article.

Introduction to H3ABioNet

H3ABioNet¹ - a pan-African bioinformatics network (Mulder *et al.*, 2016) - was established in 2013 as part of the **Human Heredity and Health in Africa**² (H3Africa) initiative (H3Africa Consortium *et al.*, 2014). H3ABioNet comprises 32 research institutions across 14 African countries with 1 partner institution in the USA and 1 partner institution in the UK. In addition to infrastructure building endeavours, H3ABioNet has a significant training component, with the aim of training bioinformaticians as well as biologists, geneticists, and clinicians in the use of bioinformatics to facilitate data analysis for their H3Africa project. The initial need for bioinformatics training was focused on addressing the needs of both the H3Africa community as well as training requests from within the H3ABioNet network. Between May 2013 and October 2016, H3ABioNet has hosted or supported 49 training events across various African countries. These events range from extensive four-week bioinformatics postgraduate training courses, to specialised training workshops on various topics, such as: data management, introductory and advanced system administration, biostatistics, genome-wide association studies (GWAS), next generation sequencing data analysis, and metagenomics. Training events have also taken the form of internships, online training, and hackathons. In total, approximately 1036 individuals have received training from H3ABioNet training events over the above mentioned period. A few select training events are highlighted below. We have learnt several important lessons about planning successful training events and have attempted to adapt our approaches to address various challenges in developing bioinformatics capacity in Africa, which is discussed in more detail later in this report.

Select training activities to date

Face-to-face training

Due to the initial lack of expertise across specialised bioinformatics analysis areas, a significant amount

of effort was put into developing and hosting formal training workshops. Over the period of the project, the network has attempted to cover as many specialised topics through the presentation of hands on, face-to-face workshops, ranging from a Train-the-Trainer workshop (covering various fundamental bioinformatics topics), to specialised training in GWAS, metagenomics, and NGS data analysis. Some of these earlier face-to-face workshops were presented by invited expert trainers from abroad, however, subsequent training was conducted by local H3ABioNet members who were identified and mentored to become competent local trainers. In addition to the formal hosting and funding of workshops, H3ABioNet has also contributed towards the planning and support of various workshops run locally at its nodes. H3ABioNet has also provided travel fellowships to H3Africa members wishing to attend training workshops provided by other H3Africa projects in order to promote interaction and knowledge transfer between these projects.

Internship program

Although the face-to-face training approach proved successful in providing participants with a good foundation to return to their institutes and further develop their skills with some assistance, the short term contact did not provide enough exposure to allow the participants to confidently and independently analyse their own data. To complement the more formal training workshops, H3ABioNet set up an internship program for both H3ABioNet and H3Africa consortium members to spend a dedicated period of time at a host laboratory in order to acquire bioinformatics skills relevant to their research interests. The host laboratories in the internship program were both local and international, with the inclusion of a dedicated internship opportunity at the Harvard node of H3ABioNet. There have been 16 internship placements of H3ABioNet students to date and interns have visited both local and international laboratories to learn specialised analysis skills in: GWAS, metabolic network and structural modelling, microbiome

Article history

Received: 06 April 2017
Published: 11 May 2017

¹<http://www.h3abionet.org>

²<http://h3africa.org/>

© 2017 Aron *et al.*; the authors have retained copyright and granted the Journal right of first publication; the work has been simultaneously released under a Creative Commons Attribution Licence, which allows others to share the work, while acknowledging the original authorship and initial publication in this Journal. The full licence notice is available at <http://journal.embnet.org>.

data analysis, NGS data analysis, computational system administration, and big data transfer processes. The internship program has proven useful in providing young, enthusiastic students with the opportunity to not only develop specialised bioinformatics skills, but also to collaborate and interact with leading groups in their field of interest. Upon returning to their home institutes, the interns were encouraged to share the knowledge gained with their peers through local training events and were earmarked to be teaching assistants for the next workshop relevant to the specific skills they had obtained.

Online training

In an effort to further increase access to training across Africa, H3ABioNet has begun offering courses with an online component. In 2016, the network ran the first iteration of its [Introduction to Bioinformatics course \(IBT\)](#). The course was very popular with over 350 enrolled participants and over 70 volunteer staff in total, across 20 local classrooms spanning ten African countries. During this three month course, classrooms met each other and the trainer biweekly in a virtual classroom.

Hackathons

As the bioinformatics capacity across the network developed, a critical mass of expertise across a range of bioinformatics areas was developed. Together with the imminent arrival of genomic data from the H3Africa projects, the need arose for a shift from capacity development to data centric events and outcomes based hackathons. The *H3ABioNet Infrastructure and Research working groups* spearheaded this endeavour. The hackathons were aimed at gathering a group of people with a diverse set of skills - from computer programmers and bioinformaticians to biologists, clinicians, biostatisticians, and mathematicians - to develop and implement solutions to a particular bioinformatics problem. H3ABioNet has hosted two hackathons to date, both yielding very successful outcomes. The first was a *Cloud Computing Hackathon* aimed at developing reproducible workflows for anticipated H3Africa bioinformatics analysis pipelines available for use on heterogeneous computing environments as Docker containers, which can also be deployed on the cloud infrastructure. H3ABioNet's second hackathon was hosted in partnership with IBM Research Africa and the University of Notre Dame and was aimed at addressing a research question that forms part of a [DREAM challenge on malaria drug resistance](#). As more data becomes available through the various H3Africa projects, and the availability of individuals with a range of skills within the network increases, the hackathon format for workshops will be implemented more regularly in future training events in the network.

Challenges

At the onset of the training programs developed and implemented by H3ABioNet, it was anticipated that there would be challenges to face; some common to other training programs and some unique to the African setting. Some of the more relevant challenges that had a direct effect on the sustainability of the training in Africa included: the high costs of airline tickets within the continent; acquiring visas on time; availability of suitable computational infrastructure at training sites and once participants returned home; socio-political instability; and over subscription to courses due to high demand. On a more positive note, the occurrence of these challenges encouraged a more flexible approach to training and led to the implementation of the different formats of training described above. In particular, the training with an online component has proven to be a cost efficient and sustainable format for training in Africa. Further, H3ABioNet funding enabled many centres to purchase equipment, and the network's *Infrastructure working group* has worked closely with these centres to set up their own computing infrastructure. In this way, many more training sites are available and individuals have greater access to resources after the training events have concluded.

Conclusions

H3ABioNet has aimed to create a sustainable approach to further the development of bioinformatics capacity in Africa in partnership with the H3Africa Consortium. Together with complementary training initiatives focused on capacity development in Africa, H3ABioNet has provided numerous young African scientists with access to bioinformatics training opportunities, better equipping them to pursue a career in the field. Planning and implementing training in Africa has also brought to light the many obstacles that are faced by African institutions in developing bioinformatics skills. Some of these obstacles can be addressed and overcome using alternative training methods to develop a sustainable approach to bioinformatics capacity development in Africa.

Acknowledgements

Research reported in this publication was supported by the National Human Genome Research Institute (NHGRI) and the Office of the Director (OD), National Institutes of Health under award number U41HG006941. The content is solely the responsibility of the authors and does not necessarily represent the official views of the National Institutes of Health.

References

1. Mulder NJ, Adebisi E, Alami R, Benkahla A, Brandful J (2016) H3ABioNet, a sustainable pan-African bioinformatics network for human heredity and health in Africa. *Genome Res.* **26**, 271-277. <http://dx.doi.org/10.1101/gr.196295.115>
2. H3Africa Consortium., Rotimi C, Abayomi A, Abimiku A, Adabayeri VM (2014) Research capacity. Enabling the genomic revolution in Africa. *Science* **344**, 1346-1348. <http://dx.doi.org/10.1126/science.1251546>

³<https://www.ibm.com/blogs/research/2016/10/hacking-anti-malarial-drug-resistance>

***H3ABioNet Education and Training working group members**

Nicola Mulder¹, Shaun Aron², Sumir Panji¹, Kim Gurwitz¹, Judit Kumuthini³, Shakuntala Baichoo⁴, Segun Fatumo⁵, Oyekanmi Nash⁵, Jonathan Kayondo⁶, Faisal M. Fadlilmola⁷, Samar Kassim⁸, Jean-Baka Domelevo Entfellner⁹, Odile Ouwe Missi Oukem-Boyer¹⁰, Samson Pandam Salifu¹¹, Winston Hide^{12,13}, Kais Ghedira¹⁴, Amel Ghouila¹⁴, Lerato Magosi¹⁵, Alia Benkhala¹⁴, Victoria Nembaware¹, Mary Piper¹², Radhika S. Khetani¹², Anne Fischer¹⁶.

¹Computational Biology Division, Department of Integrative Biomedical Sciences, University of Cape Town, Cape Town, South Africa; ²Sydney Brenner Institute for Molecular Bioscience, University of the Witwatersrand, Johannesburg, South Africa; ³Centre for Proteomic and Genomic Research, Cape Town, South Africa; ⁴University of Mauritius, Moka, Mauritius; ⁵National Biotechnology Development Agency, Abuja, Nigeria; ⁶Uganda Virus Research Institute, Entebbe, Uganda; ⁷Centre for Bioinformatics and Systems Biology, Faculty of Science, University of Khartoum/ Future University of Sudan, Khartoum, Sudan; ⁸Medical Biochemistry and Molecular Biology Department, Faculty of Medicine, Ain Shams University, Cairo, Egypt; ⁹South African National Bioinformatics Institute/Medical Research Council of South Africa Bioinformatics Unit, University of the Western Cape, Cape Town, South Africa; ¹⁰Centre de Recherche Medicale et Sanitaire, Niamey, Niger / Cameroon Bioethics Initiative (CAMBIN); ¹¹Kumasi Centre for Collaborative Research in Tropical Medicine/Kwame Nkrumah University of Science and Technology, Kumasi, Ghana; ¹²Harvard T.H. Chan School of Public Health, Boston, Massachusetts, USA; ¹³Sheffield Institute for Translational Neuroscience, Department of Neuroscience, University of Sheffield, Sheffield, United Kingdom; ¹⁴Institute Pasteur of Tunis, Tunis, Tunisia; ¹⁵Botswana Harvard AIDS Institute Partnership, Gaborone, Botswana/ University of Oxford, Oxford, United Kingdom; ¹⁶Molecular Biology and Biotechnology Department, International Centre for Insect Physiology and Ecology, Nairobi, Kenya.